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
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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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A thesis submitted in partial fulfillment
of the requirements for the degree

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in

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APPROVAL

of a thesis submitted by

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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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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I want to thank the personnel of the Gardiner Ranger District, Gallatin National Forest for assisting in field work. Also, I offer my thanks to Frances Cassirer, Harold Whitney, and the 17 people who helped count winter-killed elk. Bill and Justin Ferguson were admirable and patient pilots, thanks to both of them.

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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

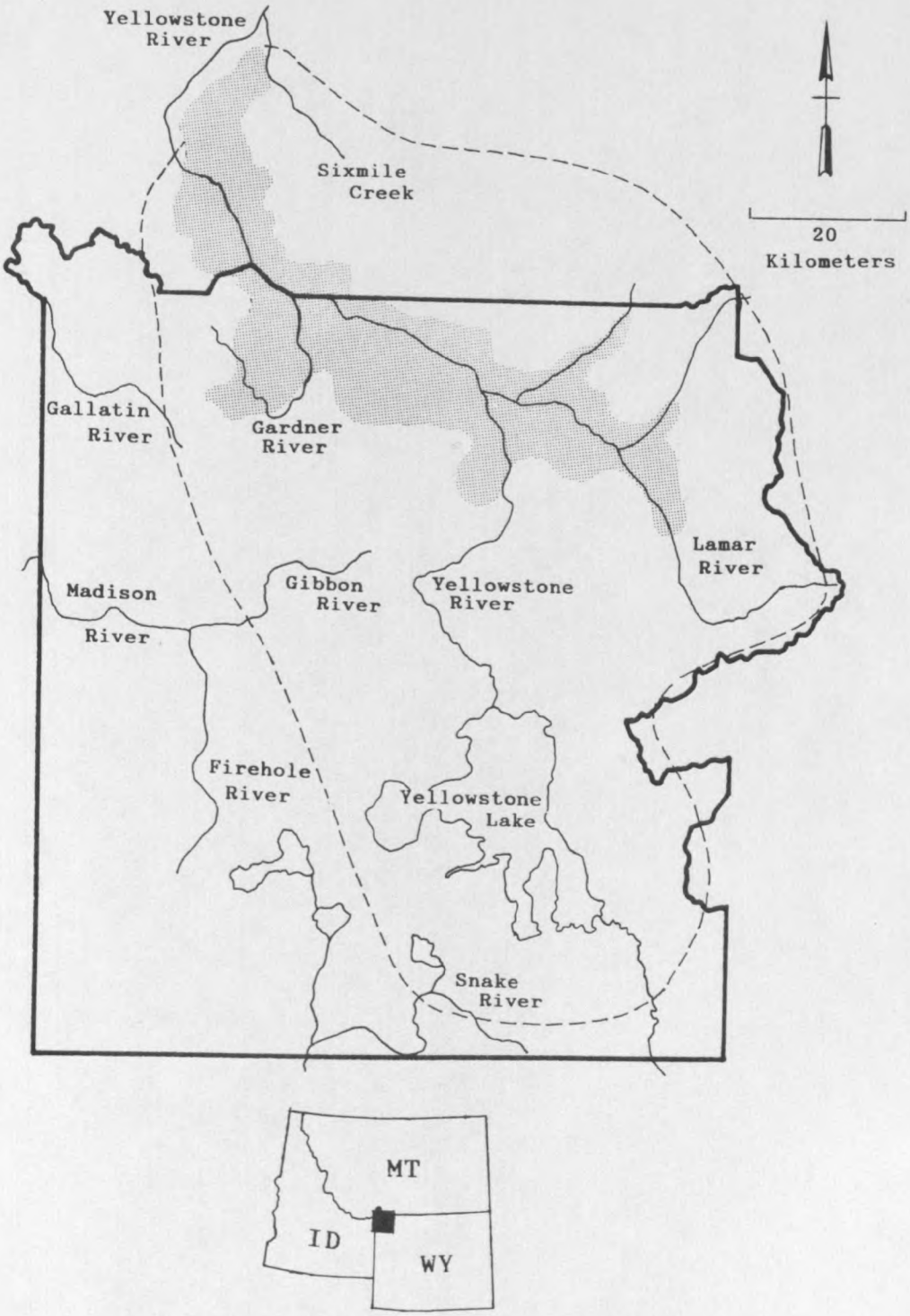

Figure 1. Map of study area showing summer range boundary (dashed line) and winter range (shaded area) of the northern Yellowstone elk.

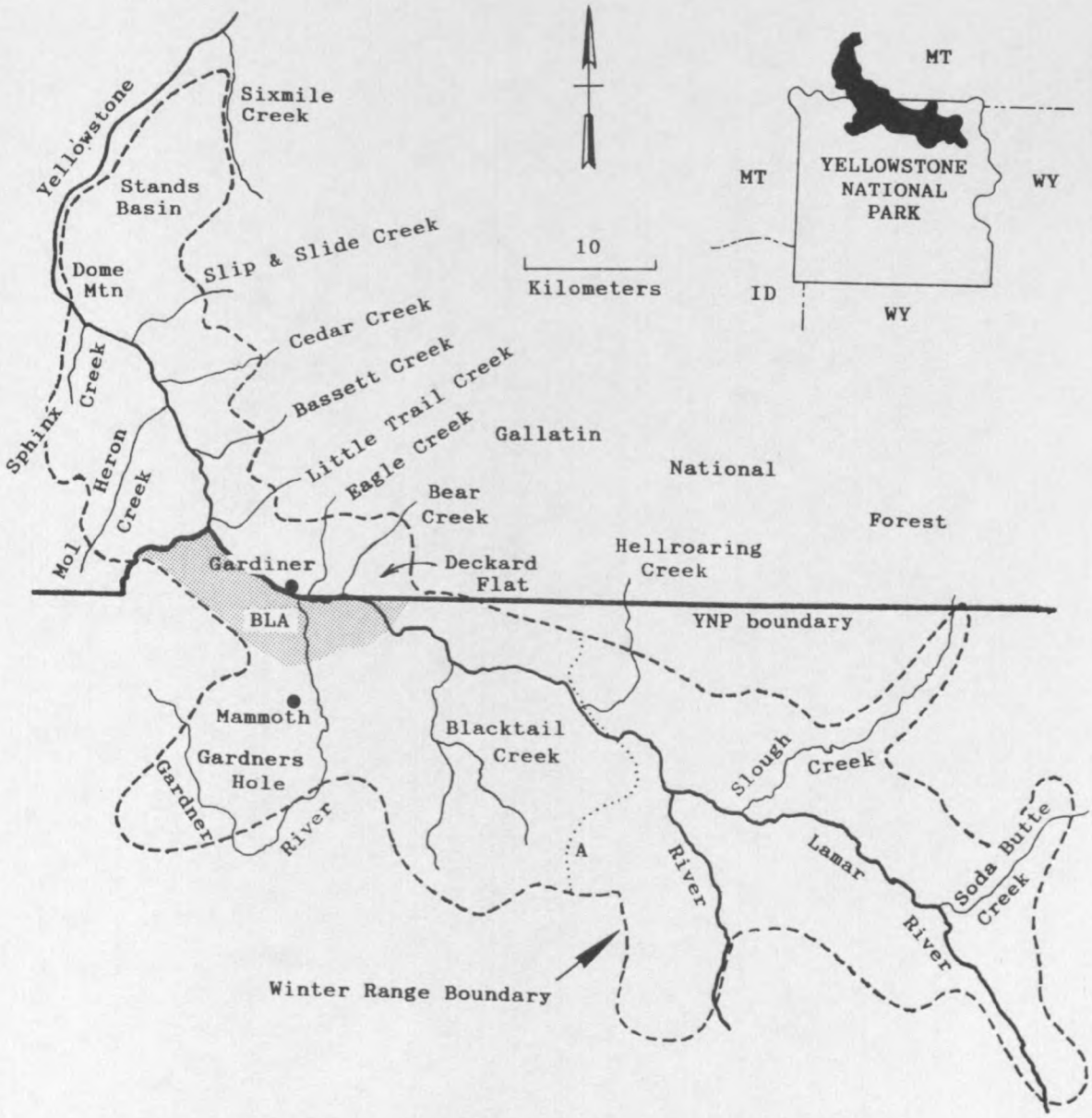

Figure 2. Map of the northern winter range. BLA is the boundary line area and A divides the upper and lower ranges according to Cole (1969).

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).

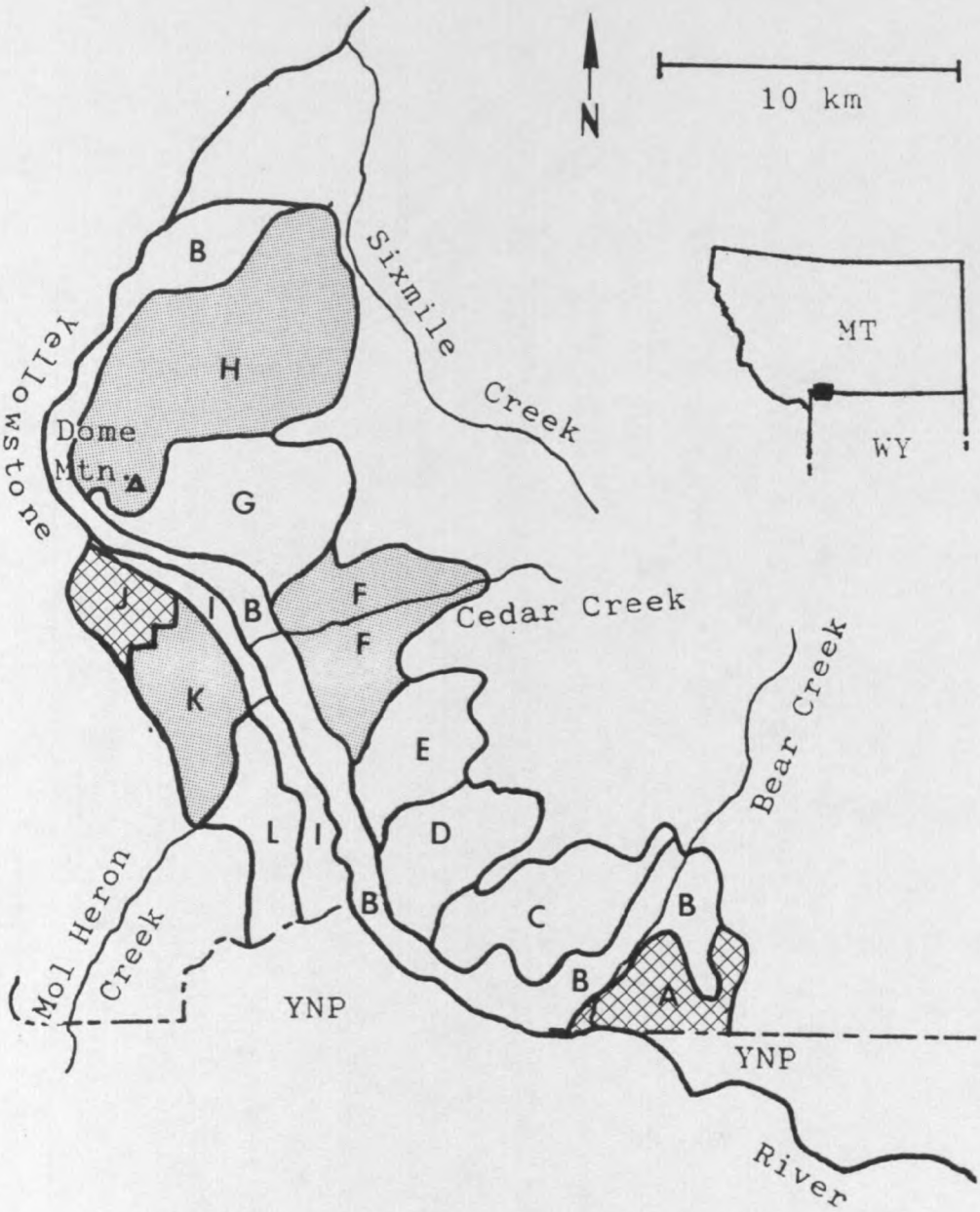

Figure 3. Study area land blocks used in analysis of elk distribution. A) Deckard Flats, B) East Road, C) Eagle Creek, D) Little Trail Creek, E) Bassett Creek, F) Cedar Creek, G) Slip and Slide Creek, H) Stand's Basin, I) West Road, J) Sphinx Creek, K) Trestle, L) Mol Heron. Stippled blocks were No-Access 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

