



Evaluation of a spike only regulation in southeastern Idaho
by Daniel L Hughbanks

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:

The vulnerability of bull elk (*Cervus elaphus*) to hunting mortality has increased in many elk herds across the western United States due to reductions in habitat security. Wildlife managers dealing with low habitat security in areas open to general bull hunting have attempted to increase male elk survival with regulations that limit harvest to either some minimum or maximum antler size. This study evaluates the efficacy of restricting harvest to spike antlered yearling bulls while maintaining a general hunting season.

To determine the mortality rates of yearling male elk under the new regulation, 86 male calves were captured and fitted with radio collars in March of 1991-1992. During the general season, the mortality rate of radioed yearling bull elk in areas open to hunting was 28% (14 of 50) in 1991-1992. None of the radio-marked branch antlered yearlings and only 1 radio-collared 2-year-old bull were illegally killed. The mortality rates of bull elk under the spike-only regulation were lower than previously reported levels for the Sand Creek elk herd. The winter composition counts also indicated that the spike-only regulation succeeded in increasing the survival rate of bull elk. I attempted to determine the cause of the increase in bull survival by comparing hunter numbers and yearling bull mortality under the any antlered bull regulation to hunter numbers and yearling bull mortality under the spike-only regulation.

Both hunter numbers and yearling bull elk mortality decreased with the implementation of the spike-only season.

I also compared hunting pressure and habitat use among yearling bulls which survived the general hunting season and yearling bulls which were harvested during the general season. Yearling bull behavior and hunter perceptions appeared to influence vulnerability more than either habitat use or hunting pressure under the spike-only regulation.

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APPROVAL

of a thesis submitted by

Daniel L. Hughbanks

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.

24 January 1994
Date

Lyman R. Libby
Chairman, Graduate Committee

Approved for the Major Department

21 January 1994
Date

Robert S. Moore
Head, Major Department

Approved for the College of Graduate Studies

1/28/94
Date

Ad Brown
Graduate Dean

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Date Jan. 21, 1994

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ABSTRACT

The vulnerability of bull elk (*Cervus elaphus*) to hunting mortality has increased in many elk herds across the western United States due to reductions in habitat security. Wildlife managers dealing with low habitat security in areas open to general bull hunting have attempted to increase male elk survival with regulations that limit harvest to either some minimum or maximum antler size. This study evaluates the efficacy of restricting harvest to spike antlered yearling bulls while maintaining a general hunting season.

To determine the mortality rates of yearling male elk under the new regulation, 86 male calves were captured and fitted with radio collars in March of 1991-1992. During the general season, the mortality rate of radioed yearling bull elk in areas open to hunting was 28% (14 of 50) in 1991-1992. None of the radio-marked branch antlered yearlings and only 1 radio-collared 2-year-old bull were illegally killed. The mortality rates of bull elk under the spike-only regulation were lower than previously reported levels for the Sand Creek elk herd. The winter composition counts also indicated that the spike-only regulation succeeded in increasing the survival rate of bull elk. I attempted to determine the cause of the increase in bull survival by comparing hunter numbers and yearling bull mortality under the any antlered bull regulation to hunter numbers and yearling bull mortality under the spike-only regulation. Both hunter numbers and yearling bull elk mortality decreased with the implementation of the spike-only season. I also compared hunting pressure and habitat use among yearling bulls which survived the general hunting season and yearling bulls which were harvested during the general season. Yearling bull behavior and hunter perceptions appeared to influence vulnerability more than either habitat use or hunting pressure under the spike-only regulation.

INTRODUCTION

Elk vulnerability to harvest is commonly defined as the probability of an elk being killed during the hunting season (Lyon and Cristensen 1992). One mechanism used by wildlife managers to alter bull elk vulnerability is the institution of hunting regulations which restrict hunters to harvesting only those bull elk with a given antler conformation. Generally, the goal of antler point regulations is to increase the numbers of older age class bulls in the population (Carpenter and Gill 1987).

There are 2 major categories of antler point restrictions, those which attempt to protect young bulls without restricting the harvest of older bulls and those that allow open hunting of young bulls and restrict the harvest of older bulls. Within these categories, a variety of antler point regulations have been implemented in the western United States. Regulations have restricted hunters to, or from, harvesting elk with the following antler conformations: spikes excluded, branched antlers, bulls with brow-tines, antlers with at least 2 points on a side, antlers with at least 3 points on a side, and antlers with at least 4 points on a side (Boyd and Lipscomb 1976, Harper 1985, Wildlife Division 1990, Dave Moody pers. commun. 1992).

None of the antler point restrictions designed to

protect the yearling age class while allowing unlimited harvest of older bulls have been successful in increasing the numbers of bulls in age classes 3 years and older (Carpenter 1991, Harper 1985, Hamlin and Ross 1992).

Illegal mortality under all of these regulations appeared to increase (DeSimone and Vore 1992, Harper 1985). Boyd and Lipscomb (1976) reported that in Colorado, regulations restricting elk harvest to antlered bulls with 4 or more points increased the numbers of 2-year-old bulls harvested; however, the total number of bulls harvested decreased, and illegal mortality increased.

In Montana, restricting hunters to harvesting bulls with a brow-tine increased the average age of bulls harvested by approximately 1 year, to 2 years of age (Hamlin and Ross 1992). Although estimates of illegal mortality under the brow tine regulation in Montana are uncertain, 10-14 percent (7-10 of 69-72) of radioed-marked yearling bulls were killed illegally in the Gravelly and Snowcrest Ranges of Montana (Hamlin and Ross 1992). Hamlin and Ross (1992) also found that survival of legal bulls in the Gravelly-Snowcrest area was 3.6% (1 of 28).

In 1978 in Clapstop County, Oregon, hunter numbers were limited by permit, and hunters were restricted to harvesting 3-point or greater antlered bulls (Harper 1985). Under these regulations, 11% (4 of 36) of radio collared yearling bull elk were illegally killed (Hatter and Smith 1987).

This system did not increase the number of mature bulls, and Hatter and Smith (1987) recommended eliminating the antler point restriction in this area because of the increased hunting pressure placed on older bulls.

The other major category of antler point restrictions protects the 2-year-old and older age classes and the more robust yearling bulls with branched antlers by restricting hunters to harvesting yearling bull elk with spike antlers. Harvest of older bulls is limited by permit. Spike-only regulations have been successful in increasing mature bull numbers in Montana and Washington (DeSimone and Vore 1992, W. Meyers pers. commun. 1992). Radio telemetry studies in Montana's Elkhorn Range reported an overall annual mortality rate, including legal and illegal harvest, of 29% for bulls 2 years and older. The illegal mortality rate for bulls 2.5 years and older was 8% (8 of 106) (Desimone and Vore 1992).

Elk vulnerability, and subsequent elk population response to hunting regulations, cannot be isolated from the environment in which they live. Youmans (1992) found that hunter numbers, road density, vegetation, weather, topography, hunter behavior, and elk behavior influenced elk vulnerability in southwestern Montana. Unsworth et al. (1993) demonstrated that road density, hunter density, and topography exhibited a greater influence on elk vulnerability than any other variables in north-central Idaho. Lyon and Canfield (1991) reported that road

densities and habitat fragmentation influenced elk vulnerability in northwestern Montana. Each elk population likely has a different set of circumstances which determine vulnerability, and these factors must be considered in evaluating elk population responses to hunting regulations.

Continued increases in hunter numbers, accessibility of elk habitat, and demand for harvest based recreation will necessitate greater precision in harvest management. Situations where habitat does not provide ample security may be managed for recreational harvest only where carefully crafted hunting management plans have been implemented. The Sand Creek area is an excellent opportunity to test precision harvest management. Bull elk vulnerability is high for the Sand Creek elk herd of southeastern Idaho. A radio telemetry study conducted from 1985 to 1987 found a 95% annual mortality rate (21 of 22) for the radio collared yearling bull elk that summered in areas open to hunting. Furthermore, all bull elk (4) captured and collared as 2-year-olds or older that summered in areas open to hunting were killed the hunting season following their capture (Winstead 1990).

Check station data also indicate that bull elk vulnerability in the Sand Creek elk herd is high. Of the antlered elk that went through the check station, 57 and 61% were shot on opening day in 1989 and 1990, respectively (Figure 1). Because of this high mortality rate and a high

degree of hunter dissatisfaction, a spike-only general season was implemented in 1991 in big game management Units 60, 61, and 62A to improve bull elk survival.

Daily Harvest Rate 1986-1990

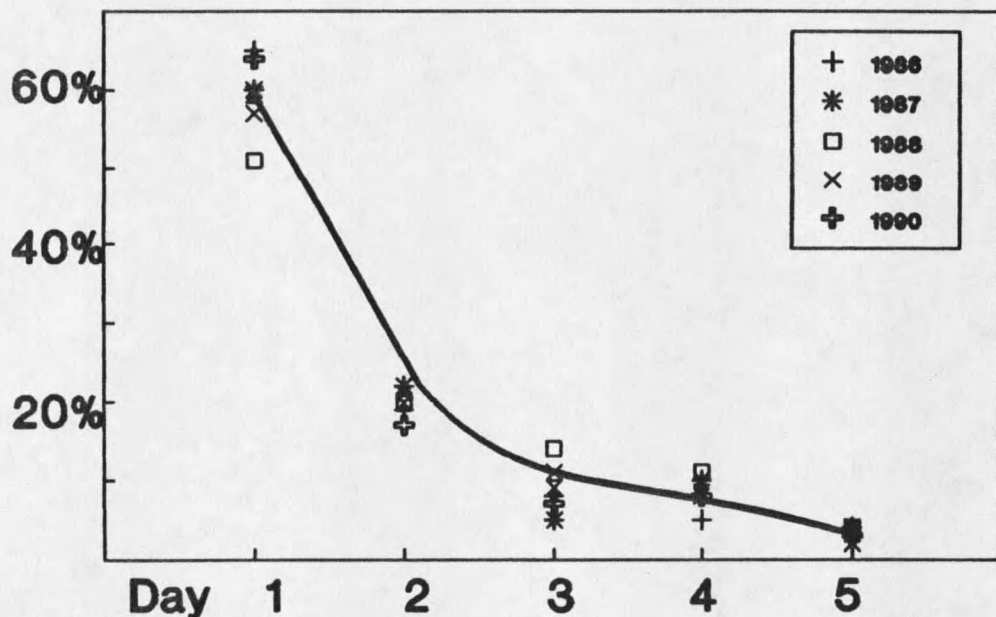


Figure 1. Daily harvest rate of antlered elk for the Sand Creek elk herd, 1986-1990.

This project was initiated to: 1) assess the effects of a spike-only general hunting regulation on bull elk survival, and 2) identify factors which contribute to bull elk vulnerability under this regulation.

STUDY AREA

The study area was in southeastern Idaho and encompassed Idaho Fish and Game big game management Units 60, 61, and 62A in sections of Freemont, Clark, Jefferson, and Madison counties. Adjoining sections of Montana, Wyoming, and Yellowstone National Park were also included in the study area (Figure 2).

The Sand Creek elk winter range was located in the southwest portion of the study area. This winter range is a complex of basalt pressure ridges, active sand dunes with vegetation typical of a high desert shrub steppe, and agricultural croplands (Pauley 1991). Sagebrush (*Artemisia tridentata*) dominates the plant community over most of the area, but bitterbrush (*Purshia tridentata*) and chokecherry (*Prunus virginiana*) are dominant on stabilized dunes (Pauley 1991). Wheatgrasses (*Agropyron* spp.) and needlegrasses (*Stipa* spp.) dominate the herbaceous vegetation.

Summer range for elk associated with Sand Creek is composed of gently sloping plateaus of the Island Park and Huckleberry Ridge Calderas and moderate to steeply sloping formations in the Centennial Range. Douglas-fir (*Pseudotsuga menziesii*), lodgepole pine (*Pinus contorta*), and subalpine-fir (*Abies lasiocarpa*) dominate forest communities (Steele et al. 1983). Shrubs in the foothill community include aspen (*Populus tremuliodes*), bigtooth

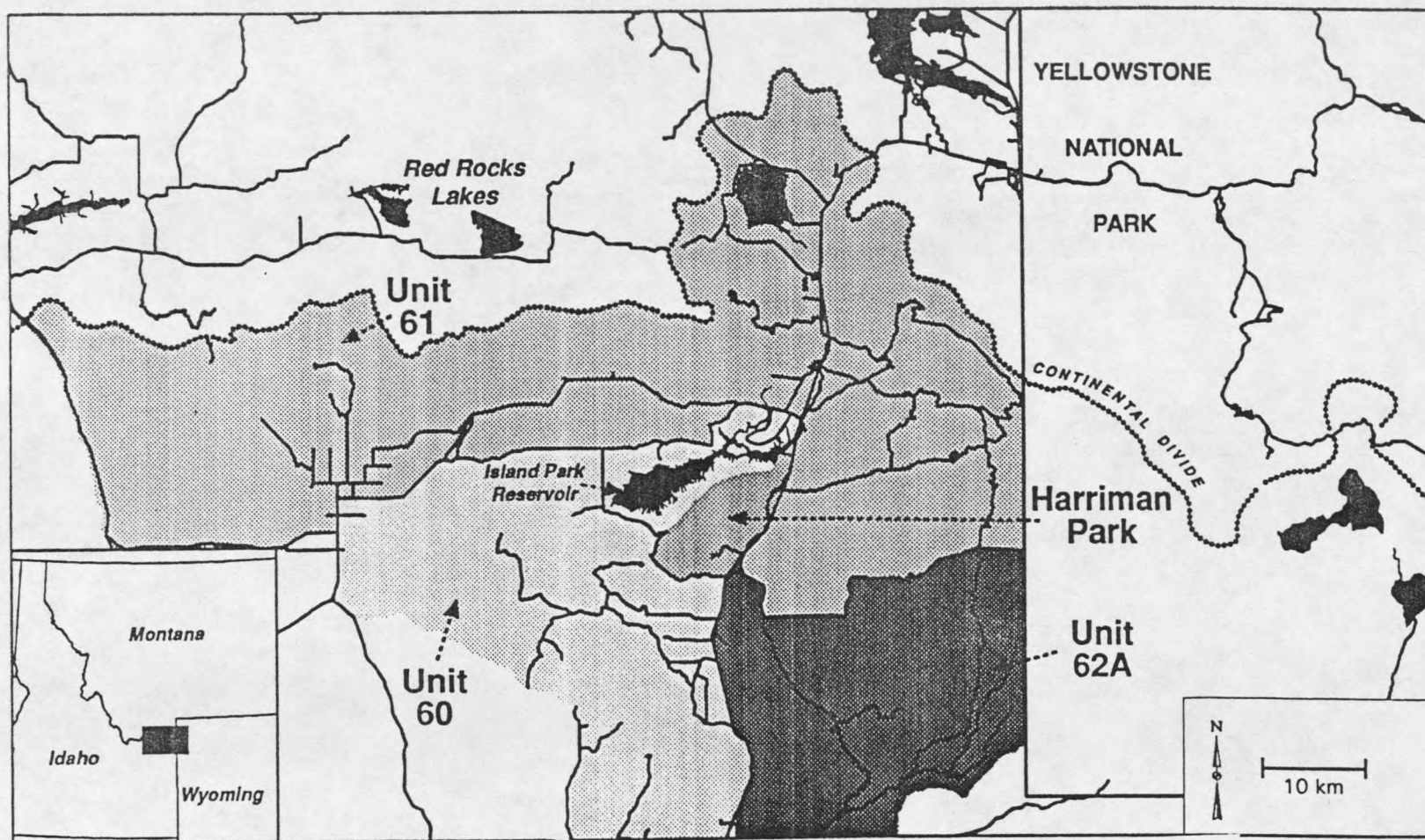


Figure 2. Study area for the Sand Creek elk herd

maple (*Acer grandidentatum*), serviceberry (*Amelanchier* spp.), snowbrush ceanothus (*Ceanothus velutinous*), and snowberry (*Symphoricarpos* spp.).

Climate

The climate in the area occupied by the Sand Creek elk herd is continental with short, cool, dry summers and long, cold winters. Average annual precipitation at the Island Park weather station averaged 66 cm from 1989-1992 with most falling during the winter months (USDA Soil Conservation Service Snow Survey Office, Bozeman, pers. comm.). At Island Park from 1989 to 1992, January daily maximum and minimum temperatures were 6.9 and -36.8 C, respectively. During January, the average daily temperature was -10.9 C. Maximum, minimum, and average daily temperatures during July were 31.1, -0.3, and 14.0 C, respectively, at the Island Park weather station (USDA Soil Conservation Service Snow Survey Office, Bozeman, pers. comm.).

Description of Hunting Units

Unit 60

Land ownership within this 99,401 ha unit is a mix of United States Department of Agriculture (USDA) Forest

Service (41,733 ha), Bureau of Land Management (BLM), Idaho Department of State Lands, Idaho Fish and Game, and private landowners. For this study, Unit 60 was divided into 4 subunits with different topography, hunter distribution, and motorized vehicle regulations. Each of these subunits had unique characteristics which influenced elk vulnerability. These areas are referred to as Antelope Flat (ATF), Big Bend Ridge (BBR), Bishop Mountain (BSH), and Harriman State Park (HSP) (Figure 3).

Neither hunting nor motorized vehicle use was allowed in HSP. Hunting and motorized vehicle use were allowed in the other 3 areas. Both BBR and BSH included portions of the rim of the Island Park Caldera. Douglas-fir communities are common on the rim of the caldera, especially on steep sites. The ATF unit contained portions of the caldera floor. Lodgepole pine communities are dominant on low gradient sites such as the caldera floor.

Densities of roads open to public vehicle use (open roads) in big game management Unit 60 averaged 0.9 km of roads per km^2 in 1991-92. However, roads were not uniformly distributed. Special regulations restricted motorized vehicle travel to designated routes in the BBR area. These regulations reduced the density of roads open to year round travel from 1.3 km/km^2 to a relatively low 0.43 km/km^2 (TIGER data 1991) in the BBR access management area. Higher densities of roads open to year round travel occurred in the