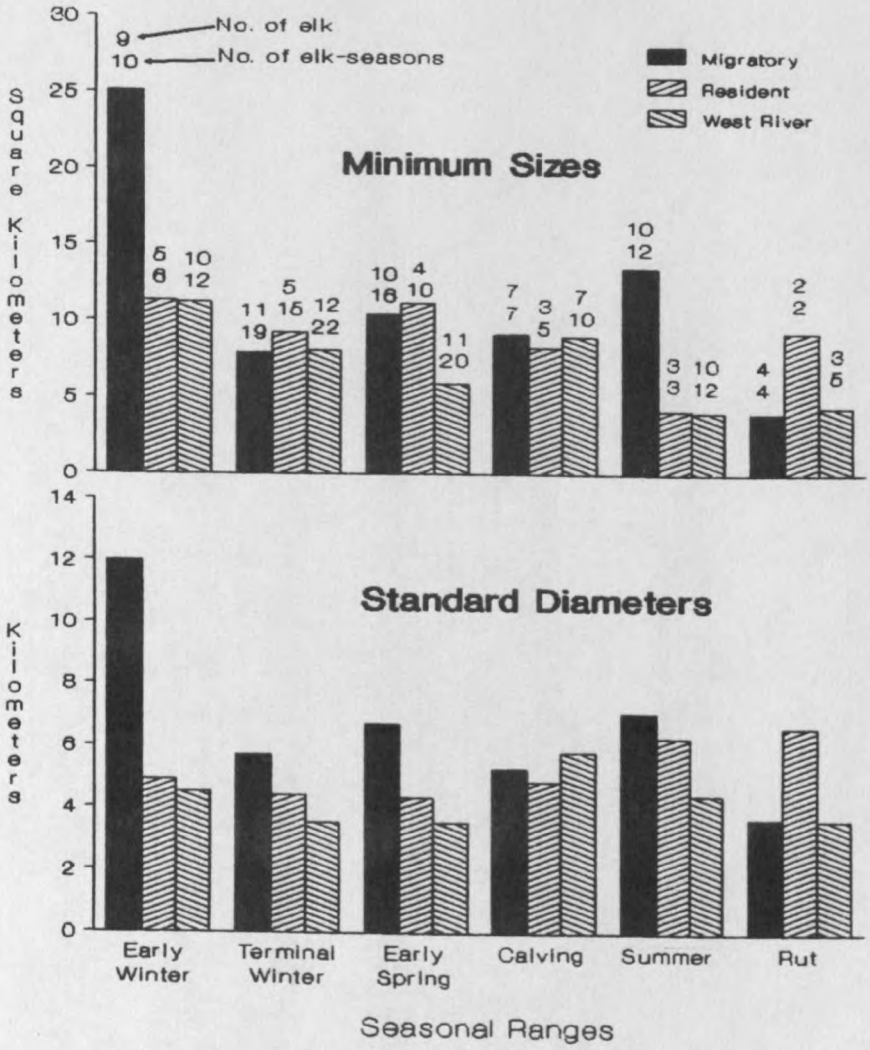

Figure 4. Average minimum seasonal range sizes and standard diameters for elk of the Migratory, Resident, and West River segments of the Northern herd during 1984-87.

winter and early spring ranges for Resident elk to 34 km between early and terminal winter ranges for Migratory elk (Fig. 5). Elk often spent more than one season on a range. The farthest distance between terminal winter and summer range was 151 km for Migratory elk 04501 which wintered near the northern extreme of the winter range and

summered east of Yellowstone Lake (Fig. 1). Two other Migratory elk made similar treks.

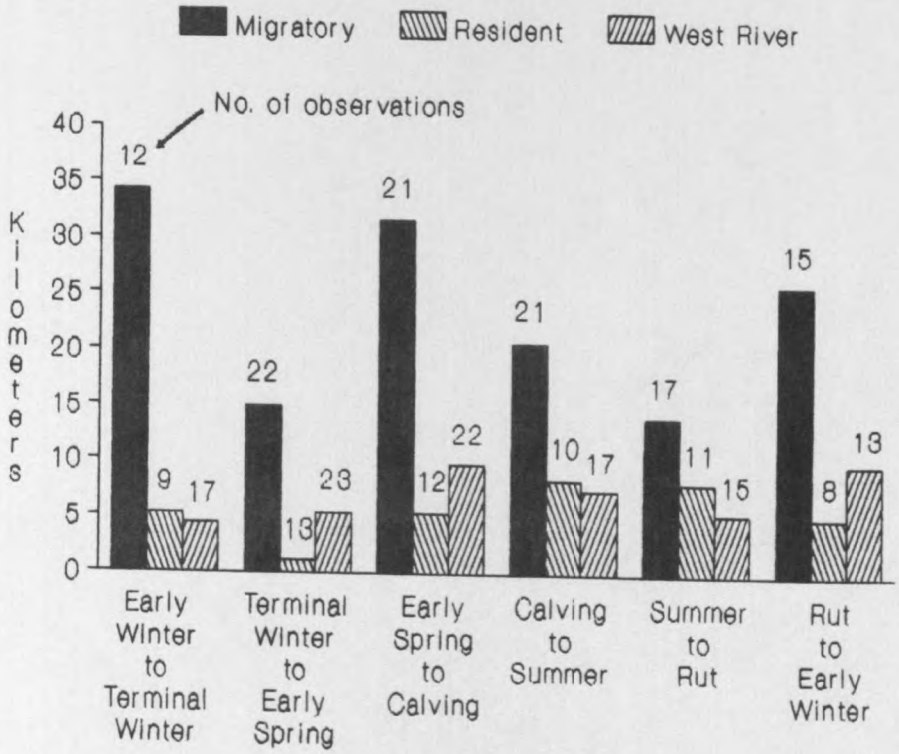

Figure 5. Average distances between seasonal ranges for marked elk of the Migratory, Resident, and West River segments of the Northern herd during 1984-87.

Elk migratory movement routes outside YNP were generally within 4 km of and roughly parallel to the Yellowstone River (Fig. 6). These routes most often traversed relatively open areas of gentle topography and were locally constricted by topography and timber. West River elk that crossed the Yellowstone River usually did so near the airport 4 km north of Gardiner (Fig. 2). Movement routes of Resident elk between seasonal ranges

were mostly within the Cedar Creek drainage, between Cedar Creek and Stands' Basin via Slip and Slide Creek and/or the Slip and Slide/Sixmile Creeks divide (Fig. 2).

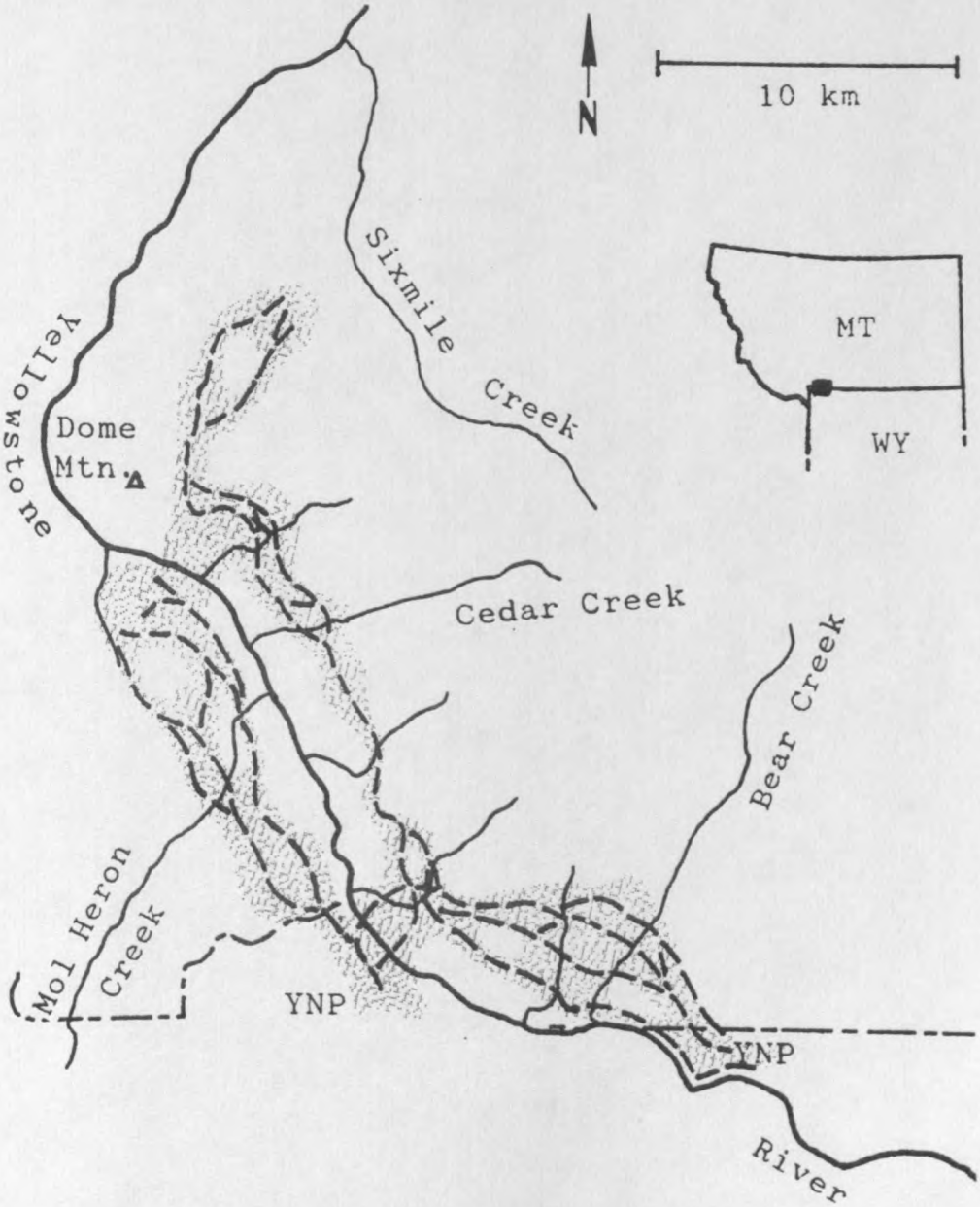

Figure 6. Migration movement routes used by northern Yellowstone elk outside of YNP. Dashed line shows known trails and stippled area shows generalized movement corridors.

The Late Hunts

Late season harvest averaged 1029 (range 828-1553), about a quarter to a third of the estimated number of elk that wintered outside the Park (Table 3). Areas open to hunting were from Bear to Sixmile Creeks on the east side of the Yellowstone River (Hunting Areas 2-4) and from the YNP boundary to Mol Heron Creek (Hunting Area 5) on the west side (Fig. 7). Areas 3 (Slip and Slide Creek) and 4 (Dome Mountain to Sixmile Creek) did not open to hunting until after the arrival of Migratory elk. This varied from 09 December to 04 January in Area 3 and from 20 December to 23 January in Area 4. Hunting was open for 4 days weekly from Friday through Sunday.

An average of 92% (range 88-97%) of the harvest occurred in hunting Areas 2 and 5, which are closest to the Park (Fig. 7, Table 4). The south portion of Area 2 was the most heavily hunted, accounting for 76% of the total harvest in 1984. This segment of the Area was readily accessible by a county road crossing the major elk migration route on the east side of the Yellowstone River. Bear Creek, the Hunting/No-hunting boundary, was usually within sight from the road. Relatively few elk were harvested north of Bassett Creek on the east side of the Yellowstone River (north portion of Area 2 and Areas 3 and 4, Fig. 7). The harvest in Area 5 averaged 11% (range 8-14%) of the total harvest.

Table 3. Number and distribution of elk observed during six censuses of the Northern range outside YNP and estimates of the number of elk wintering outside YNP.

	Date					
Map Area	Apr. 12&13 1985	Apr. 1,4&10 1986	Dec. 11 1986	Feb. 26&27 1987	Apr. 6 1987	Apr. 18 1987
A	13	15	559*	317*	12	2
B	0	4	0	30	2	1
C	118	52	15	375	55	90
D	15	153	5	99	32	96
E	174	135	0	92	17	129
F	967*	1098*	400*	735*	941*	362*
G	90	354	19	147	64	13
H	472*	176*	204*	737*	98*	177*
I	0	0	0	0	0	0
J	23	--	0	44*	0	0
K	303*	--	1*	212*	85*	46*
L	101	85	83*	104	17	13
TOTAL	2276[a]	2072[b]	1329	2893[c]	1323	929

* Considered a No-access area (see text).

[a] In addition 1206 elk were harvested during the late hunt and an estimated 500 had moved into the Park for an estimated minimum of 3982 wintering outside YNP.

[b] In addition 1058 elk were harvested during the late hunt and an estimated 750 had moved into the Park for an estimated minimum of 3980 wintering outside YNP.

[c] In addition 822 elk were harvested during the late hunt for a minimum of 3715 wintering outside YNP.

Late Hunt-May 15 Distribution

An estimated average of 3733 (SD=153) elk migrated out of the Park annually from 1985-87 (Table 3). Based on tracks and observations of elk movements and distribution, an estimated 60% of the elk outside YNP during the Hunt

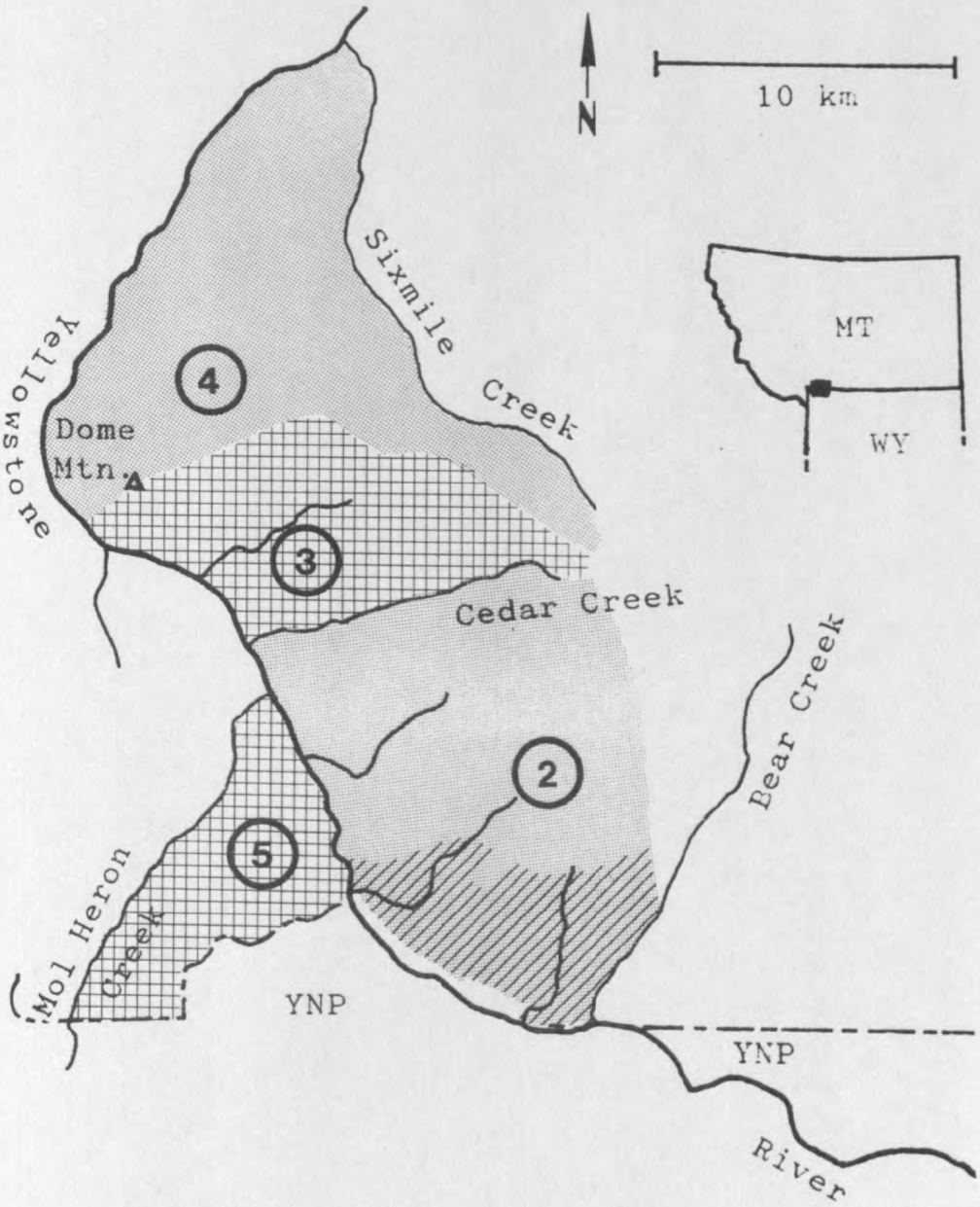

Figure 7. Late hunt administrative hunting Areas on the northern Yellowstone range. Diagonal-lined portion of Area 2 is the most heavily-hunted area.

Table 4. Gardiner late hunt harvest(percent of total) by hunting Area for 1984-87.

	Areas				
Year	2	3	4	5	Total
1984	1252(81)	91(6)	36(2)	174(11)	1553
1985	990(83)	23(2)	18(2)	165(14)	1196
1986	785(77)	72(7)	53(5)	112(11)	1012
1987	679(82)	53(6)	32(4)	64(8)	828
Total	3706(81)	239(5)	139(3)	515(11)	4599

period had moved along migration routes east of the Yellowstone River. An average of 90% (range 81-97%) of elk censused were east of the Yellowstone River. Elk distribution observed during each of 6 censuses and for all censuses combined was positively associated with No-Access land blocks (Chi square test, $p<.001$). These blocks averaged 44% of the winter range, depending on Season (see p.13), and harbored 75% of observed elk. During 1986-87 the percentage of elk observed on No-Access blocks for combined censuses during the Hunt period (census dates 11 December 1986 and 26&27 February 1987) was not different than for combined censuses during the Spring period (census dates 06 and 18 April 1986)(Chi square 1 df=3.46, p=.063). The No-access blocks that harbored the most elk were Cedar Creek, Stands Basin, and Trestle (Fig. 3). These comprised 41% of winter range and held 65% of all elk observed. Most notable among them was the Cedar Creek block with 12% of the winter range and 42%

of all observed elk. Elk densities in winter range blocks ranged from 0 to 42.25 elk/km^2.

Marked elk spent an estimated 22% of 6,080 elk-days in Access blocks for all years and both periods combined (Table 5). Of all ANOVA model interactions involving elk of the Migratory, Resident, and West River herd segments; Hunting and Spring periods; and year; only those among elk herd segments were significantly different ($F_{2,17}$=3.28, p=0.043) (Table 6).

There was no difference among elk of the Migratory, Resident, and West River herd segments use of Access blocks during the Hunt period; nor were there differences between the Hunt and Spring period use of Access blocks by elk of any herd segment. However, changes in elk use of Access blocks between the Hunt and Spring periods were enough so that during the Spring period Migratory elk used them more than either Resident (grouped t, p=0.01) or West River animals (grouped t, p=.03).

Late Hunt-May 15 Movements

Most movements on winter range outside YNP occurred at night. Fourteen West River elk were followed for 26 elk-winters. During 8 of these elk-winters the animals were not known to leave the Park. During 18 there were known movements into Access blocks. Fourteen of these movements

Table 5. Number of marked elk, relocations (loc), elk days, and the estimated weighted mean percent of days that marked Migratory (Mig.), Resident (Res.), and West River elk spent in Access blocks during the Hunt and Spring periods on the Northern winter range outside YNP from 1985-87.

		Hunt Period		Spring Period	
Elk	Year	Number of elk:loc:elk-days	% of days in access areas	Number of elk:loc:elk-days	% of days in access areas
Mig.	1985	7: 15: 332*	13.3	8: 31: 693	35.6
	1986	4: 18: 243	28.1	5: 34: 390	32.6
	1987	3: 12: 139	3.0	1: 6: 57	17.5
	Combined	14: 45: 714	15.3	14: 71:1140	32.6
Res.	1985	4: 8: 184	15.7	3: 12: 279	<0.1
	1986	3: 11: 159	8.8	4: 28: 363	5.7
	1987	2: 7: 71	1.5	2: 24: 178	32.0
	Combined	9: 26: 414	10.2	9: 64: 820	10.4
West River	1985	4: 32: 32	7.5	6: 39: 558	39.8
	1986	7: 31: 329	24.7	7: 59: 658	17.8
	1987	9: 85: 603	9.8	9:100: 766	5.8
	Combined	20:148: 905	14.6	22:198:1982	18.9
All elk	1985	15: 55: 516	12.4	17: 82:1530	30.8
	1986	14: 60: 772	22.2	16:121:1411	19.4
	1987	14:104: 850	7.2	12:130:1001	9.8
	Combined	41:195:2138	21.2	45:333:3942	22.1
	Combined periods	86:528:6080	21.7		

* Days for migratory elk are from the estimated date they left YNP to reentering it.

were into adjacent blocks open to hunting: 3 moved through areas open to hunting to closed areas beyond, 1 stayed in hunting Area 5 for 47 days and then moved through, 5 were killed, 3 returned after spending an average of 29 days (range 19-56) in areas open to hunting, and 2 stayed in

Table 6. ANOVA table for 3-way model of the effects of elk herd Segment, Season (Hunt or Spring), and Year on the natural log of the proportion of total days elk were estimated to be in public Access areas. Weight of each observation in cell ΣΣ of squares=total days of the observation.

Source	DF	ΣΣ of Squares	Mean Square
Model	17	7423.694	436.688
Error	70	13470.773	192.440
Corrected Total	87	20894.467	

Model F=2.27 Prob>F=0.008

Source of model error	DF	ΣΣ of Squares	F	Prob>F
Segment	2	1261.845	3.28	0.043
Year	2	86.729	0.23	0.799
Segment*Year	4	417.042	0.54	0.705
Season	1	83.408	0.43	0.512
Year*Season	2	210.967	0.55	0.580
Segment*Year*Season	4	777.135	1.01	0.408

areas open to hunting until they made a spring movement back into the Park. Cow 19103 stayed in hunting Area 5 from the beginning of the late hunt until shortly after 2 elk were harvested on 05 February 1987 near where she had been.

Four movements into Access blocks were noted after the Hunt period. These animals stayed an average of 43 days (range 19-53). Two of these elk returned to the Park sooner than would be expected for a spring movement. No animal was known to make more than one movement during a winter.

Movement analysis of elk that were captured and wintered near the Hunting/No-hunting boundary followed 12 elk (10 west river, 2 migratory) for 21 elk winters. During 6 there was no movement. Of 9 elk moving during the Hunting period 5 were killed, 3 returned (duration noted above), and 1 stayed. There were 6 moves after the hunt.

Movements by Migratory elk as they crossed the Hunting/No-hunting boundary were less well documented than those of West River elk. Many had moved through the heavily-hunted south portion of hunting Area 2 by the time the late hunt opened. Although movements occurred during the general season, the chances of a cow elk being killed were much less because of the relatively lower probability that a hunter possessed a permit to kill an antlerless elk. The only marked elk killed during the general season was a bull.

Elk moving through areas open to hunting usually did so in <5 days. Of five Migratory animals killed by hunters, all were killed near the Hunting/No-hunting boundary. These animals were estimated to spend 3,3,3,7 and 13 days in areas open to hunting before being killed.

Although not classified as movements because of duration of stay, elk in No-access blocks commonly made nightly forays into Access blocks to feed. Such movements

were at night and the animals returned before daylight or shortly thereafter.

Although some of the documented movements were during general season and not the late hunt, they illustrate how hunting affects elk movements. Elk 88401 summered on the divide along the the Wyoming/YNP border. During the falls of 1985 and 1986 she made movements into the Park after the opening of Wyoming's bighorn sheep and early elk seasons. In both years she later migrated across the >2800 m divide to winter range in Wyoming.

Two hundred twenty-seven between-relocation intervals were analyzed to determine the number of elk making movements versus those that did not (Table 7). Mean interval length was 24 days (SD=9). There was no difference between early and late in the Spring period (X^2 1 df=1.476, p=0.224) so data were pooled. Migratory elk moved during 62% of 88 time intervals; Resident and West River elk moved during 20% of 50 and 39% of 89 intervals respectively. Differences were significant (Chi square 2 df=25.16, p<0.001). Elk initially in Access blocks moved more than those in No-access blocks (X^2 1 df=6.80, p=0.009) however this was not true for elk of all herd segments. Migratory and Resident elk did not move more if they were in Access blocks (X^2's 1 df=1.547 and 0.0248, p's=0.2136 and 0.8749 respectively) but West River elk did (X^2 1 df=4.409, p=0.0357). Eighty percent of relocations

of elk initially in Access blocks were of Migratory and West River elk, both of which moved significantly more than Resident elk. Migratory elk that moved from terminal winter range often continued moving until they arrived on early spring range. An example is 3½-year-old cow 31602 which moved from Deckard Flats to Hellroaring Creek between 27 Feb. and 03 Mar. 1986.

Table 7. Number of movements and no-movements between relocations made by marked elk of the Migratory, Resident, and West River herd segments of the Northern herd during 2 parts of the Spring period in Access and No-access land blocks from 1984-1987.

		Access			No-access			
		Mig	Res	W.R.	Mig	Res	W.R	Total
Move	< ≈04/15	6	2	7	20	4	11	50
	>	18	1	6	11	3	10	49
	Total	24	3	13	31	7	21	99
No-move	< ≈04/15	5	7	6	15	12	30	75
	>	5	4	4	8	17	15	53
	Total	10	11	10	23	29	45	128
Total		34	14	23	54	36	66	
			71			156		227

Spring movements by Migratory elk were generally in the direction of summer range, however there were exceptions. In 1984 elk 25901 had moved to Maiden Basin by 08 May but was found in Cedar Creek on 13 May (Fig 2).

Elk 36401 was in Cedar Creek on 14 Mar. 1986 but was near Sixmile Creek on 10 Apr (Fig 2).

Spring Movement Timing

A weak negative correlation ($F\ reg_{1,58}=7.87$, $p=0.007$, $r=-0.35$) between the mean dates marked elk were estimated to leave their terminal winter range and the years 1984-87 suggested that elk moved earlier in successive years (Table 8), however 1985 and 86 were identical (grouped t, $p=0.99$). The relationship between the average movement dates for marked animals and year is similar to changes in the dates that honeysuckle, but not lilac, began blooming (Table 8). Estimates of the percentage of elk wintering outside YNP that had moved into the park by early April were greater each year from 1985 to 1987 (Table 8).