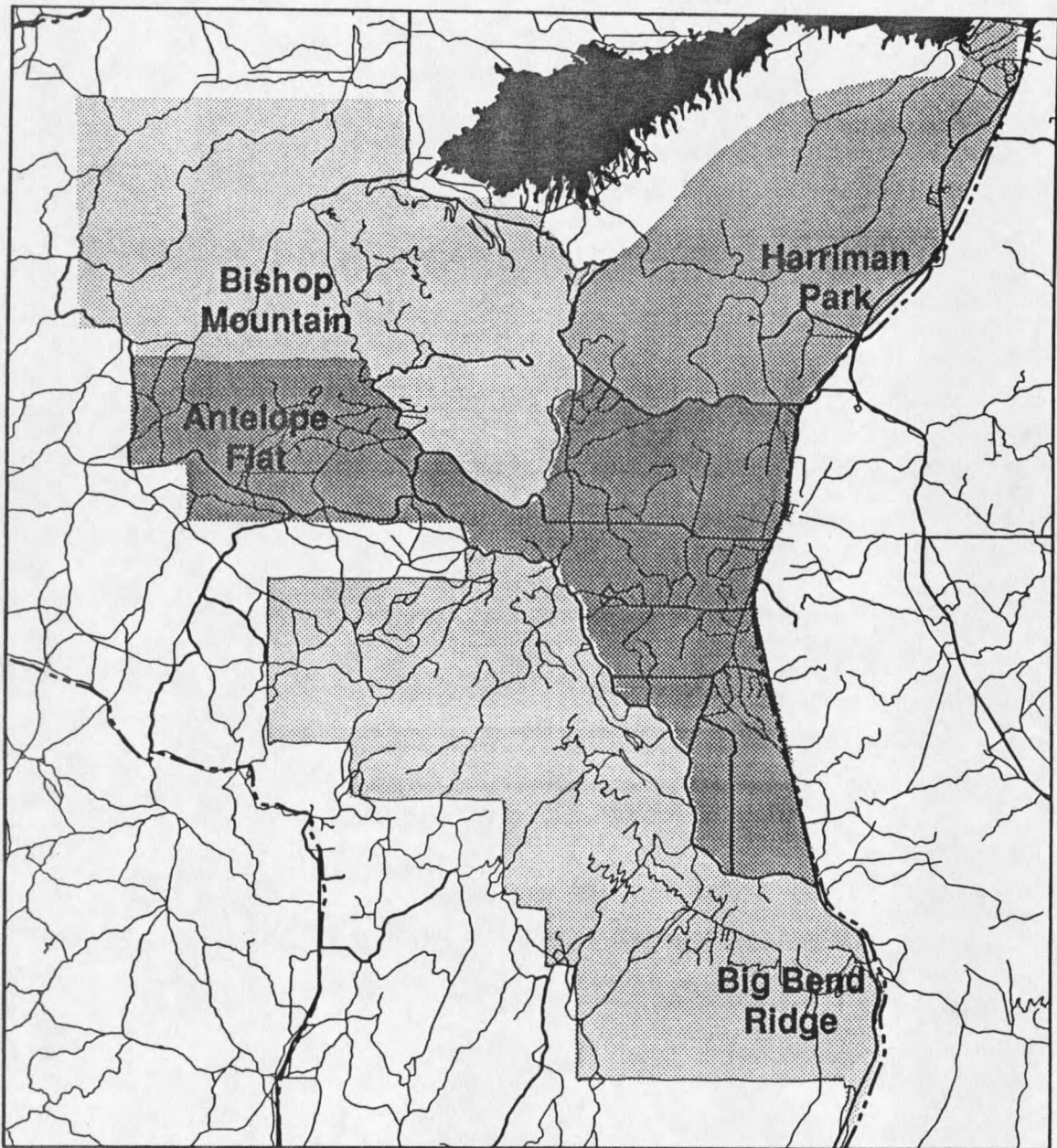


Figure 3. Subunits and roads within Big Game Management Unit 60.

BSH and ATF areas. Motorized vehicle use was not restricted in the ATF and BSH units although many of the roads in the BSH unit were gated. Road densities in the BSH and ATF units were 0.98 km/km² and 1.6 km/km², respectively, in 1991-92.

Unit 61

Most of the 197,733 ha within this area is administered by the Targhee National Forest (61% or 122,367 ha). The western portion of Unit 61 contains the Centennial Range, a mixture of moderate to steeply sloping igneous and sedimentary formations. Elevations range from 2,027 m to 3,109 m. Lodgepole pine and Douglas-fir communities are common in lower elevation sites. Spruce (*Picea* spp.) and subalpine fir communities are common along drainage bottoms. Subalpine fir and whitebark pine (*Pinus albicaulis*) communities occur at higher elevations. The southeastern portion of Unit 61 is characterized by gently sloping plateaus with vegetation dominated by lodgepole pine communities. Although road densities in Unit 61 averaged 0.9 km/km² in 1991-92; the western portion of Unit 61 contained the lowest density of roads with 0.38km/km² of roads open to year round travel.

Unit 62A

Topography in Unit 62A is characterized by the buttes and plateaus of the Huckleberry Ridge Caldera. Vegetation on the plateaus is dominated by lodgepole pine communities. The few drainages in the area are deeply incised. Douglas-fir dominated communities are common in canyons. Land ownership within this 61,200 ha Unit is mostly USDA Forest Service (86% or 52,813 ha).

Road densities in this area were relatively high in 1991-92 with 1.0 km/km². However, many of these roads were gated and not open to motorized vehicle travel. Open road densities according to the 1991 Targhee National Forest travel plan, averaged 0.58 km/km².

Timber Harvest/Habitat Changes

Timber management practices in the 1970-1990's have altered summer range in the study area. In 1974, approximately 85% of the merchantable lodgepole pine stands on the Targhee National Forest were classified as dead or dying due to mountain pine beetle (*Dendroctonus montanus*) infestation (USFS 1981). In response, the Targhee National Forest accelerated timber harvest. Of the 216,600 ha administered by the Targhee National Forest 35,210 ha (16%) were classified as seedling or nonstocked timber stands in

1992 (USDA Targhee National Forest unpublished data 1992). Most of the timber management activity occurred in Big Game Management Units 60 and 62A. Of the 94,332 ha (233,000 acres) administered by the Targhee National Forest in Units 60 and 62A, 22,672 ha (56,000 acres) (24%) were classified as seedling or nonstocked timber stands in 1992 (USDA Targhee National Forest unpublished data 1992).

METHODS

Capture and Relocation

Elk calves were captured using net guns on winter range in March of 1991 and 1992 (Barrett et al. 1982). Male elk calves were fitted with radio collars (150-151 MHz Telonics Inc., Mesa, Ariz.). Colored neck bands were placed on female calves. Radio transmitters were equipped with activity sensors (4-6 hour delay) to detect mortality.

Aerial radio-tracking was conducted from a Maule M5-235 aircraft. An onboard computer recorded location coordinates in latitude and longitude to 0.01 minute using a LORAN-C navigation system. Yearling bulls were located from the air monthly prior to the hunting season and every 2 to 3 days during the general rifle hunting season.

Radio-tracking error was evaluated by locating radio collars placed at known locations. The distance between the observed location and the actual location was then determined on 1:24,000 scale maps. Mean radio-tracking error during the study was 277 ± 99 m.

Elk Survival and Mortality

Mortality rates and confidence intervals were calculated for the archery, general, and controlled hunting

seasons using the Kaplan-Meier procedure (Kaplan and Meier 1958, Pollock et al. 1989). Differences in mortality rates were tested with a 2 X 2 contingency table (White and Garrot 1992). I also reviewed Idaho Fish and Game winter herd composition counts for the Sand Creek elk to determine if any survival trends were apparent from the age structure of the male portion of the elk population.

Hunter Dynamics

I reviewed Idaho Fish and Game telephone survey and check station data to determine trends in hunter numbers. Temporal variation in hunter effort over the general season was not directly measured, but I used the daily rate of antlered elk harvest (elk harvested on day X divided by the total harvest) as an index. Daily rates of antlered elk harvest during the general season were calculated from check station data for the years 1986-1992. I included 1992 check station data although check station operations changed in 1992. Check stations were not operated throughout the general season in 1992, and the season length increased from 5 to 10 days.

Elk Movements and Home range

The minimum convex polygon home range and rate of

animal movement in km/day for each radio-marked elk were calculated using the program TELDAY (Mohr 1947, Lonner and Burkhalter 1983). This method generally overestimates home range size because non-habitat areas may be included within the home range; however, this method has the advantage of being commonly used (White and Garrot 1992). Summer-fall home ranges were calculated by combining locations from June through October. Locations and movements obtained during the general hunting season (October) were compared to those collected prior to the hunting season (June-September). Correlation coefficients were calculated to determine if home range sizes were related to the number of relocations.

Calculation of Habitat Variables

The habitat used by radio-collared elk in October was calculated from circular areas centered on individual locations. Separate comparisons among yearling bulls were made for each day on which animals were located. Habitat variables were calculated from digital information databases and included road density, topography, and vegetative cover.

Topographic variables were calculated from data produced by the United States Geological Survey (USGS) (1990). Elevations in this database are given on a rectangular grid with points approximately 90 m apart in latitude and 60 m apart in longitude. The topographic

variables calculated for the area within each circle were: mean elevation, relief (the difference between highest elevation and lowest elevation), standard deviation (STD) in elevation, mean gradient, STD in gradient, and STD in aspect. Points with zero gradient were not used to calculate deviation in aspect. Deviations in aspect (angular deviation) were calculated according to Zar (1974).

Cover types were available from the USDA Targhee National Forest digital database (USDA Targhee National Forest, unpublished data 1993). I grouped forested cover types into 3 categories: 1) mature timber stands; 2) post-pole and sapling timber stands; and 3) seedling and clearcut timber stands (Appendix Table 20). Non-forested cover types were classed as either open grasslands or tall shrublands. These 5 vegetative classes were expressed as percentages of the area within a circular area centered on each elk location. I estimated the percentage of these cover types from aerial photographs for the few locations on or near privately owned land because the Forest Service database did not include non-Forest Service lands.

I compared road maps created from US Bureau of the Census Topologically Integrated Geographic Encoding and Referencing (TIGER) data to road maps created from data provided by the Targhee National Forest (Appendix Figures 10 and 11). The TIGER Database (1990) provided the closest approximation to existing road densities, so I used it to

calculate total (open and closed) road density. Because roads with special travel restrictions were either not designated or not included in the Targhee National Forest or TIGER Database, I calculated open road densities based on my notes on USGS 1:24,000 scale maps. I was unable to check all roads in many of the subunits, so I only calculated open road densities for elk within the BBR access management area.

The effects of varying the area of the circle were evaluated by calculating values of habitat variables for each location over a set of 10 circles with radii of 0.5 to 5 km in 500-meter increments. Each habitat variable for each circle size was then independently tested for intergroup differences. The most pronounced separation among groups occurred with a circular area of 12.6 km². Using this area maximized the differences in habitat variables between elk categories and minimized radio-tracking error. I have only included results from 12.6 km tests in tables in the results section. Elk that remained in YNP or Montana throughout the general season were not included in tests of circle size.

Factors Influencing Survival

Habitat factors, human modifications of habitat, variations in hunting pressure (spatial and temporal),

behavior of individual animals, and distributional changes are potential factors influencing elk survival (Basile and Lonner 1979, Hillis et al. 1991, Vales et al. 1991). I investigated these factors using univariate tests on several data sets. Although weather has been identified as a factor influencing elk vulnerability (Youmans 1992), I did not have enough variability in weather during hunting seasons between years to include it.

I compared the habitat use of harvested elk to all nonrefuge elk (all yearling bulls accessible to hunters) that survived the general season to determine the influence of habitat variables (without consideration of elk behavior or hunter distribution) on hunting mortality. I considered those animals located in HSP, Montana, and YNP prior to and during the general hunting season refuge animals and excluded them from this analysis.