Marked Migratory elk left their terminal winter range as early as March 2. In 1985 and 1986 (the 2 years with the greatest sample sizes and frequencies of locations), Migratory animals had made movements in the direction of summer range by late March or early April (Fig. 8). In 1984, 2 of 8; in 1985, 3 of 8; and in 1986, 4 of 6 marked Migratory elk had moved from terminal winter range by April 1. Only 1 Migratory animal was followed in the spring of 1987. It departed terminal winter range on April 4th.

Table 8. Estimated dates that marked elk moved off their terminal winter range compared with changes in honeysuckle and lilac blooming and estimations of the percent of post-hunt elk moving into YNP by early April.

Year	Mean dates marked elk moved			Days < normal blooming[a]		Est. % of post-hunt elk moving into YNP[b]
	n	X	sd	honey-suckle	lilac	
1984	12	05/14	32	0-5	0-5	--
1985	18	04/22	25	10-15	0-5	18
1986	19	04/22	36	10-15	0-5	27[c]
1987	11	04/07	19	25-30	25-30	54

[a] Data from Caprio (1984, 1985, 1986, 1987).

[b] 1985-86 estimates from ground impression of elk movements at the park line. 1987 estimate from the difference between late-Feb. and early-April censuses.

[c] No data.

There were 56 and 49 observations of the date marked elk left their terminal winter range and the distance they travelled to spring and summer ranges, respectively. Slopes of the departure date on distance regression lines did not differ among years (Student's t p's>0.45). By translating within-year observations (addition or subtraction of a constant) the effects of different years on the date that elk left were eliminated (resulting regression among years was r<0.001, b=0.005, p=0.999) and data were pooled. A weak correlation suggested that the further marked elk travelled to spring and summer ranges the earlier they left terminal winter range (Table 9). However, among elk that moved >16 km to spring and/or >30

km to summer ranges there was no correlations between date of departure from terminal winter range and distances travelled (p_{reg} >0.50).

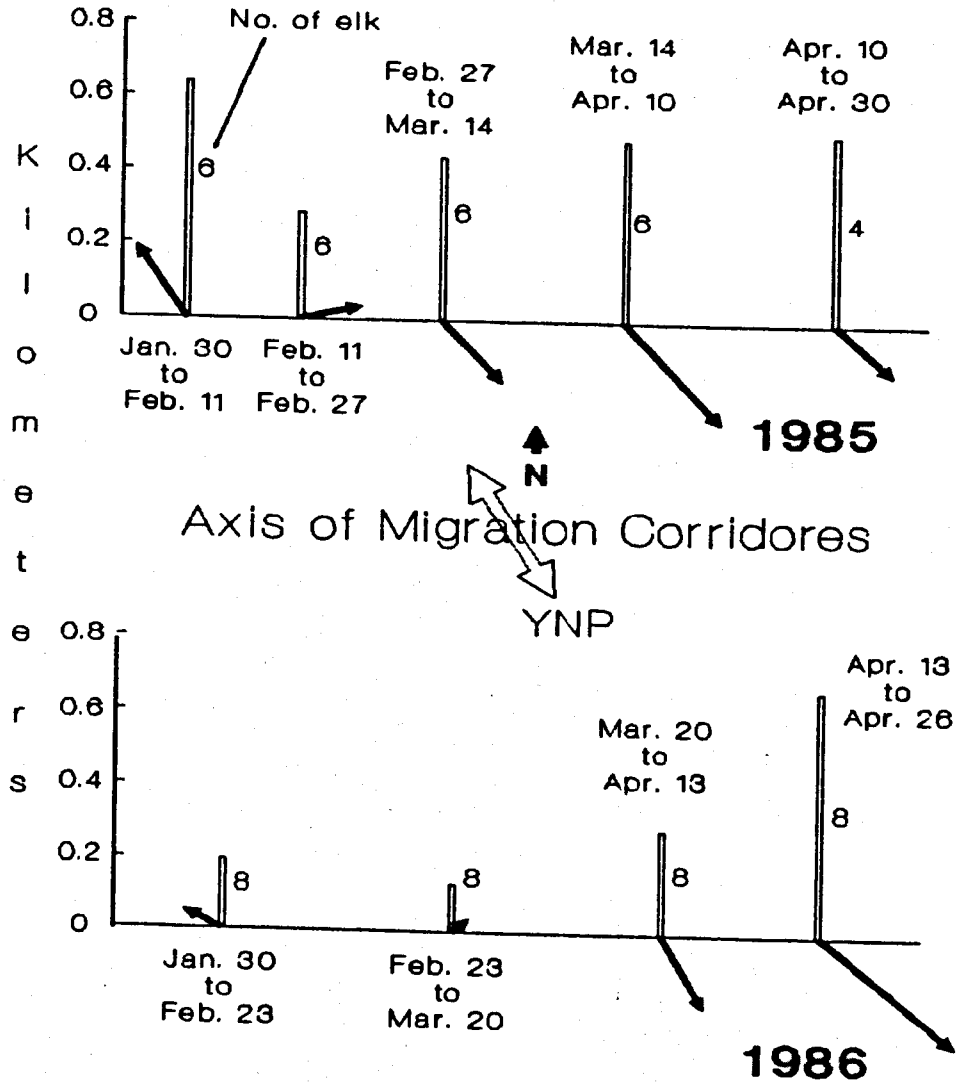

Figure 8. Average daily movement (bars) and average daily movement vectors (arrows) for elk of the Migratory herd segment of the Northern herd from Jan. 30th to the end of April 1985 and 1986.

Table 9. Regression results of the date marked northern Yellowstone elk left terminal winter range versus the distance to early spring and summer ranges.

Regression	n	r^2	b	F(df1,df2)	p
Date leave vs. Dist. to spring (1984-87)	56	.22	-0.71	15.5(1,54)	0.00
Date leave vs. Dist. to spring (1984-86)	45	.26	-0.78	15.4(1,43)	0.00
Date leave vs. Dist. to summer (1984-86)	49	.27	-0.46	17.7(1,47)	0.00

Classifications

Ten elk classification surveys were conducted: 3 on the entire winter range and 7 on winter range outside YNP. Calf:cow ratios were consistently higher on the lower range than on the upper (Table 10). Outside the Park, ratios ranged from 27:100 in Stands Basin to 89:100 on Deckard Flats (Table 11, Fig. 2). Because marked Resident elk were among those classified in Stands Basin on 4 Feb. and 12 Mar. 1987, it is assumed these classifications are representive of Resident elk. Calf:cow ratios observed in 1987 were significantly different among all comparisons of upper range, lower range, and Resident elk (Chi square $p<.02$).

A total of 1,590 bull elk was classified with respect to antler shedding: 1,040 in 1986 and 550 in 1987 (Table 12). Observations in 1986 grouped spike and branch-

antlered bulls together, but 1987 observations did not. During both years, about half of observed bulls had dropped their antlers by 15 Apr., and over 90% had by the first week in May (Table 12).

Table 10. Winter classifications of elk on the Northern Yellowstone winter range, 1984-85.

YEAR	LOWER RANGE			UPPER RANGE		
	cows	calves	ratio*	cows	calves	ratio*
1984-85	270	130	48:100	365	86	24:100
1985-86	198	83	42:100	436	117	27:100
1986-87	583	257	44:100	647	138	21:100

* calves:100 cows

Table 11. Classifications of elk on the Northern Yellowstone winter range outside YNP, 1986-1987.

Date	Location	F*	½	1½ M	Ad M	½:F
12/12/86[a]	Deckard Flats	462	327	0	0	71:100
12/15/86	Deckard Flats	493	438	21	6	89:100
01/21/87	Cedar Creek	128	66	8	2	52:100
02/04/87	Stands Basin	154	41	16	10	27:100
03/12/87	Stands Peak	286	88	16	6	31:100
04/09/87	Cedar Creek	132	73	11	1	55:100
05/09/87	Slip&Slide Cr.	53	29	2[b]	--	55:100

* Abbreviations: F=female, ½=calves, M=male.

a Data from Tom Pulchlerz, USFS, (pers comm.)

b Male animals that had shed their antlers

In utero Sex Ratios and Conception Dates

The reproductive status of 57 cow elk older than calves was determined based on findings at elk kill sites from Dec. 1985 to Feb. 1986. Forty-six (81%) were

pregnant. Of 43 fetuses, 20 were male and 23 were female. This did not differ from unity (X^2 1 df=0.093, p=0.76). One set of twins, both female, was noted on Dec. 19,1985.

Table 12. Percent of bull elk observed with at least one antler shed.

Year / Week	Lower range	Upper range
1986		
03/08-03/15	2 (117)[a]	10 (87)
03/16-03/22	12 (81)	27 (11)
03/23-03/29	20 (65)	16 (93)
03/30-04/05	29 (40)	23 (98)
04/06-04/12	37 (71)	48 (138)
04/13-04/19	62 (69)	68 (68)
04/20-04/26	--[b] --	-- --
04/27-05/03	91 (91)	91 (11)
1987		
03/07-03/14	-- --	-- --
03/15-03/21	-- --	-- --
03/22-03/28	24 (42)	-- --
03/29-04/04	-- --	32 (197)
04/04-04/11	22 (32)	71 (210)
04/12-04/18	22 (23)	-- --
04/19-04/25	-- --	95 (42)
04/26-05/02	100 (4)	-- --

[a] percent (sample size)

[b] no data

The weighted mean back-calculated conception date of measured fetuses was Sept. 28 (Fig. 8). The earliest estimated conception date was Sept. 13 and the latest Oct. 30. Dates of conception for the earliest- and latest-conceived fetuses were 13 days before and 33 days after the conception peak, respectively. Using a gestation

period of 247-262 days (Bubinik 1982), the mean birthing dates of collected fetuses would have been from 06 to 18 June; the earliest would have been about 18 May and the latest about 20 July.

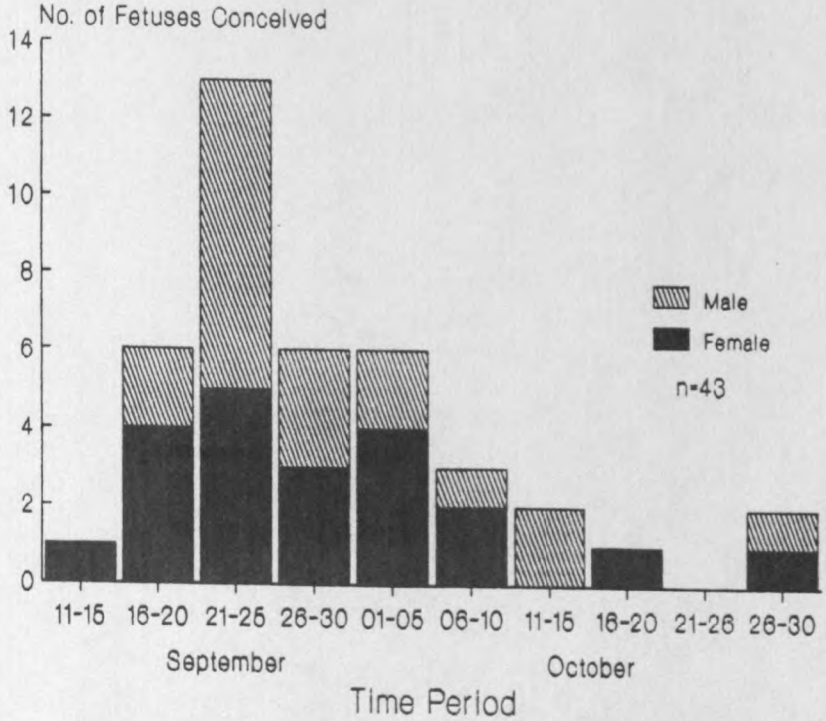

Figure 9. Sex and back-calculated conception periods of 43 elk fetuses collected on the northern Yellowstone range from Dec. 7, 1984 to Feb. 11, 1985.

Diet Composition

Rumen samples were collected near the Hunting/No-hunting boundary from hunter-killed elk during the 1984-85 late hunt. Graminoids made up 97% by volume of all samples; with one exception, individual rumens contained from 93 to 100% graminoids (Table 18, Appendix A). Conifers, the second most common item, made up 1.3% of the

sample. Douglas fir and Rocky Mountain juniper were the most common conifer species found. The latter made up 52% of the volume of a sample taken on 20 Jan. 1985 -- by far the largest percentage of anything but graminoids in any sample. Non-coniferous browse and forbs each made up <1% by volume of the total sample. Sagebrush was present in 40(50%) of the samples but made up <1% of all samples by volume. Big sagebrush was the most common species found.

Winter-killed Elk Carcass Survey

The winter-killed elk carcass survey in the spring of 1989 followed the drought of 1988, the Yellowstone fires of 1988, and a winter of normal severity which followed a number of mild winters during the 1980's. A preliminary survey to determine elk condition at time of death was done on 07 Mar. 1989. About 1 km of Bear Cr. on the Hunting/No-hunting boundary, starting about 2 km from its mouth, was searched for carcasses (Fig 2). Twenty-five carcasses were found: 10 calves (7 females:3 males), 7 adult females, 3 adult males, and one unsexed adult. Femur marrow fat of 18 was visually checked. All elk except one had the "red jelly" marrow associated with starvation. No bullet wounds were found on any carcass. One elk was determined to have been handled by people because of slits cut in the rear legs between the Achilles tendon and the tibia as is commonly done preparatory to

hanging a carcass. Bone marrow of this animal showed it to have been in very poor condition.

The carcass distribution survey was done on 20 Mar. 1989. Transects are shown in Fig. 10. Seventeen people walked a total of 82.8 km of which 57.0 km was stream-bottom transect (Table 13). Carcasses of 378 ungulates were found including 328 elk, 42 deer, 7 pronghorn, and 1 bison. Five elk bore signs of bullet wounds.

Table 13. Distances walked and number and density of winter-killed elk carcasses found along 13 transect (Tran) and non-transect (Non-tran) routes on the Northern range on March 20, 1989.

	Length(km)		Number of carcasses		Carcass density (No./km)	
Transect	Tran	Non-tran	Tran	Non-tran	Tran	Non-tran
1	2.1	2.2	21	9	10.0	4.0
2	5.2	6.1	39	9	7.5	1.5
3	2.1	1.7	20	2	9.6	1.2
4	3.2	1.6	61	0	18.9	0.0
5	1.5	0.9	6	13	3.9	14.4
6	5.1	0.4	19	0	3.7	0.0
7	2.4	2.7	21	4	8.9	1.5
8	8.3	0.2	38	2	4.6	8.0
9	3.3	4.6	16	8	4.9	1.7
10	4.4	5.2	19	10	4.3	1.9
11	4.2	0	1	0	0.2	---
12	10.3	0	3	0	0.3	---
13	4.9	0	7	0	1.4	---
Tot	57.0	25.8	271	57	Ave. (6.0)	(3.4)

Eighty-three percent of carcasses were found along the stream-bottom transect routes. Carcass numbers per transect varied from 1 in Sphinx Cr. to 61 along the

transect varied from 1 in Sphinx Cr. to 61 along the Hunting/No-hunting boundary (Table 13). The sex of 95% of the carcasses was determined. Age was estimated for 63% of adult (>1 yr old) animals (Table 14).

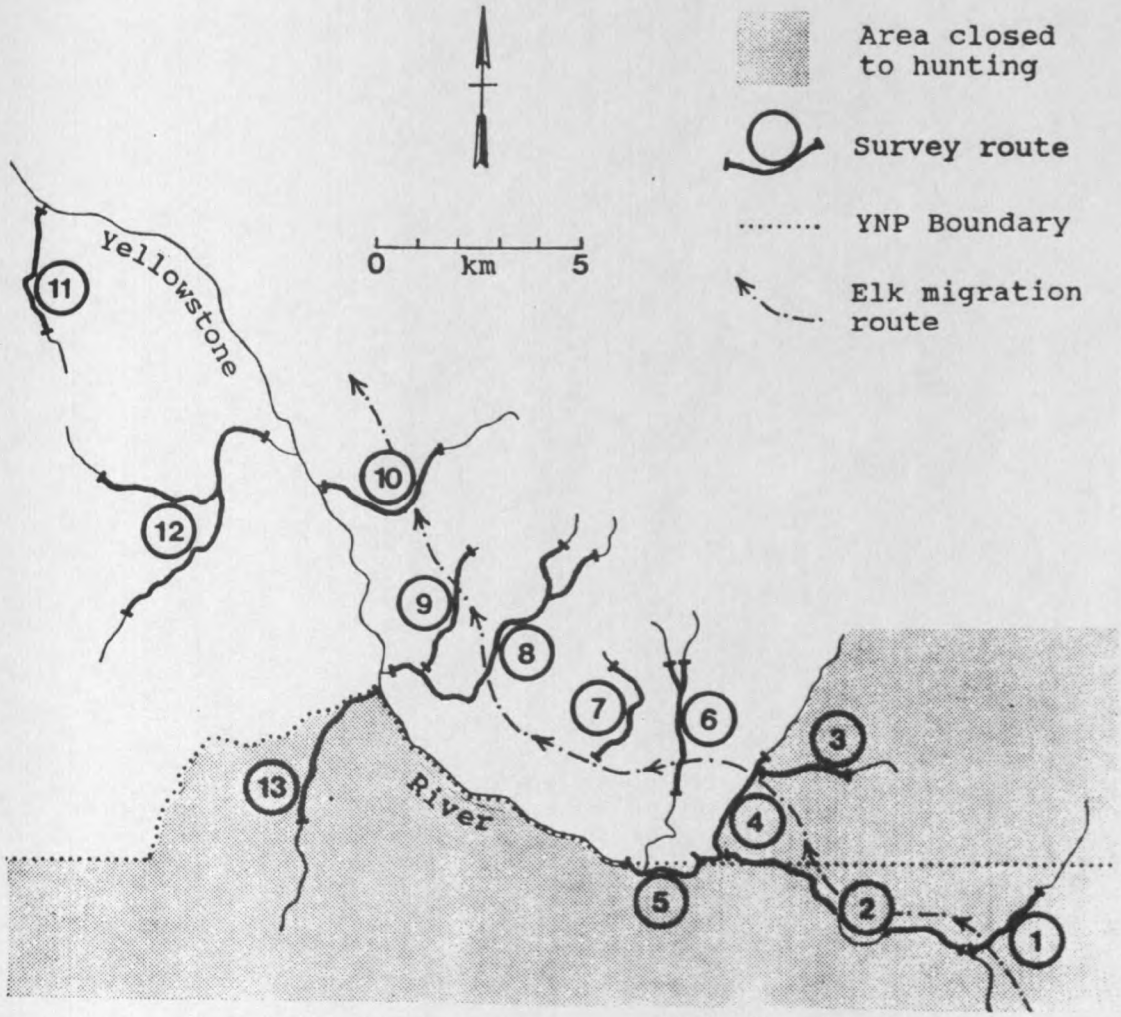

Figure 10. Winter-killed elk survey transect routes on the northern Yellowstone range. 1) Crevice Creek, 2) Upper Yellowstone, 3) Palmer Creek, 4) Hunting/No-hunting Boundary, 5) Lower Yellowstone, 6) Eagle Creek, 7) Phelps Creek, 8) Little Trail Creek, 9) Maiden Basin, 10) Bassett Creek, 11) Sphinx Creek, 12) Mol Heron/Cinnabar Creeks, 13) Reese Creek.

Forty-eight percent of all carcasses observed were calves (Table 14). In this age class, females strongly and significantly outnumbered males (89F:55M)(Chi square 1df=7.56, P=0.006), especially along the Hunting/No-hunting boundary and Lower Yellowstone transects where 38 female versus 13 male calves were found. Females were also most abundant among the carcasses of adult animals (102F:68M). Of adult elk whose age was estimated, elk older than 10 were more common among females (28%) than among males (6%).

Table 14. Numbers, sex, and age-at-time-of-death of 328 winter-killed elk carcasses observed along 13 transects (Tran.) on the Northern range on March 20 1989.

	Female					Male					Uncl		
Tran.	½	1	2-9	10+	Ad	½	1	2-9	10+	Ad	½	Ad	Tot
1	3	7	5	3	1	4	1	3	2	0	3	0	30
2	7	2	8	11	10	2	3	2	1	3	2	1	48
3	6	0	3	0	0	6	5	2	0	0	0	0	22
4	25	3	0	0	12	12	2	0	0	6	1	0	61
5	13	0	0	0	4	1	0	0	0	0	0	1	19
6	3	4	2	0	4	1	1	0	0	4	0	0	19
7	5	1	0	0	7	4	3	0	0	5	0	0	25
8	9	1	8	2	1	8	5	5	0	1	0	0	40
9	5	0	2	0	0	9	0	5	0	1	2	0	24
10	10	3	2	1	0	8	2	1	0	0	2	0	29
11	0	0	0	0	0	0	1	0	0	0	0	0	1
12	0	0	0	1	0	0	0	0	1	0	1	0	3
13	3	0	0	0	0	1	0	0	1	0	2	0	7
Total	89	21	24	18	39	55	23	18	5	22	12	2	328

Transect carcass densities varied from 0.2/km in Sphinx Cr. to 19.2/km along the Hunting/No-hunting

boundary (Table 13). The number of carcasses found at High Carcass Density (HCD) sites varied similarly from 1 in Sphinx Cr. to 32 along the Hunting/No-hunting boundary (Table 15).

Table 15. Slope characteristics and carcass densities at High Carcass Density (HCD) sites on winter-killed elk carcass transects east of the Yellowstone River, 20 March 1989.

Transect	Left/Right Sideslopes (degrees)	Average of Sideslopes (degrees)	Stream Gradient (degrees)	Carcass Density (#/km)
1	13/19	16	7	17
2A[a]	23/--[b]	23	<1	17
2B	18/--	18	<1	13
3	11/8	9	9	17
4A	20/19	19	3	32
4B	17/25	21	4	19
5	21/--	21	<1	6
6	7/7	7	6	8
7	11/10	10	11	13
8A	17/25	21	7	10
9B	18/19	18	9	11
10	25/22	23	11	10
11	28/7	17	9	18

[a] Capital letters designate different HCD sites on the same transect.

[b] Indicates that one side of the transect is bounded by the Yellowstone River.

Along the major elk migration route leading out of the Park east of the Yellowstone River, carcass densities averaged 10.29 carcasses/km in areas of no hunting, 19.25 at the Hunting/No-hunting boundary, and 6.11 in areas open to hunting (Fig 11). This was also true when comparing carcass densities at HCD sites which averaged 16/km in areas closed to hunting, 25/km at the Hunting/No-hunting

boundary, and 11/km in areas open to hunting. The topography of HCD sites as determined from sideslope and stream gradient measurements did not seem to explain the number of carcasses found (Table 15).

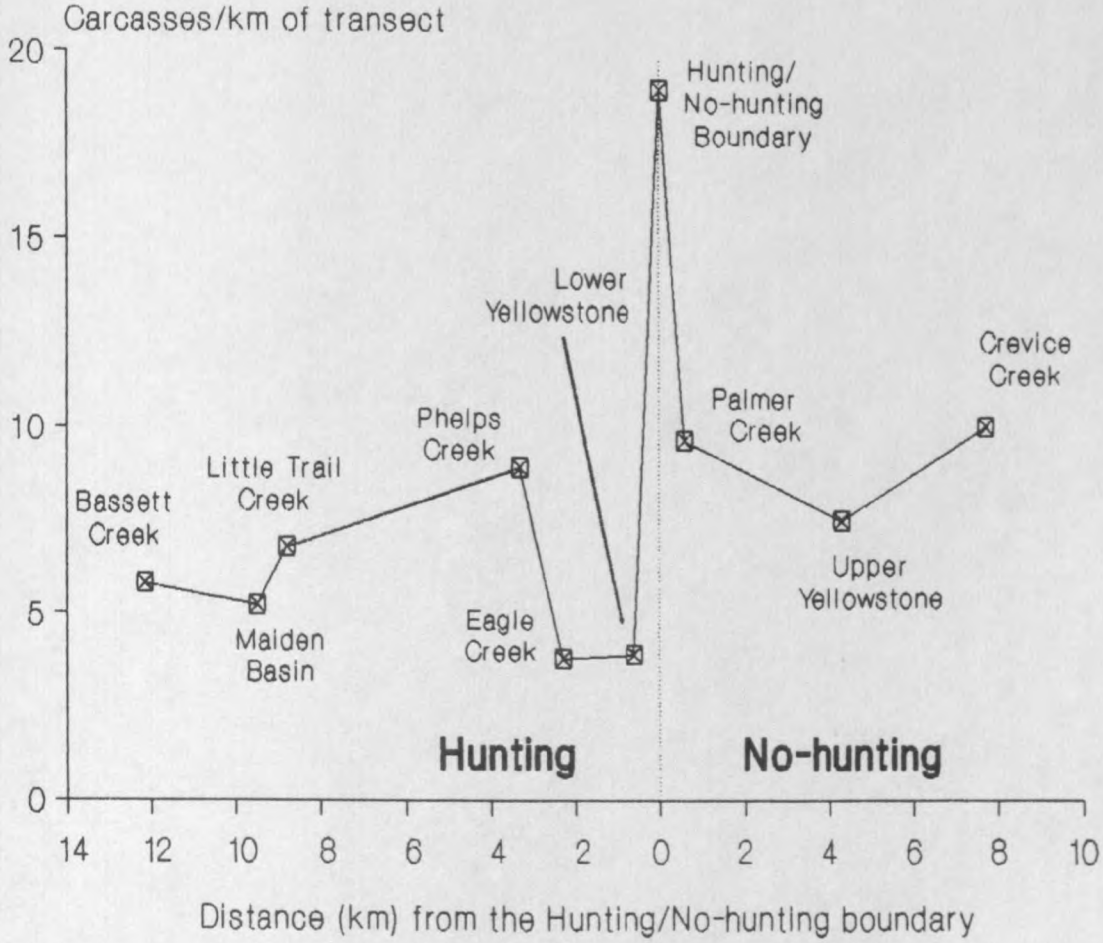

Figure 11. Winter-killed elk carcass survey transect carcass densities and transect distances from the Hunting/No-hunting Boundary.