The relationship between habitat conditions, yearling bull behavior, and survival on opening day (the time period of greatest vulnerability) were determined by grouping yearling bulls accessible to hunters into 3 categories: 1) survivors (those elk that remained on their summer range and survived); 2) harvested elk (those which remained on their summer range and were harvested); and 3) displaced elk (those which either abandoned their summer range or moved into refuge areas during the general season).

I used a pairwise Kruskal-Wallis (1952) test to detect

intergroup differences in habitat use among these groups. I tested for intergroup differences 2 times. In the first test I included only those displaced elk which abandoned their summer range (moved ≥ 8 km) during the general season. This test was to determine if elk which abandoned their summer range used areas with different habitat conditions than elk which survived or were harvested. The second test included all elk which moved into either a refuge area or areas with lower hunting pressure during the general season. The survivor and harvested elk categories were the same in both tests. The yearling bull that occupied a refuge area prior to the general season and moved into a nonrefuge area during the general season was excluded from consideration in both tests.

Hunter Density

I examined hunter density as a survival factor independent of habitat and behavior by calculating the correlation between a hunter density index and survival. My hunter density index (hunter days/day/km²) for 1991 and 1992 was calculated for each game management unit by dividing hunter days by the length of the hunting season and by the size of the area. Large nonforested areas within these units were excluded from these calculations. Number of hunter days for 3 areas within Unit 60 were calculated using

information on hunter distribution collected at check stations in 1992. I assumed that hunters used subunits in proportions similar in 1991 to those reported in 1992.

Survival Versus Distribution of Radio-marked Bulls

To determine if survival and behavior differed among elk populations within different political boundaries, I compared survival, mortality, and behavior among populations within different boundaries.

Yearling bulls were grouped into spatially segregated populations. I compared the movements and fates of yearling bulls within these subpopulations to the movements and fates of those radio-marked bulls which survived the 1991 general season. I also reviewed the tagging records for elk marked on the Sand Creek winter range from 1949-1992 to determine if movements of yearling bulls in 1992 were unusual.

Distribution Changes Over Time

Changes in distribution over time may give information on the influence of changes in habitat conditions or hunter distribution over a longer time span than that permitted during a 2-year study. I compared the summer distribution of radio-marked yearling bulls in 1991-1992 to the distribution of yearling bulls in the 1985-87 study

(Winstead 1990) to determine differences. Summer locations for the 1985-1987 study were plotted to ensure that elk were placed in groups comparable to those used in 1991-1992. Elk were grouped into 5 populations for this comparison: Unit 60, Unit 62A and East Unit 61 (that portion of Unit 61 East of highway 20), Centennial Range (Unit 61), HSP, and YNP. Elk that moved from one area to another during the summer and fall were grouped based on locations immediately prior to and during the early portion of the hunting season. Yearlings that had established a summer range but died prior to the hunting season were included in this comparison.

RESULTS

Capture and Relocation

Eighty-six male elk calves were captured and radio-collared on winter range using net guns in March 1991 (n=49) and March 1992 (n=37). These 86 elk were relocated 741 times from May through October 1991 and 1992.

Survival of Radio-Collared Animals

Radio-marked Animals

Of the 86 elk calves captured and fitted with radio-collars, 10 were not tracked through the fall. Three radio-marked calves died on the winter range sometime between March and May. In June, a vehicle on Highway 20 struck and killed a radio-marked yearling. The radio-collar of 1 calf expanded prematurely, allowing the radio-collar to fall off in early July. Another radio-marked animal either left the area or had a radio malfunction during July. During September, a yearling bull was harvested by a member of the Shoshone-Bannock tribe. Unknown individuals shot 2 other yearling bulls prior to the hunting season, and the radio-collar of 1 of these yearlings had failed. One yearling bull died from unknown causes in early October.

I tracked 77 yearling bulls over 2 hunting seasons and 32 2-year-old bulls over 1 hunting season during 1991-1992. Hunters killed 17 yearling bulls and 3 2-year-old bulls during this period (Appendix Table 8). Idaho hunters harvested 14 yearling bulls during the general hunt. Of the 2 yearlings killed during the archery season, 1 was a wounding loss (Table 1). A yearling was legally harvested in November during a controlled hunt.

Table 1. Survival rates of radio-marked yearling elk during 1991-1992, calculated with the Kaplan-Meier procedure (Kaplan and Meier 1958, Pollock et al. 1989)

	Elk	Deaths	Survival	95% CI
<u>Winter Mortalities</u>				
	86	3	0.97	
<u>Summer Mortalities</u>				
Accidental	81	1	0.99	
Unknown	81	3	0.96	
Shoshone-Bannock	81	1	0.99	
<u>Archery Hunt</u>				
Unit 61	12	2	0.83	0.72-0.94
Unit 62A	2	0	1.00	1.00-1.00
Total	14	2	0.86	0.76-0.95
<u>General Hunt</u>				
Unit 60	37	12	0.68	0.60-0.76
Unit 61	11	2	0.82	0.70-0.93
Unit 62A	2	0	1.00	1.00-1.00
Nonrefuge	50	14	0.72	0.66-0.78
Refuge	24	0	1.00	1.00-1.00
<u>All Licensed Hunting</u>				
Refuge	24	1	0.96	0. -0.
Nonrefuge	52	16	0.69	0.63-0.76

Winter Composition Counts

Winter composition counts indicated an increase in bull elk survival. Bull recruitment into the older age classes increased in 1991 and 1992 (Appendix Table 9). The number of bulls on the winter range doubled following the first year of the spike-only regulation. Of the 450 additional bulls on the winter range following the first year of the spike-only regulation, approximately 220 were yearling bulls and 230 were subadults (bulls 2-3 years of age). In 1992, after the second year of the spike-only season, bull numbers were 3 times the levels reported in 1989 and 1990 under the any-antlered-bull season. The total elk count increased from approximately 2900 in 1989 to 3600 in 1992, with the increase in bull numbers accounting for most of the increase. The corresponding post-season bull to cow ratio increased from an average of 23 bulls per 100 cows under the any-antlered-bull regulation (1989-1990) to 68 bulls per 100 cows in 1992.

Illegal Mortality

In 1991 and 1992, hunters were restricted to harvesting antlered bulls with no antler branch greater than 2.54 cm. None of the radio-marked branch antlered yearlings were killed during either the archery or general hunting seasons.

Although some illegal mortality of yearling bulls did occur in 1991-1992, few yearlings were killed and abandoned by hunters. Hunters appeared to be reluctant to abandon illegal yearlings, and in one instance a hunter attempted to transform a branch antlered yearling into a spike with a rifle shot.

Although 2-year-old bulls were infrequently located during 1992, approximately 16 were in areas open to hunting during the general season (Appendix Table 10). One (6%) of these 16 bulls was killed illegally in 1992.

Hunter Dynamics

Hunters were not distributed proportionately either among the 3 game management units or within Unit 60. Hunters used Unit 60 more than the other 2 Units ($\chi^2=34.6$, $df=2$, $P<0.0001$), and within Unit 60, proportionately more hunters used BBR than the other 2 subunits ($\chi^2=7.3$, $df=2$, $P=0.025$). Hunter densities were not correlated with open road density, topography, or elk density either among the 3 game management units or within the 3 subunits of Unit 60.

Idaho Fish and Game telephone and check station data indicated substantial temporal variation in hunter numbers both between years and within the general season. Telephone harvest survey data indicated that both hunter days and antlered elk harvest in big game management Units 60, 61,

and 62A decreased under the spike-only regulation (Fig. 4). Hunter days and antlered elk harvest decreased 60% and 80%, respectively, the first year of the spike-only regulation. Hunter days partially recovered in the second year of the spike-only season but still remained 50% of the 3-year average under the any-antlered-bull season.

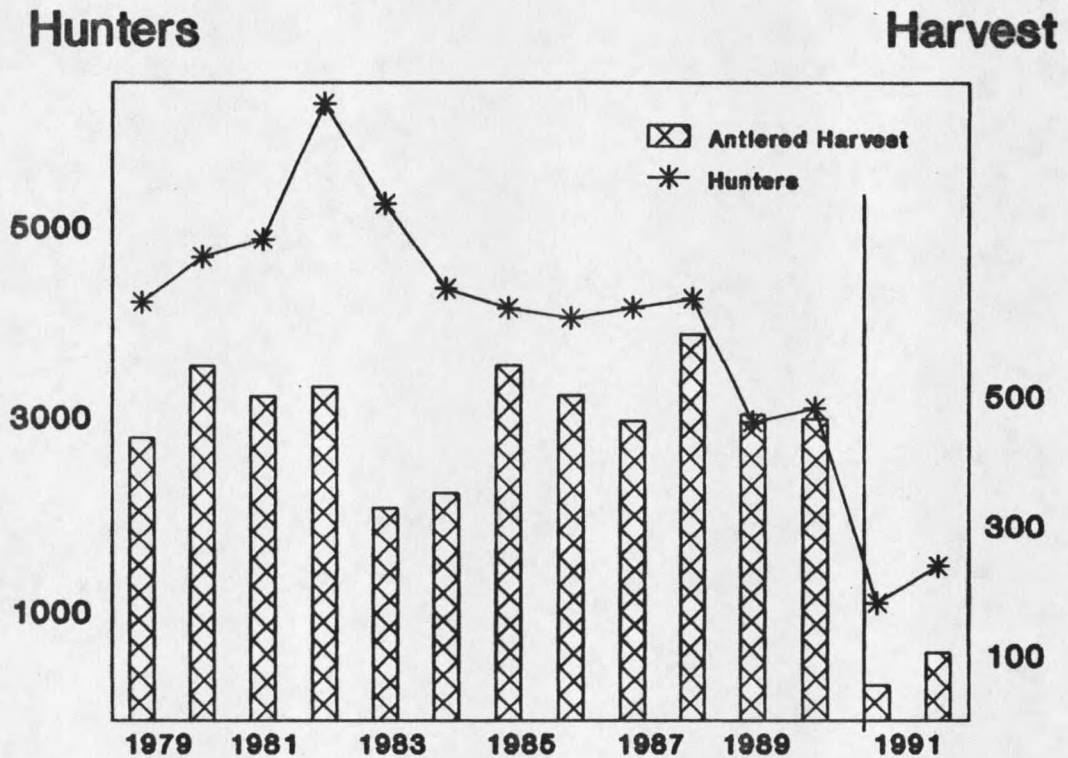


Figure 4. Hunter numbers and antlered elk harvest for the Sand Creek elk herd, 1979-1992

The daily harvest rate was similar for all years (Fig. 5). Check station data indicated that >50% of the antlered elk harvest occurred on opening day. Although check station data were not collected over the entire season in 1992, the trend in daily harvest rate does not appear different under the longer season.