Fifty-five percent of all adult elk carcasses found showed some sign of visitation by humans -- upper canine teeth removed, antlers sawed off, or both (Table 16). Overall, this included 79% of the males and 34% of the

females (Table 16). Within the Park, 22% of carcasses had been visited (6% of females:56% of males) while outside 67%, had been disturbed (48% of females and 86% of males). Nine of 12 (75%) carcasses of males >2 years old inside YNP had been visited while 31 of 33 (94%) outside had been. These values were not significantly different (Chi square 1 df=1.12, p=0.29). Three instances of removing the canine teeth from calf carcasses were noted.

Table 16. Number of adult elk (≥1½ years) carcasses observed and number with canines taken (C) and/or antlers taken (A) or dropped (D) inside verses outside YNP and total. March 20, 1989, Northern range.

		Females		Males				
Locale	Age	No.	C	No.	C	A	C or A	D
Inside YNP	All	35	2	16	9	9	9	1
	Ylg	9	0	4	0	0	0	1
	>2	26	2	12	9	9	9	0
Outside YNP	All	67	32	52	37	43	45	5
	Ylg	12	6	19	12	13	14	4
	>2	55	26	33	25	30	31	1
Combined	All	102	34	68	46	52	54	6
	Ylg	21	6	23	12	13	14	5
	>2	81	28	45	34	39	40	1

DISCUSSION

Seasonal Ranges

Seasonal ranges of elk documented here reconfirm those previously known (Skinner 1925, Rush 1932, Kittams 1963, Craighead et al. 1972, Houston 1982). Migratory elk use of ranges outside the Park was eliminated by elk reductions in the 1950's and 60's (Houston 1982). Elk have re-established the historical patterns of use of these ranges. Moreover, the use of marked animals confirms Erickson's (1981) observation of Migratory elk as far north as Sixmile Creek. This apparently had not been observed since sometime before 1938 (Tyers 1981). Houston (1982) felt that few elk wintering on the northernmost portions of the winter range moved to the southern extent of summer range, yet in this study 3 of 12 migratory elk made such treks.

The Effects of Hunting

Hunting is the major factor influencing elk distribution outside the Park and in the BLA. Based on his observations of elk distribution during the 1976 and 1978 late seasons, Houston (1979) rejected the hypothesis that hunting was not concentrating elk inside

the Park. Later (Houston 1982:199), commenting on a personal communication from Erickson, he suggested that hunting had apparently not caused concentrations in the Park. Swenson (in prep) stated that concentrations of elk had not been a problem since 1980. However, movement and distribution data from 1984-87 show that hunting concentrated elk at the Hunting/No-hunting boundary and in areas with limited public access. Also, the distribution of winter-killed elk indicate that hunting concentrated elk at the boundary in the winter of 1988-89.

Elk concentrations at park or refuge boundaries due to hunting have been noted by others (Rush 1932, Lovaas 1970, Picton and Picton 1975, Houston 1979, Morantini and Hudson 1979, Edge et al. 1984). Animal concentrations in areas of little or no hunting have been observed for red deer (*Cervus elaphas*) and chamois (*Rupicapra rupicapra*) (Douglas 1971), pronghorn (Copeland 1980), and elephants (*Loxodonta africanus*)(Douglas-Hamilton 1975, Eltringham 1982, Moss 1988). They have been hypothesized as being caused by aboriginal hunters (Hickerson 1965, also the narrative account of Raynolds 1868), and by wolves (*Canis lupus*)(Mech 1977).

Elk differed in their reaction to the hunting/no-hunting boundary. Based on movements of marked elk and observations in the field, elk, both Migratory and West River, originally captured north of the Hunting/No-hunting

boundary were less hesitant and more successful in moving through areas open to hunting than were elk from either herd segment captured near the boundary. Apparently, elk that do not traditionally use winter ranges north of the Park are less motivated to move into or through hunting areas. Therefore conclusions concerning elk behavior at the Hunting/No-hunting boundary drawn from elk known to be successful in crossing it may be biased by differences in elk behavior.

Some of these observations are likely due to behavior differences among individual elk and elk groups (Murie 1951, Craighead et al. 1972, Shoesmith 1979). Also, elk likely remember the boundary from year to year (Baker 1982, Geist 1982). Douglas (1971) found that red deer and chamois distributed themselves and behaved as if hunted for 2 years following its cessation.

The Effects of Spring Recreationists

The effects on elk of spring recreationists including antler gatherers, are difficult to evaluate. Migratory elk began spring migrations as early as March 2. Coster noted that elk began moving back to the Park on 10 Mar. in 1933 (cited in Tyers 1981:39). These dates also coincide with bull elk beginning to cast their antlers which is a harbinger of antler hunting activity. Moreover, environmental factors such as climatic moderation may

stimulate elk migration and outdoor activity in humans equally. It is tempting to speculate that the latter causes the former, but migration should not be confused with displacement. Marcum and Scott (1985) also cautioned against conclusions on the effects of human disturbance.

Most areas that provided security for elk during the Hunt period did so during the Spring period as well. Recreationists likely perpetuate the elk distribution caused by the hunt but apparently with less impact because elk were located more often in Access areas following the Hunt period. This may be partially explained by migratory movements.

Over the course of this study winters were mild (Meagher 1989) and, based on phenology, spring arrived earlier than normal. During more "normal" years when elk continue moving out of the Park in large numbers after the late hunt and/or stay on winter ranges later, spring recreationists would likely have more effect on elk movements and distribution.

People gathering antlers do not neccessarily seek nor kill elk, and thus antler gathering does not have the impact that hunting does. Hornocker (1970) noted that mountain lions did not displace elk until they made a kill. However human activity other than hunting can displace elk (Lyon 1979). Harassment whatever its guise can potentially be detrimental (Geist 1971).

Mortality

Differences in the natural mortality rates of West River and Migratory elk are uncertain. Murie (1940:47) also noted mortality and poor condition of elk in summer in Yellowstone, although it is uncertain if these were West River or Migratory elk.

Classifications

Based on radiotelemetry, most elk classified by age and sex on the lower range were West River elk. Therefore the summer ranges differ between those elk classified on the upper and those on the lower winter range. Moreover, calf:cow ratios were different between Resident elk and groups comprised mostly of Migratory elk although both segments winter outside the Park. Singer and Harting (1988) hypothesized that calf:cow ratios on the lower range are different from those observed on the upper because of predation. Julander (1961) noted the effect of summer ranges on mule deer population parameters. The importance of summer range in modeling the number of elk in the Northern herd is noted by Merrill et al. (1989).

Two classifications done on Deckard Flats (Fig. 2) on Dec. 12 and 15, 1986 showed inordinately high calf:cow ratios of 71 and 89:100 respectively. Hunting on Deckard Flats was intense and concentrated during the last few weeks of the general elk season. On Nov. 25, 1986 I estimated 50-75 hunters were present on Deckard Flats.

Concentrated hunting on the treeless flats may have caused calves to be separated from their dams thus biasing the classifications. Furthermore, many of the calves were seen among groups of elk with calf:cow ratios >150:100. An alternative explanation is that many of the cows were among the first to make pre-dawn movements to bedding areas thus were not included in the classifications. In either case the Dec. 1986 cow:calf classifications are suspect.

Diet Composition

Greer (1970:18) reported that the rumens of elk killed by hunters in the Eagle Creek area during the winters of 1957 (16 rumens) and 1965 (15 rumens) contained from 83% to 99% grass-like plants averaging 93% and 92% by volume for each year respectively. These averages are less than those noted during this study. No willow (*Salix* spp.) was found in any rumen from 1984-85 whereas it was represented in 75% of rumens in 1957 and 5% in 1965.

The high percentage of graminoids found in rumens collected during 1984-85 may be attributable to 2 factors: a mild winter with good accessibility of graminoid forage, and perhaps a paucity of alternative browse species.

Winter-killed Elk Count

The distribution of winter-killed elk carcasses reflects the influence of hunting on elk distribution.

Contrary to what might be supposed, wounding was not a major factor in elk deaths. Although hunting arguably did not predispose elk to winter-kill, it did figure in where they died -- concentrated at the Hunting/No-hunting boundary.

Recommendations

I agree with Houston's (1982:199) contention that an "... innovative and experimental approach to management.." is needed. Although much of the land outside the Park is managed primarily as elk winter range (Gallatin National Forest Plan 1986) elk are excluded to some extent from using about 48% of it, mostly because of hunting. Current *de facto* strategy is to harvest elk at the Hunting/No-hunting boundary while allowing hunting over most of the winter range outside the Park. This concentrates elk, results in under- and overutilization of areas, and limits harvest opportunity.

Many of the following management suggestions have been previouly suggested or implied by others (Rush 1932, Houston 1982, Lemke and Singer 1989):

1) Design flexibility into the hunting season at the hunting/no-hunting boundary. Options might be:

   A) Close areas adjacent to the boundary after a certain number of elk have been killed.

   B) Open areas sequentially beginning near the boundary and moving north to encourage elk to move away from the boundary.

2) Discourage having the Hunting/No-hunting boundary perpendicular to migration routes. A "migration corridor" would permit elk to move across open terrain unhindered and reach security cover. Such a closure during portions of the general season would allow elk to move north and provide greater sportsman opportunity.

3) Do not start the late hunt until a substantial number of elk have migrated out of the Park.

Option 3 has been tried with apparent success. However, because of the unpredictability of season openings, it was unpopular with local businesses (Arnold Foss, pers. comm. 1986). Of more importance in the long-range management of northern Yellowstone elk is the purchase or acquisition by easement of elk ranges north of YNP. This is vital to managing elk numbers and distribution outside the Park.

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APPENDICES

APPENDIX A

MARKED ELK SEASONAL RANGE GEOGRAPHIC ACTIVITY CENTERS

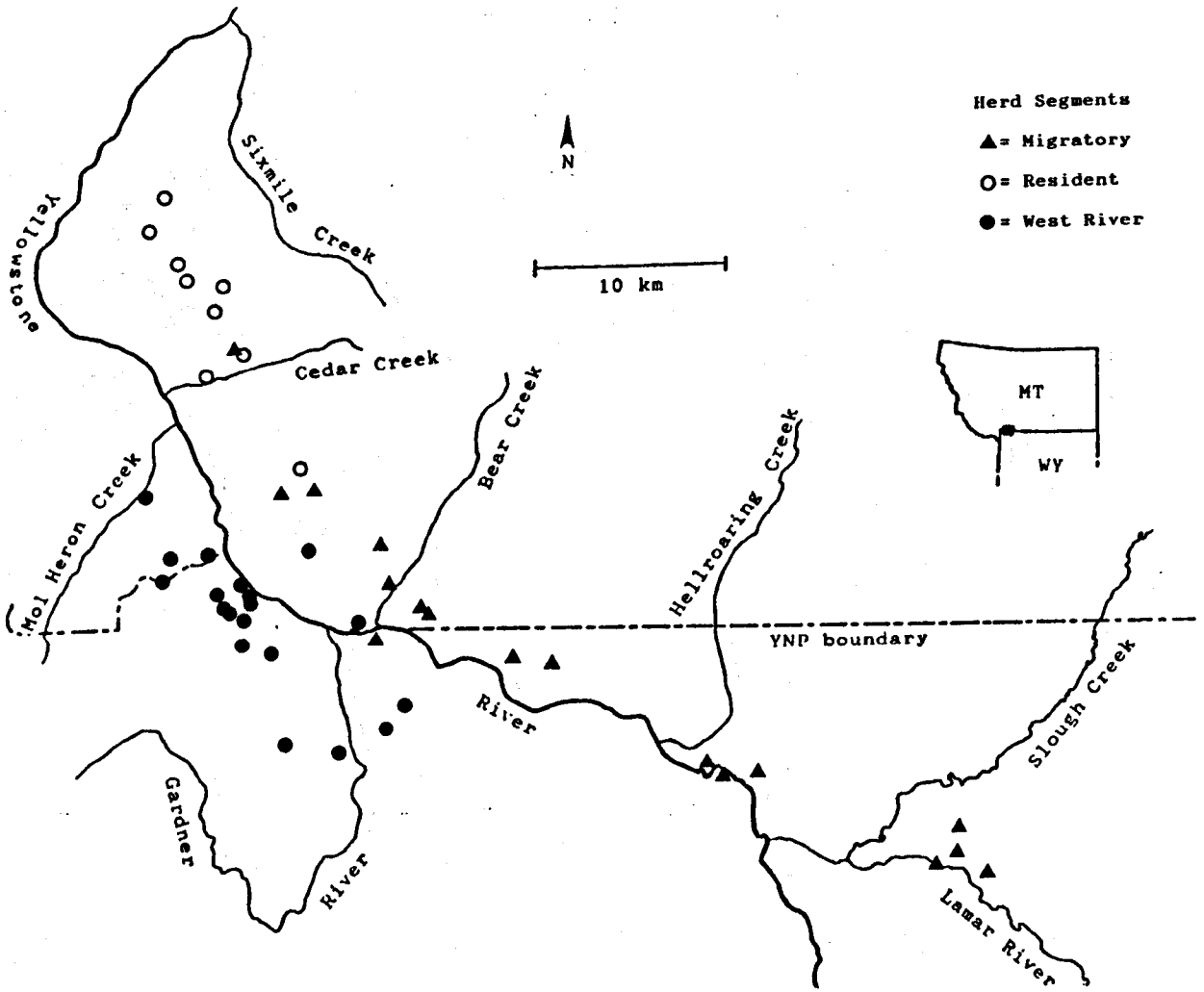

Figure 12. Early Winter Geographic Activity Centers of 27 marked elk from 3 herd segments of the Northern herd during 45 elk-seasons on the Northern range from 1984 to 1987.

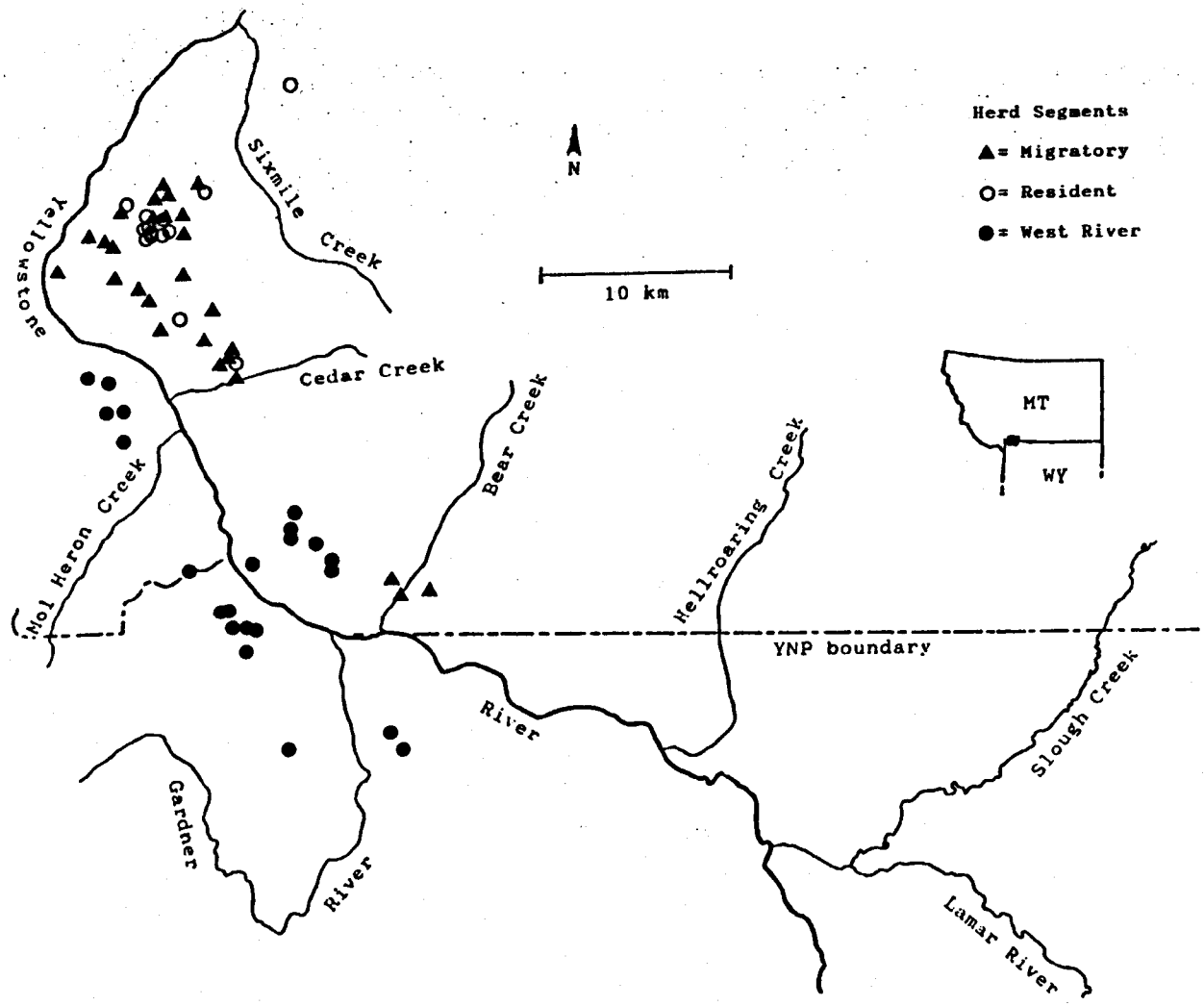

Figure 13. Terminal Winter Geographic Activity Centers of 29 marked elk from 3 herd segments of the Northern herd during 63 elk-seasons on the Northern range from 1984 to 1987.

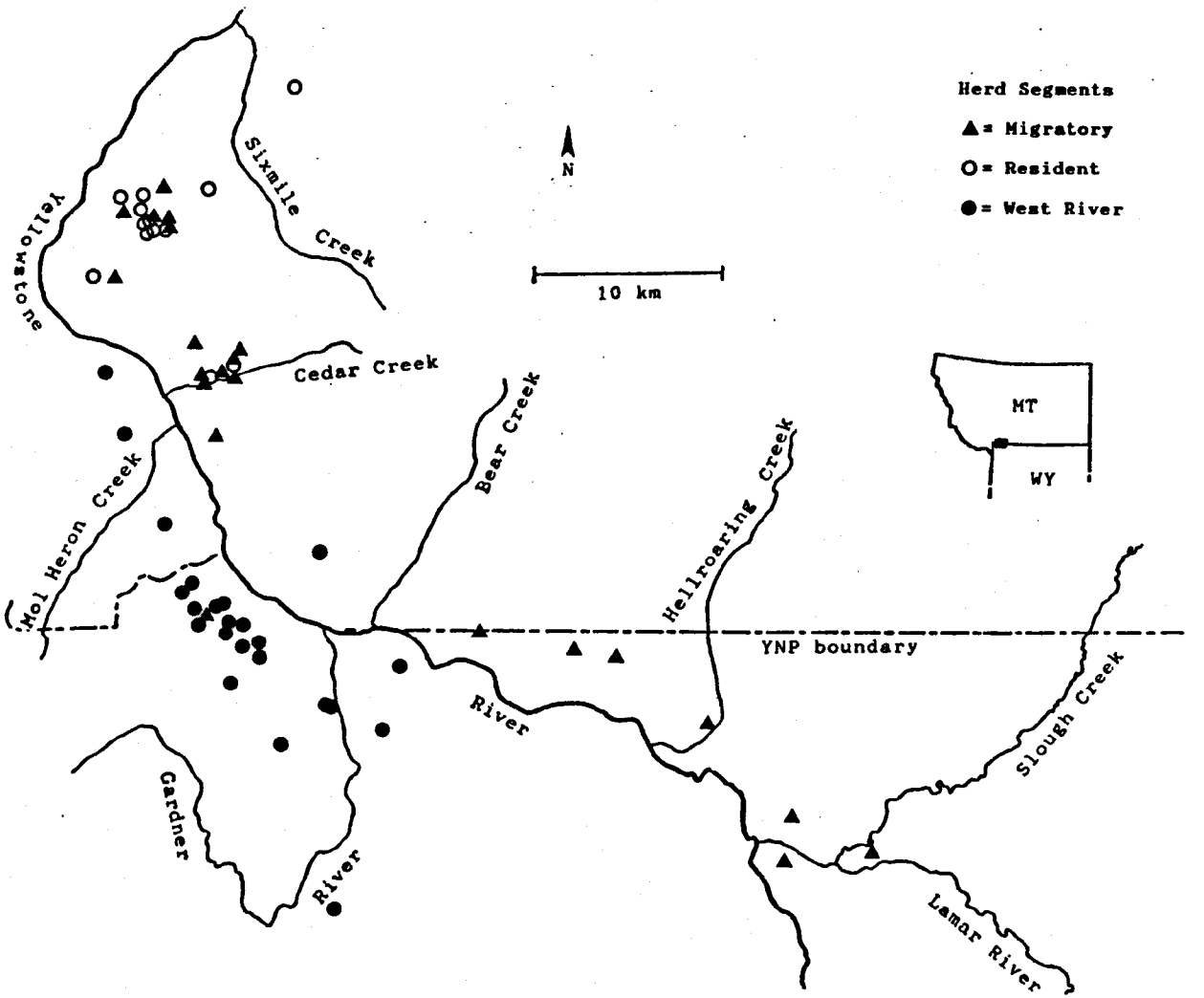

Figure 14. Early Spring Geographic Activity Centers of 28 marked elk from 3 herd segments of the Northern herd during 58 elk-seasons on the Northern range from 1984 to 1987.

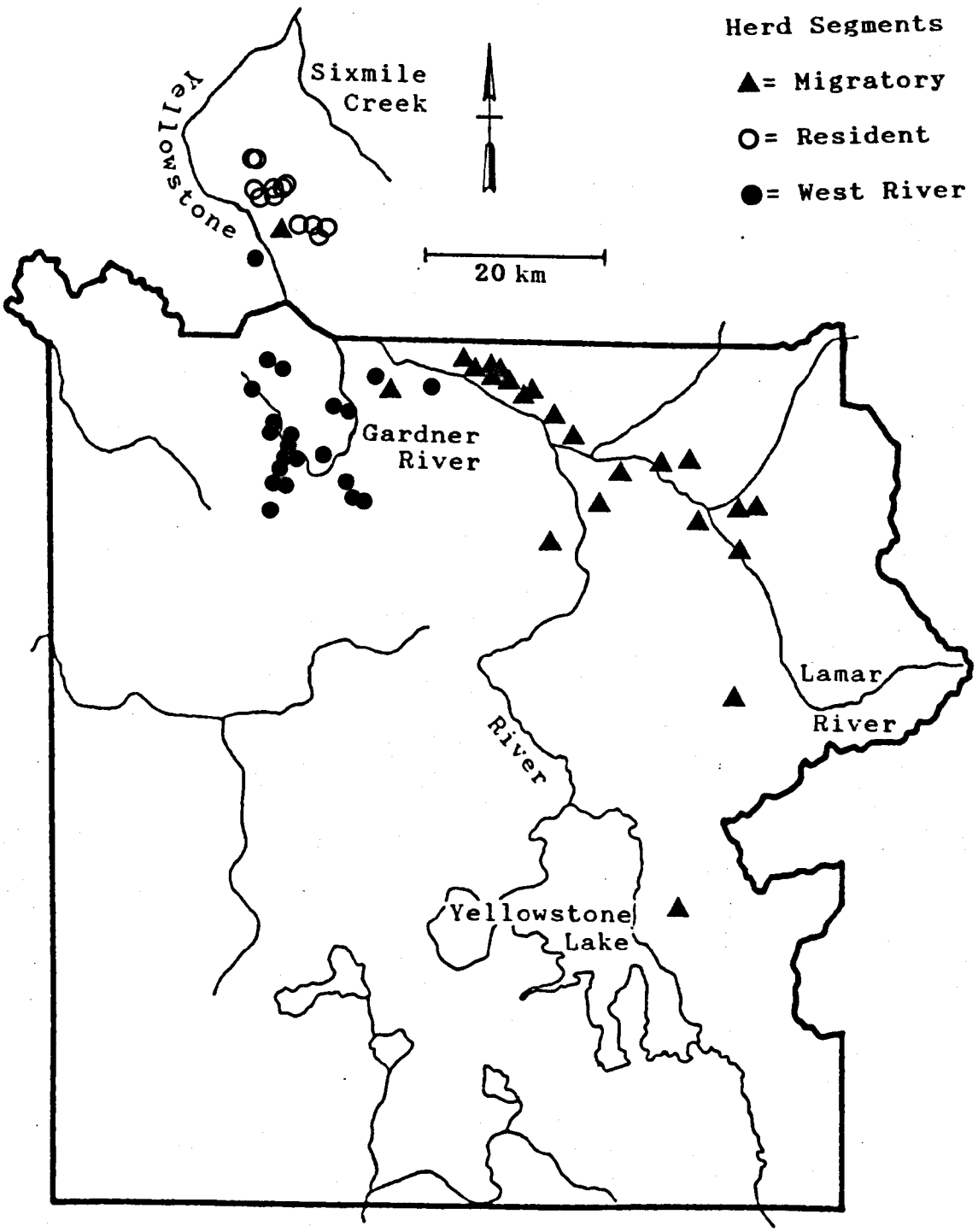

Figure 15. Calving Geographic Activity Centers of 29 marked elk from 3 herd segments during 57 elk-seasons on the Northern range from 1984 to 1987.