Radio-telemetry data also indicated a pronounced opening day effect. Of the 14 yearlings harvested during the general season, 12 (86%) were killed on opening day.

Daily Harvest Rate 1986-1992

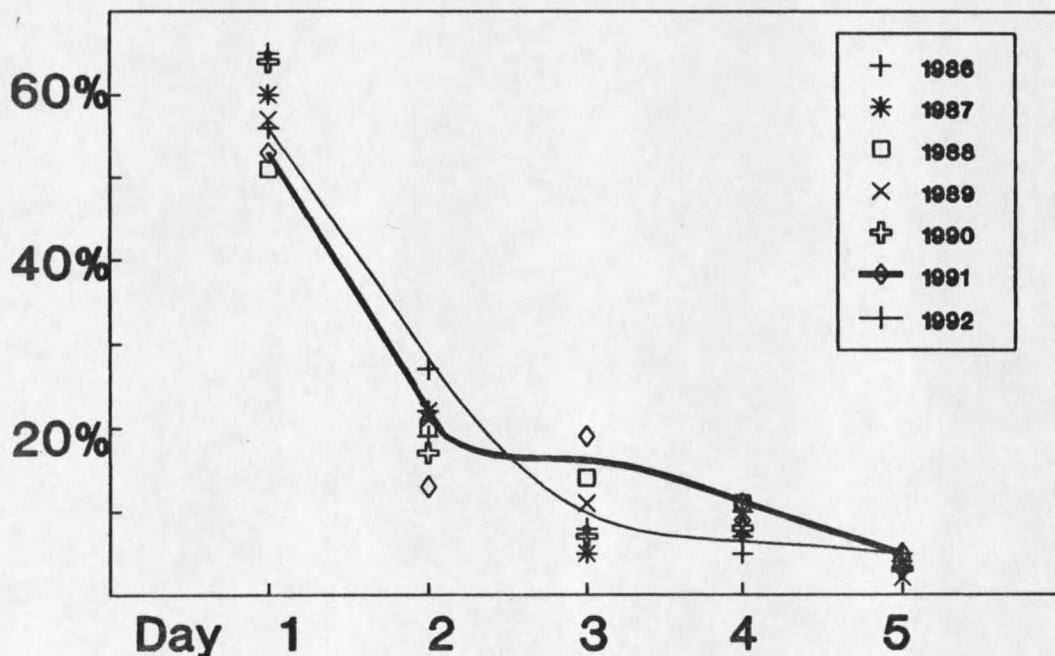


Figure 5. Daily harvest rate of antlered elk, 1986-1992

Spatial Use Patterns

Elk Movements

The average daily movement of yearling bulls accessible to hunters was greater than the average daily movements of elk in refuges ($P < 0.001$) during the general hunting season (Table 2). Daily movements prior to the hunting season were similar between these groups ($P = 0.172$). Prehunting and hunting season movements were not directly comparable because hunting season locations were more frequent than prehunting season locations. The greatest increase in movement between the prehunt and hunt period occurred in Unit 60.

Table 2. Average daily movement rate of radio-marked yearling elk and percent increase in rate of movement from prehunt to hunt, during 1991 and 1992

Area	N*	Prehunt km/day	Hunt km/day	Percent increase
Unit 60	26	0.2	2.4	1,227
Unit 61	9	0.3	0.8	285
Unit 62A	2	1.1	1.9	179
Harriman Park	10	0.3	0.7	242
Yellowstone Park	2	0.1	0.4	454
Montana	1	0.1	0.5	468
Refuge	13	0.3	0.7	259
Nonrefuge	37	0.3	2.0	781

* Number of elk included in calculating means

During the general season, 13 yearling bulls moved into refuge areas and 3 yearling bulls moved into areas with lower hunter density (Fig. 6). Although the movements of 6 of these bulls remained within their summer range, 8 moved ≥ 8 km from their summer range. Five yearling bulls returned to nonrefuge areas before the end of the general season. Two of the 8 elk that abandoned their summer ranges during the general season were harvested (Appendix Fig. 12).

In 1991, 2 yearling bulls disappeared from Unit 60 during the general season (after October 12). These 2 bulls were not located again until November 12 when they were located in the southwest portion of the winter range. These 2 elk probably moved to the winter range before October 14, as they were unlikely to have remained undetected within Unit 60 during the October 14 flight. One of these bulls migrated approximately 70 km to Camas National Wildlife Refuge during the 1992 general hunting season.

Home Range

Geographic activity centers (Fig. 7) and summer-fall home range areas (Appendix Table 11) were estimated for 77 yearling bulls. Home range size averaged 11 km² (SD =13.2). Home range size and the number of relocations were not correlated ($r=-0.0147$, $df=1$, $P=0.89$). Because of the influence of range shifts of some (11) yearlings during

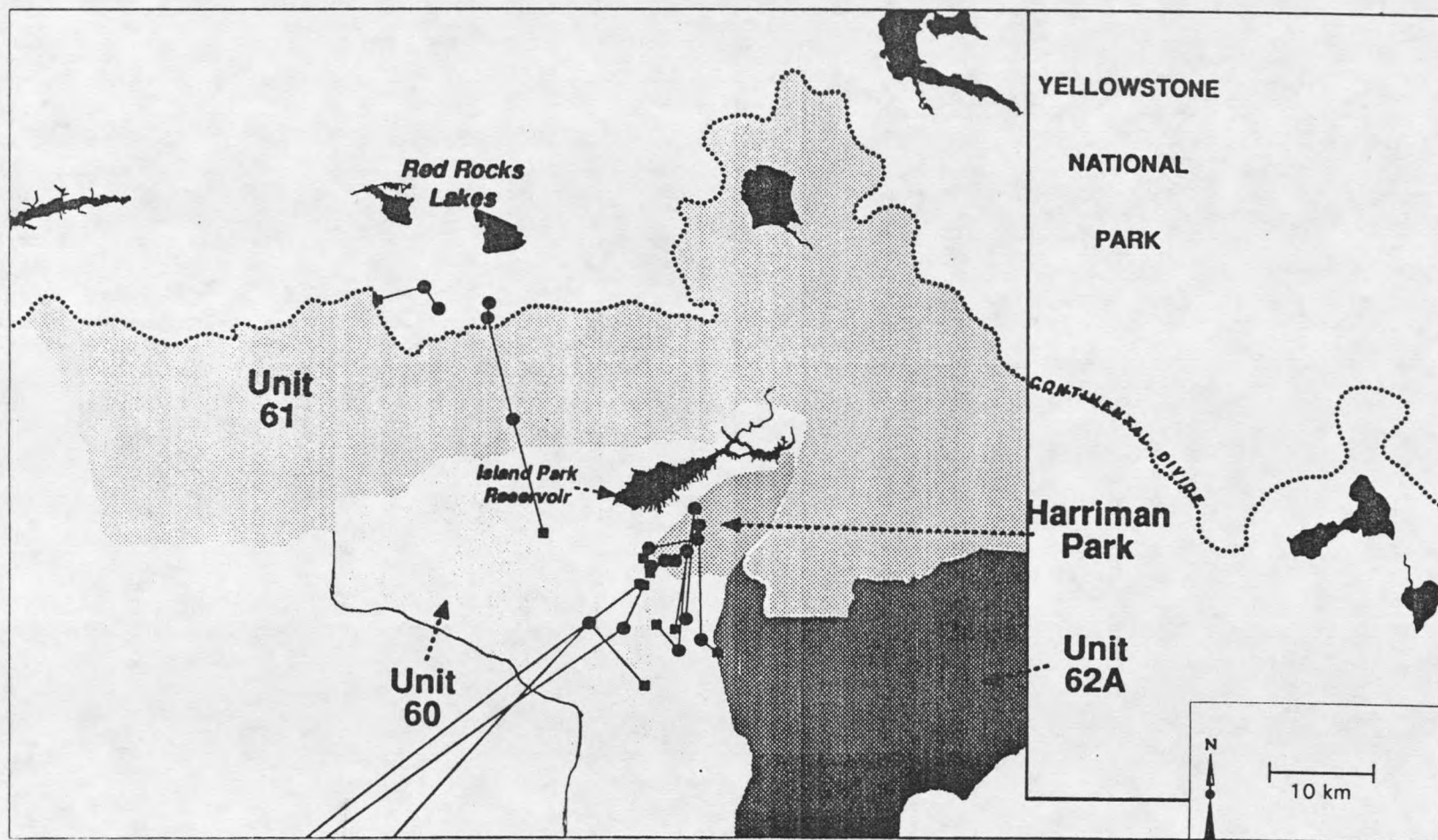


Figure 6. Movements of radio-marked elk into refuge areas during the general season, 1991-1992. A ■ indicates location prior to the general season.

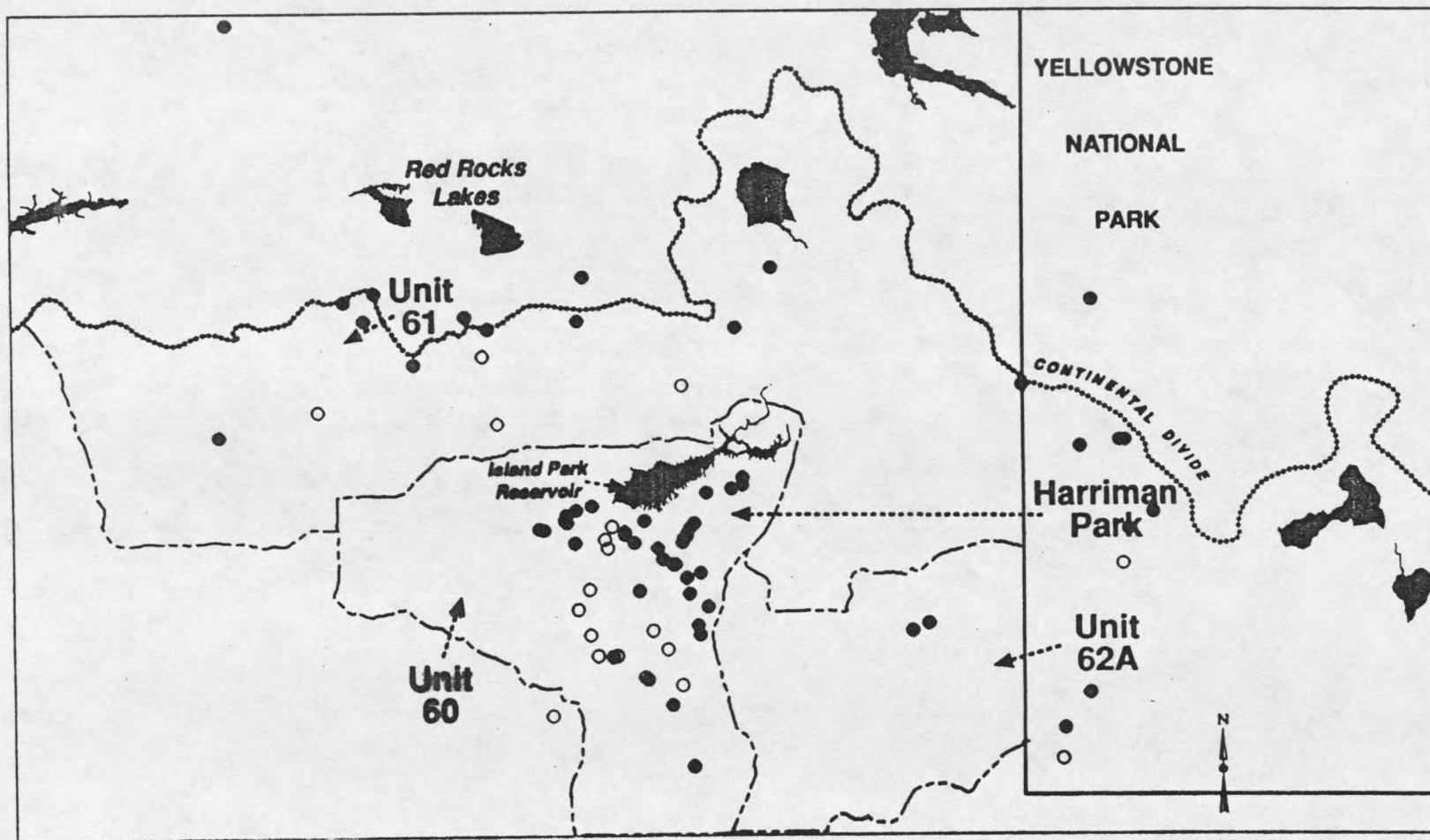


Figure 7. Geographic Activity Center of 77 radio-marked yearling elk 1991-1992. A ○ indicates mortality, a ● indicates survivorship.

October, some summer-fall home range were exaggerated. They contained large areas that were only used as travel ways.

Factors Influencing Survival

Survivors Versus Harvested Yearlings

Eleven of the 13 variables I tested were similar between harvested elk and elk that survived the general season (Table 3). Cover types and hunter density were different. The 36 nonrefuge elk (those elk which were available to hunters and survived the general season) used areas with proportionally more seedling\clearcut timber stands than harvested elk prior to ($P=0.004$) and during ($P=0.036$) the general season. Elk that survived the general season used areas with lower hunter density than harvested elk ($P=0.004$).

Table 3. Median habitat values for areas used by radio-marked yearling bulls that survived and those harvested during the general season during October of 1991 and 1992.

Variable	Location Date	Harvested n=12	Survivor n=35
Mean Elevation (m)	Prehunt	1959 *	2047 *
	Hunt	1994	2047
Elevation Deviation	Prehunt	64	78
	Hunt	45	62
Topographic Relief	Prehunt	244	297
	Hunt	181	264
Gradient (degrees)	Prehunt	10	10
	Hunt	2	9
Aspect Deviation	Prehunt	57	55
	Hunt	56	54
Mature Stands (%)	Prehunt	88	67
	Hunt	79	73
Post-pole\Sapling (%)	Prehunt	0 *	8 *
	Hunt	3	7
Seedling\Clearcut (%)	Prehunt	0 *	14 *
	Hunt	2 *	14 *
Grassland (%)	Prehunt	0	0
	Hunt	0	0
Tall Shrubland (%)	Prehunt	0	0
	Hunt	0	0
All Roads (m/km ²)	Prehunt	0.91	0.78
	Hunt	0.94	0.78
Open Roads	Prehunt	0.41	0.56
	Hunt	0.42	0.60

Harvested - elk harvested on opening day of general season.

Survived - elk accessible to hunters that survived the general season.

* indicates significance at the P=0.1 level using a Kruskal-Wallis test

Survivors Versus Displaced Versus Harvested Yearling

The influence of habitat factors on elk vulnerability was not apparent without consideration of elk behavior. I included 2 sets of tests to incorporate elk behavior as a

factor in survival. The first test set included 41 yearling bulls: 1) the 12 harvested bulls (elk harvested within 8 km of their summer range on opening day), 2) 21 survivors (elk which remained within their summer range and survived), and 3) 8 displaced elk that abandoned their summer range. The second test set included all 49 of the yearling bulls which were available to hunters on opening day. The second test included the same 12 harvested and 21 survivor elk but included 8 additional displaced elk (all 16 elk which moved into refuge areas or areas of lower hunting pressure during the general season).

Topographic features. In the first test set, only 1 of the 6 topographic variables analyzed was consistently different among the 3 categories (Table 4). Survivors used areas with more deviation in elevation (standard deviation of elevation) than harvested elk on opening day ($P=0.067$) and prior to the general season ($P=0.096$). Displaced elk (set 1) used areas with intermediate levels of topographic relief and deviation in elevation. Neither relief nor deviation in elevation were statistically different among displaced and survivor elk groups. In the second test, none of these 6 topographic variables were different among elk groups.

Table 4. Median topographic values for areas used by 4 categories of radio-marked yearling bulls during October 1991 and 1992

Variable	Location Date	Harvested n=12 ^a	Survivor n=21 ^b	Displaced1 n=8 ^c	Displaced2 n=16 ^d
Mean Elevation	Prehunt	1959 *	2109 m *	2046	2046
	Hunt	1994	2068 m	2048	2046
Elevation Deviation	Prehunt	64 *	78 *	53	54
	Hunt	45 *	65 *	44	48
Topographic Relief	Prehunt	244 m	307 m	220	244
	Hunt	181 m *	264 m *	195	221
Gradient	Prehunt	10	10	8	8
	Hunt	2	10	6	7
Aspect Deviation	Prehunt	57	53 *	58	58 *
	Hunt	56	53	55	58

a - elk harvested on opening day.

b - elk that remained on their summer range and survived.

c - elk that abandoned (moved >8 km) from their summer range during the general season.

d - elk which moved into a refuge area during the general season.

* indicates significance at the P=0.1 level using a pairwise Kruskal-Wallis test.

Cover Types. Of the 5 cover types, only the seedling\clearcut timber stands differed among cover categories (Table 5). In the first test set, survivors used areas with a greater proportion of seedling\clearcut timber stands than areas used by harvested elk on opening day (P=0.020) and areas used prior to (P=0.008) the general season. In the second test set both survivor (P=0.007; P=0.003) and displaced elk (P=0.026; P=0.079) used areas with a greater proportion of seedling\clearcut timber stands than harvested elk, both prior to and on opening day, respectively. Although displaced elk tended to use areas with fewer mature timber stands and more post-pole\sapling timber stands than

either harvested or surviving elk, these differences were not statistically significant in either the first or second test set.

Table 5. Median percentage of cover types used by 4 categories of radio-marked yearling bulls during October 1991 and 1992

Cover Type	Location Date	Harvested n=12 ^a	Survivor n=21 ^b	Displaced n=8 ^c	Displaced n=16 ^d
Mature Stands	Prehunt	88	70	65	65
	Hunt	79 *	73	48 *	61 *
Post-pole\Sapling	Prehunt	0 *	6 *	9 *	11 *
	Hunt	3	6	8	7
Seedling\Clearcut	Prehunt	0 *	14 *	7 *	14 *
	Hunt	2 *	14 *	10	16 *
Grassland	Prehunt	0	0	1	1
	Hunt	0	0	1	0
Tall Shrubland	Prehunt	0 *	0 *	0 *	0
	Hunt	0	0	0	0

a - elk harvested on opening day.

b - elk that remained on their summer range and survived.

c - elk that abandoned (moved >8 km) from their summer range during the general season.

d - elk which moved into a refuge area during the general season.

* indicates significance at the P=0.1 level using a pairwise Kruskal-Wallis test.

Road Densities. Both total and open road densities were similar for areas used by harvested and survivor elk in both the first and second test sets (Table 6). In the first test set, the difference in open road density among areas used by harvested elk and displaced elk were statistically significant on opening day but not prior to the general season (P=0.099, P=0.203, respectively).