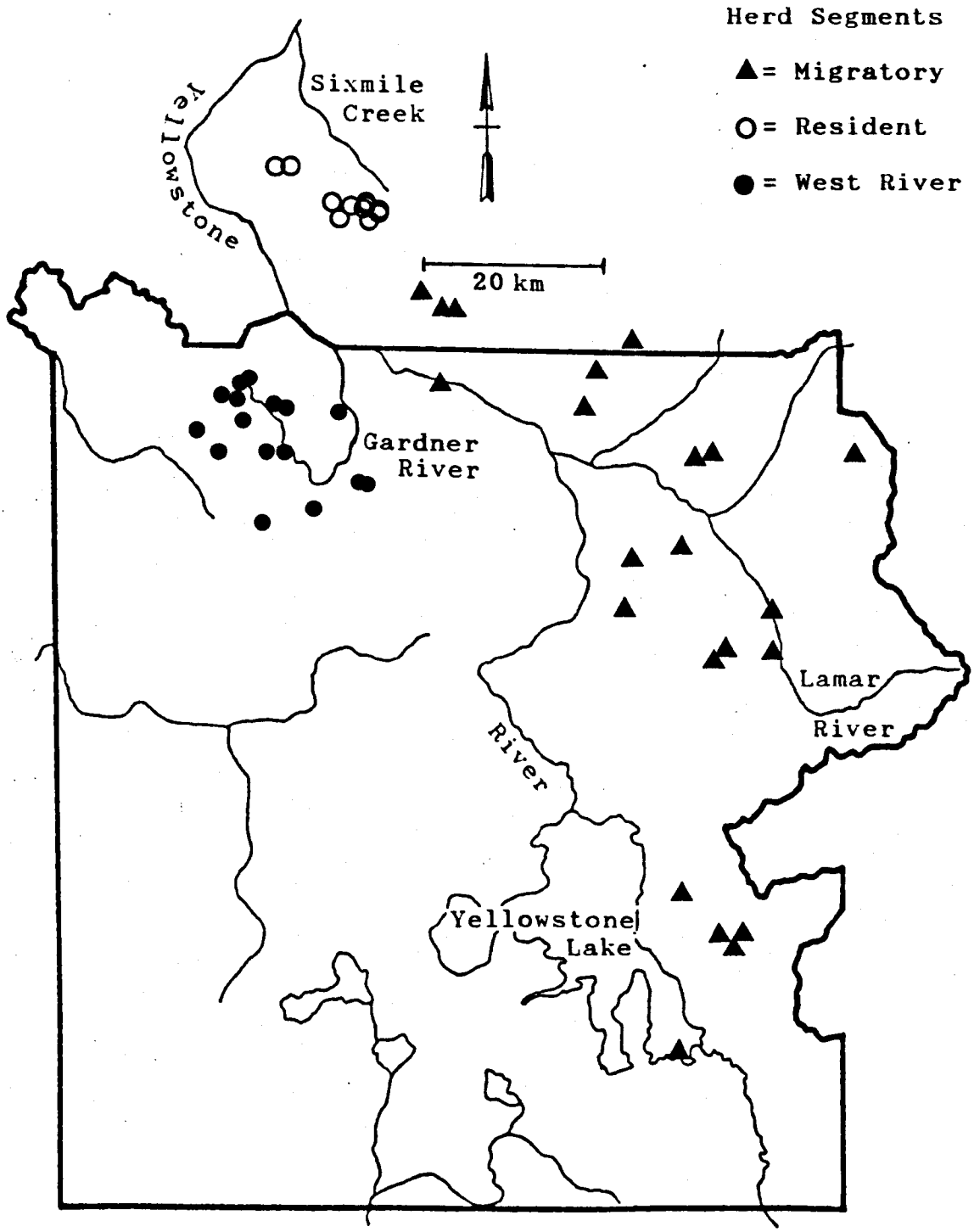

Figure 16. Summer Geographic Activity Centers of 29 marked elk from 3 herd segments during 49 elk-seasons on the Northern range from 1984 to 1987.

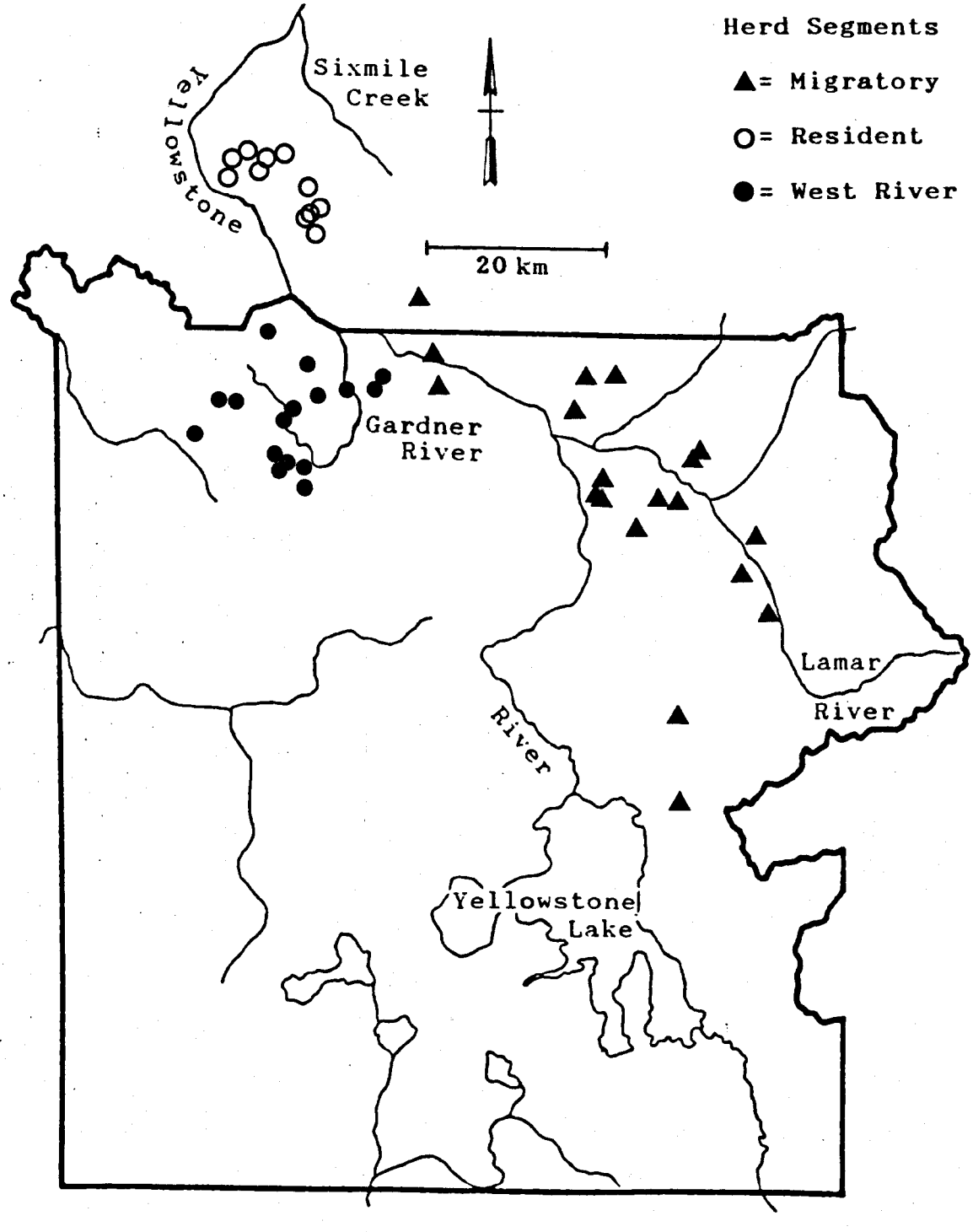

Figure 17. Rut Geographic Activity Centers of 27 marked elk from 3 herd segments during 46 elk-seasons on the Northern range from 1984 to 1987.

APPENDIX B

TABLES

Table 17. Elk radio-marked on the Northern Yellowstone winter range during 1984-86.

Radio Freq(mhz) -I.D.a	Date and Location Captured	Sex and Age at Capture	MDFWP Ear Tag Numbers
150.760 -01	04/29/86 Stephens Cr.*	Female 2	A8536 A8537
150.790 -01	02/03/85 Stephens Cr.*	Female 1 1/2	A8587 A8588
150.790 -02	02/03/85 Sphinx Mtn.	Female 3 1/2	A8529 A8528
150.837 -01	02/08/85 Reese Cr.*	Female 2 1/2	
150.884 -01	02/02/85 Stephens Cr.*	Female 1/2	A8580 A8581
150.884 -02	03/18/85 Hitchin Post	Female 2	
150.949 -01	01/31/85 Stephens Cr.*	Female 3-5	A8575 A8574
150.949 -02	01/15/86 Stephens Cr.*	Female 3 1/2	A8593 A8554
151.019 -01	02/04/85 Reese Cr.*	Male 2 1/2	A8590 A8589
151.045 -01	03/10/84 Stands Basin	Female 6-8	A8694 A8695
151.063 -01	04/01/85 Eagle Cr.	Female 1 1/2	
151.063 -02	01/17/86 Buffalo Pass	Female 1/2	
151.063 -03	02/23/86 Slip&Slide Cr.	Female 4 1/2	A8569 A8571
151.115 -01	03/10/84 Stands Basin	Female 15+	A8698 A8699
151.191 -01	01/17/84 Stands Basin	Male 1 1/2	A8656 A8657

Table 17. continued.

Radio Freq(mhz) -I.D.a	Date and Location Captured	Sex and Age at Capture	MDFWP Ear Tag Numbers
151.191 -02	01/04/86 Stephens Cr.*	Female 1/2	
151.191 -03	04/17/86 Stephens Cr.*	Female 2	A8534 A8535
151.237 -01	01/27/85 Stephens Cr.*	Female 9-11	A8517 A8518
151.259 -01	01/17/84 Stands Basin	Female 7-8	A8662 A8663
151.316 -01	03/10/84 Stands Basin	Female 6-8	A8616 A8617
151.316 -02	01/18/86 Buffalo Pass	Female 3 1/2	A8573 A8572
151.334 -01	02/05/85 Reese Cr.*	Female 3 1/2	A8596 A8594
151.334 -02	01/26/86 Sphinx Cr.	Female Adult	
151.364 -01	01/17/84 Stands Basin	Female 3 1/2	A8661 A8689
151.419 -01	01/17/84 Stands Basin	Female 3 1/2	A8658 A8659
151.492 -01	01/17/84 Stands Basin	Male 2 1/2	A8660 A8688
151.492 -02	02/22/86 Slip&Slide Cr.	Female Adult	A8570
151.569 -01	03/10/84 Stands Basin	Female 3-5	A8690 A8691
151.714 -01	03/10/84 Stands Basin	Female 9-11	A8692 A8693
151.763 -01	03/10/84 Stands Basin	Female 3-5	A8614 A8700

Table 17. concluded.

Radio Freq(mhz) -I.D.a	Date and Location Captured	Sex and Age at Capture	MDFWP Ear Tag Numbers
151.816 -01	03/10/84 Stands Basin	Female 3 1/2	A8696 A8697
151.816 -02	02/01/85 Stephens Cr.*	Male 1/2	A8576 A8577

[a] I.D. denotes different elk that have worn the same radio collar.

* Location in Yellowstone National Park

Table 18. Composition percent by volume and occurrence of forage types in 80 rumen samples from hunter-killed elk near the YNP boundary, Dec. 1984-Feb. 1985. Trace amounts (tr.) are <1% by volume.

Forage type	Percent	
	Volume	Occurrence
Sub-alpine fir (*Abies lasiocarpa*)	tr.	12
Rocky Mountain juniper (*Juniperus scopulorum*)	tr.	20
Horizontal juniper (*Juniperus horizontalis*)	tr.	1
Lodgepole pine (*Pinus contorta*)	tr.	15
Limber pine (*Pinus flexilus*)	tr.	15
Douglas fir (*Pseudotsuga menziesii*)	tr.	40
Spruce (*Picea* spp.)	tr.	1
Pine family (*Pinaceae*)	tr.	1
Total Conifer	1	65
Big sagebrush (*Artemesia tridentada*)	tr.	42
Oregon Grape (*Berberis repens*)	tr.	1
Rubber Rabbitbrush (*Chrysothamnus nauseosus*)	tr.	7
Winterfat (*Eurotia lanata*)	tr.	5
Aspen (*Poplus tremuloides*)	tr.	14
Buffaloberry (*Sheperdia canadensis*)	tr.	1
Alder (*Alnus* spp.)	tr.	1
Sagebrush (*Artemesia* spp.)	tr.	7
Saltbush (*Atriplex* spp.)	tr.	1
Wild Rose (*Rosa* spp.)	tr.	1

Table 18. concluded.

Forage type	Percent	
	Volume	Occurrence
Rose family (*Rosaceae*)	tr.	1
Unidentified browse	tr.	46
Total browse	1	86
Alfalfa (*Medicago sativa*)	tr.	1
Thistle (*Cirsium* spp.)	tr.	5
Buckwheat (*Erioginum* spp.)	tr.	6
Prickley Pear (*Opuntia* spp.)	tr.	6
Penstemon (*Penstemon* spp.)	tr.	1
Cattail (*Typha* spp.)	tr.	1
Mule's ears (*Wyethia* spp.)	tr.	2
Legume sub-family (*Leguminosae*)	tr.	10
Unidentied Forb	tr.	11
Total Forbs	tr.	39
Grass family (*Poaceae*)	97	100
Rush family (*Juncaceae*)	tr.	12
Sedge family (*Cyperaceae*)	tr.	2
Total Graminoids	97	100
Unidentified leaf	tr.	20
Unidentified Seeds	tr.	1
Unidentified Bark	tr.	1
Unidentified	tr.	11
Total Unidentified	tr.	34

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