Table 6. Median road densities of areas used by 4 categories of yearling bull elk during October 1991 and 1992

Road Type	Location Date	Harvested n=12 ^a	Survivor n=21 ^b	Displaced1 n=8 ^c	Displaced2 n=16 ^d
All	Prehunt	0.91 km/km ²	0.54 km/km ²	0.81 km/km ²	1.04 km/km ²
	Hunt	0.94 km/km ²	0.69 km/km ²	1.08 km/km ²	1.11 km/km ²
Open	Prehunt	0.41 km/km ²	0.41 km/km ²	0.63 km/km ²	0.91 km/km ²
	Hunt	0.42 km/km ²	0.51 km/km ²	1.05 km/km ²	1.02 km/km ²

a - elk harvested on opening day.

b - elk that remained on their summer range and survived.

c - elk that abandoned (moved >8 km) from their summer range during the general season.

d - elk which moved into a refuge area during the general season.

* indicates significance at the P=0.1 level using a pairwise Kruskal-Wallis test.

Hunter Density. In the first test set, harvested elk used areas with higher hunter densities than survivors (P=0.005) but not displaced elk (P=0.112). Hunter densities were similar for displaced and surviving elk (P=0.425). In the second test set, hunter densities were higher for harvested than either survivor (P=0.006) or displaced (P=0.008) elk, but not different among displaced and survivor (P=0.975) elk.

Survival Versus Season Length. The proportions of radio-marked yearlings available to hunters that were harvested during the general season were 25% (7 of 28) in the 1991 5 day season and 32% (7 of 22) in the 1992 10 day season. Harvest rates of radio-marked elk did not differ between years ($\chi^2=0.0465$; Df=1; P=0.83).

Distribution of Marked Yearling Bulls

Yearling Bulls 1991 and 1992

Yearling bulls marked on the Sand Creek winter range summered in 7 areas: 4 subunits within Game Management Unit 60, Game Management Unit 62A, the Centennial Mountains, and Yellowstone National Park. Considerable interchange occurred between the groups. Of the 48 yearlings which summered in Unit 60, 44% (21) moved into another subunit during the summer and fall, and 6 of the 21 that moved (29%) spent time in at least 1 other game management unit (Fig. 8).

Twenty-four yearlings were located within HSP, a subunit within Unit 60, during some portion of the summer and fall. However, only 11 yearlings summered exclusively in HSP. During August, 8 yearlings left HSP for adjacent areas, but 62% of these yearlings returned during the general season. Only 3 of the yearlings that moved into HSP during the general season were not located in HSP during the summer (Appendix Table 12).

Twenty-one yearlings were located in the BSH subunit of Unit 60 during some portion of the summer and fall. Sixteen yearlings used the BSH area during the general season, and 56% exclusively used this area. During the general season, 7 yearlings left the BSH area, and 1 left and returned. Seven of the 9 yearlings that remained in this area survived

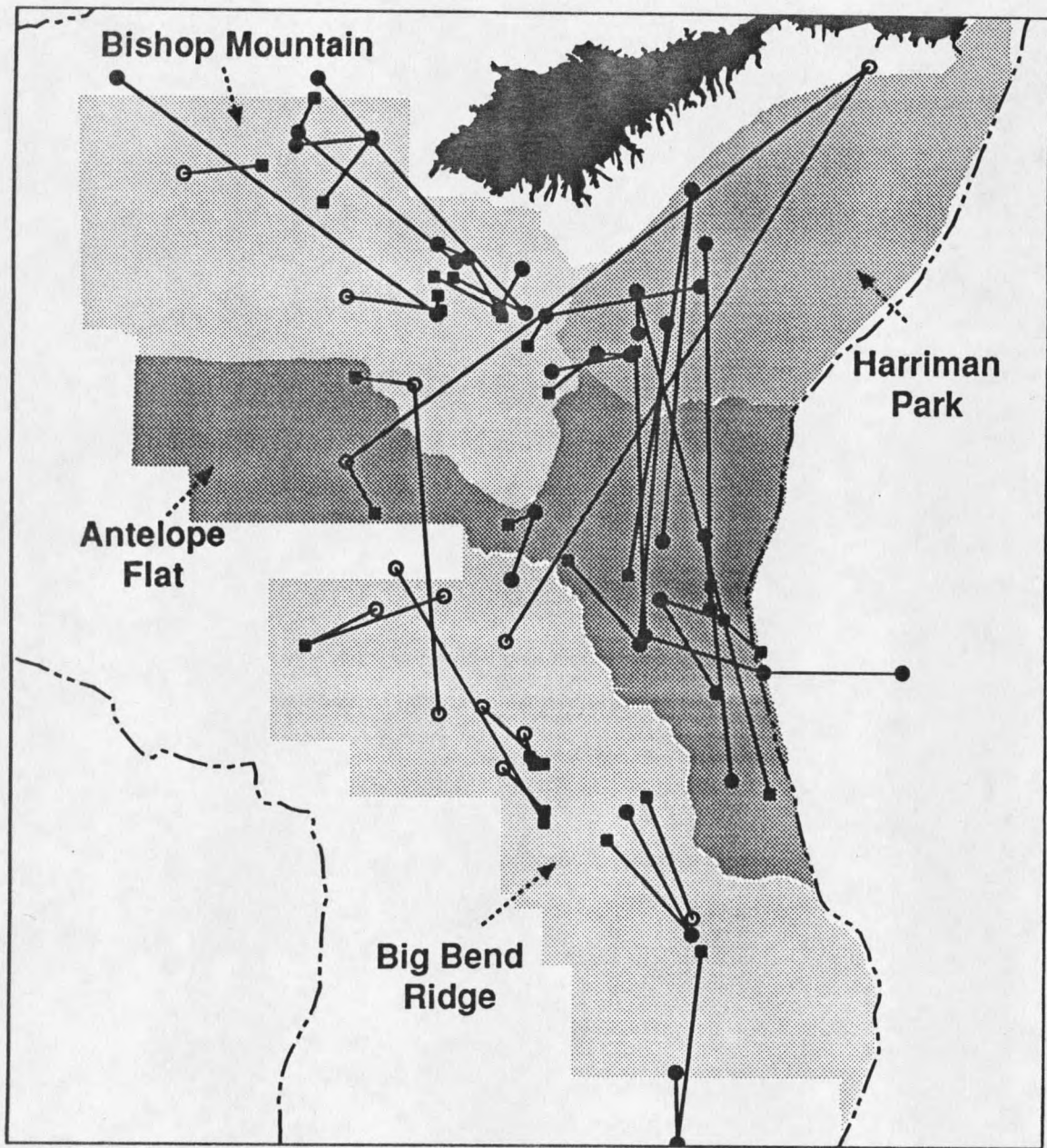


Figure 8. Movements of radio-marked yearling bulls within Big Game Management Unit 60 during the general season, 1991-1992. A ■ indicates location prior to the general season. A ○ indicates mortality, a ● indicates survivorship.

the general season (Appendix Table 13).

Twenty yearlings were located in the BBR subunit during the summer and fall, and 35% exclusively used this area. During the general season, 12 yearlings were in the BBR area, 3 yearlings left and 2 survived (Appendix Table 14).

During the summer and fall, 15 yearlings were located in the ATF subunit of Unit 60, but none exclusively used this area (Appendix Table 15). Five moved into the ATF area during August but left during the general season. Only 3 yearlings remained in the ATF area during the general season, and all 3 survived.

Two yearling bulls spent the summer and fall in Unit 62A. Both survived the archery, general, and controlled hunting seasons (Appendix Table 16).

Fifteen yearling bulls spent the summer and fall in the Centennial range (Appendix Table 17). Eleven (73%) of these yearlings were available to Idaho hunters during some portion of the general season. Two yearling bulls were killed during the archery season, and 2 were harvested during the general season. A hunter that harvested one of these radio-marked bulls reported that this elk had been wounded during the archery season.

Not all of the yearlings summered in the study area. Eleven yearlings summered in Yellowstone National Park (Appendix Table 18), and 1 yearling summered in the Gravelly Mountains of Montana. All of these yearlings survived the

archery and general season, but 2 yearlings which summered in Yellowstone National Park were harvested during a controlled hunt in Unit 62A. The yearling which summered in the Gravelly Mountains also wintered in Montana near the Blacktail Wildlife Management area (K. Hamlin, pers. comm.).

2-year-old Bulls 1992

Twenty-six of the 36 yearling bulls known to have survived the 1991 hunting season returned to the same area they summered in as yearlings (Fig. 9). However, at least 6 of these bulls dispersed to areas ≥ 20 km from their original summer range. Three of the 6 bulls moved into another state. The bull that moved the greatest distance was harvested east of Bozeman, Montana about 130 km from the area it summered in as a yearling. The fates of 4 bulls which survived the 1991 hunting season are not known since they were not located after November 1991.

One 2-year old bull was killed illegally in Idaho in 1992, 2 bulls were legally harvested during the general hunt in Montana, and 1 was killed by a train in Idaho. Two other bulls moved to the Idaho National Engineering Laboratory where they were subsequently captured and translocated in January of 1993.

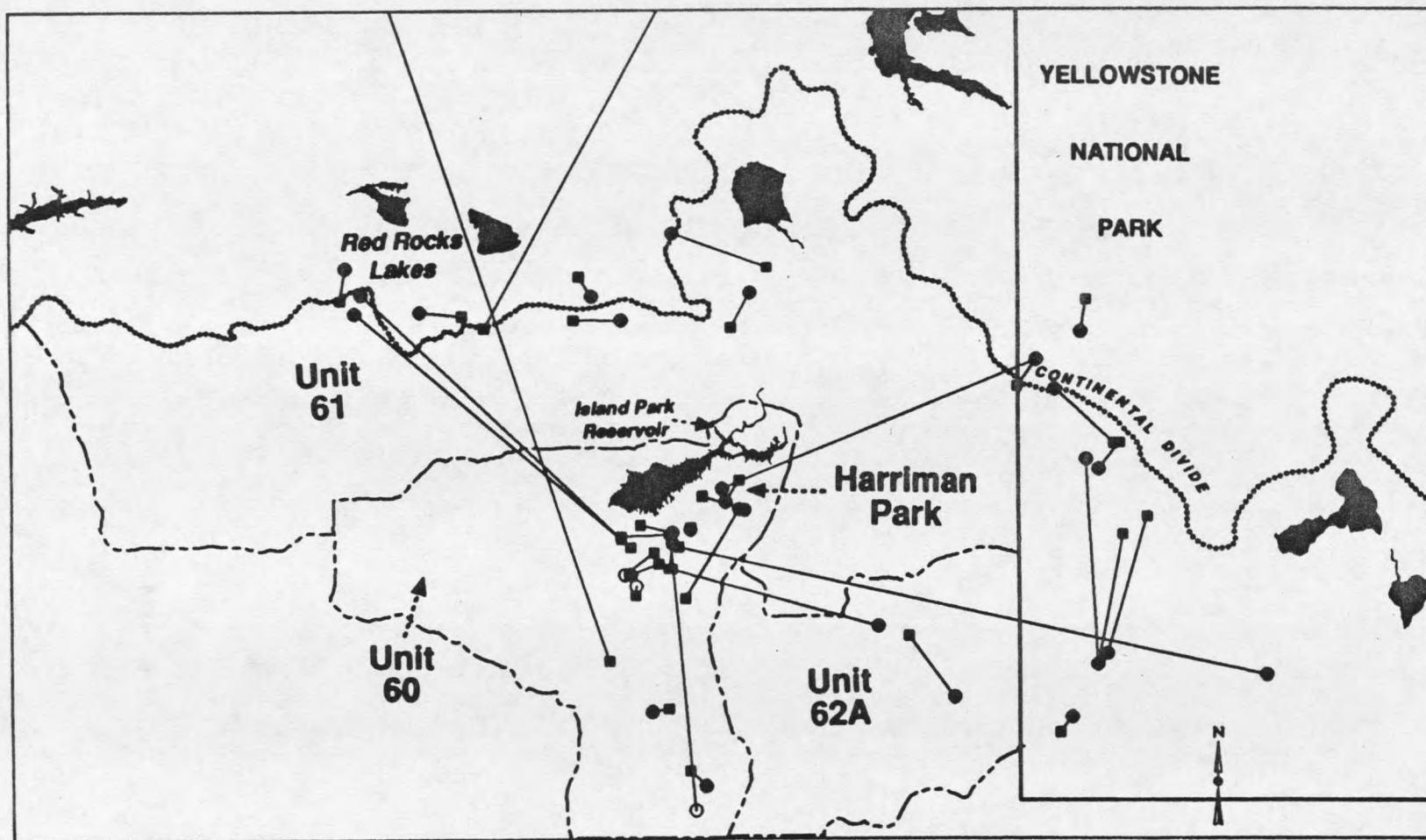


Figure 9. 1991 Geographic Activity Center and 1992 locations of elk radio-marked in 1991. A ■ indicates 1991 activity center. A ○ indicates mortality, a ● indicates survivorship.

Fate of Tagged animals 1949-1992

Of the nearly 900 elk marked on the Sand Creek Winter Range from 1949-1992, 19 (2%) were harvested in either Montana or Wyoming. Tagging records indicate that 4% of all tagged males and 1% of all tagged females were harvested in either Montana or Wyoming. Four of these elk were harvested over 150 km from the winter range (Appendix Table 19).

Distribution Changes Over Time

The distribution of 81 radio-marked yearling elk on summer range during the summers of 1991 and 1992 were different than the distribution of 35 radio-collared yearling males during 1985-1987 ($\chi^2=34.0$, $df=4$, $P<0.0001$). The most dramatic change occurred in Unit 62A. Only 2% of (2 of 81) radio-marked yearlings summered in Unit 62A and Unit 61 East in 1991-1992; but in the 1985-1987 study 29 percent (10 of 35) of radioed yearling bull elk summered in Unit 62A and that portion of Unit 61 east of highway 20 (Table 7).

Table 7. Summer-Fall distribution of radio-marked yearling bull elk

Area	1985-87		1991-1992	
	N	Percent of radios	N	Percent of radios
Unit 60	11	31	40	49
Antelope Flat (ATF)	1	3	9	11
Big Bend Ridge (BBR)	6	17	13	16
Bishop Mountain (BSH)	3	9	17	21
Unit 61				
Centennial Range	5	14	15	19
Unit 61 East and Unit 62A	10	29	2	2
Harriman Park	5	14	12	15
Yellowstone Park	2	6	11	14
Unit 60A	2	6	0	0
Montana	0	0	1	1
Refuge	9	26	24	30
Nonrefuge	26	74	57	70
Total	35	100	81	100

DISCUSSION

Impacts of Regulation Changes

Mortality Patterns

Elk mortality prior to the general season was lower in 1991 and 1992 than previously reported levels for radio-marked yearling bulls in the Sand Creek elk herd. Winstead (1990) reported a 12% (5 of 43) winter mortality rate for radio-marked bull calves, but only 3% (3 of the 86) of radio-marked calves died during early spring in 1991-1992. A radio-marked yearling bull was killed by a vehicle during both studies (Winstead 1990). Although at least 1 radio-marked yearling bull was harvested by a Shoshone-Bannock tribal member in 1991-1992; none of the radio-marked yearling bulls were harvested by Shoshone-Bannock tribal members during the 1985-1987 study (Winstead 1990). None of the yearling bulls radio-marked in 1985-1987 were harvested by archers. Two (3%) were killed by archers in 1991-1992.

During the general season, 72% (1991 and 1992 combined) of the yearling bulls accessible to hunters in my study area survived the general hunting season. Pauley (1991), in the same study area, reported that 72% of the yearling bulls summering in areas open to hunting were harvested during the general hunting season in 1985-1987. Elk were grouped

differently (as refuge or nonrefuge) in the 2 studies so mortality rates are not directly comparable, but bull elk mortality was lower under the spike-only regulation than during the any antlered bull regulation.

The spike-antlered-bull only regulation focused hunting pressure on yearling bulls. This should increase the survival rates of branch-antlered-yearlings and bulls 2-years and older. Radio-telemetry and winter herd composition counts indicate a low mortality rate for bulls 2-years-old and older.

Conversely, the survival of spike-antlered-yearling bulls should decrease because only spike-antlered bulls are legal. This was not the case. The antler conformation of radio-marked yearling bulls which survived the general season was not known. However, even if 25% of these elk were branch antlered, the survival rate of spike-antlered yearlings would be greater than yearling bulls under the any-antlered-bull regulation.

The winter compositions counts also indicated an increase in bull elk survival. Bull numbers on the winter range increased 170% and the bull to cow ratio tripled. Some of the increase in the bull to cow ratio after the implementation of the spike-only regulation was due to a greater harvest of antlerless elk than bull elk, but survival of bulls that would have been shot under an any-antlered-bull regulation contributed greatly to the

increase. Bull numbers and the bull to cow ratio increased following implementation of the spike-only regulation in the Elkhorn Mountains of Montana; however, the bull to cow ratio was ≤ 15 bulls per 100 cows in 1992, 5 years after implementation of the spike-only season (DeSimone and Vore 1992).

Why did implementation of the spike-only regulation in Idaho produce different results than in Montana. Prior to the implementation of the spike-only regulation the bull to cow ratio was much lower in the Elkhorn Mountains than for the Sand creek herd. Refuge areas contribute substantially to bull numbers in the Sand Creek winter herd composition counts, but not in the Elkhorn Mountains. Hunter numbers decreased much less in the Elkhorn Mountains and yearling bull survival during the general season was also lower.

Illegal Mortality

Although illegal mortality levels under any new regulation can be high (Boyd and Lipscomb 1976, Wildlife Division 1990), illegal mortality did not appear to be a significant problem during my study. None of the radio-marked yearling bulls and only 1 of the radio marked 2-year-old bulls were killed illegally under the spike-only regulation in 1991-1992. However, researchers in the Elkhorn Mountains of Montana under a similar regulation

found that 7.6% of the radio-marked bulls 2-years-old and older and 1 of the 48 radio-marked yearling bulls were killed illegally (DeSimone and Vore 1992).

In Oregon under a 3-point or better regulation, Harper (1985) reported that illegal bull mortality increased with hunter numbers. Current hunter densities (hunters\km\day) in the Elkhorn Mountains are somewhat greater than historic hunter densities for Units 60, 61, and 62A. This suggests that even with substantial increases in hunting pressures within Units 60, 61, and 62A the level of illegal mortality will remain low.

Hunter Dynamics

In 1991 and 1992, hunter densities were greater in Unit 60 than in either Unit 61 or 62A. This distribution was consistent with telephone survey data from 1981-1990. However, hunter densities for Unit 60 in 1991 and 1992 were lower than levels prior to the implementation of the spike-only regulation. Evidently some hunters who used these units prior to implementation of the spike-only regulation hunted in other areas in 1991 and 1992, particularly the Salmon, Idaho area. Brown (1985) reported a 5-year average (1979-1983) of 5.1 general season hunters per km² of elk habitat in Unit 60. Using the same area of elk habitat (446 km²) for Unit 60, in 1991 and 1992 there were 73% (1.0 and

1.4 per km², respectively) fewer general season hunters. Decreases in general season hunters were less dramatic in Units 61 and 62A.

In spite of changes in regulations and hunter numbers, the proportion of the total antlered elk harvest occurring on opening day remained as high after implementation of the spike-only regulation as prior to implementation of the spike-only regulation. Most radio-collared yearling bulls accessible to hunters (36 of 38) which survived opening day in 1991-1992 survived the entire general season. The reduced mortality rate after opening day is likely due partially to removal of vulnerable animals (Lonner and Cada 1982), increased wariness of surviving animals (Picton 1991), and movement of elk into refuges. Hunter perception also likely played a role. Hunters, based on past experiences, may have expected success to decline as the season progressed and consequently reduced effort after opening day.

Spatial Use Patterns

Elk Movements

Some yearling bulls in areas accessible to hunters evidently responded to hunting pressure by increasing rates of movement, moving into refuge areas, and/or abandoning

their summer ranges. The rate of daily movement by yearling bulls was greater during the hunting season for nonrefuge bulls than refuge bulls. In Montana, Lyon and Canfield (1991) also found that distance between elk relocations increased during hunting season. Only yearling bulls in nonrefuge areas abandoned their summer ranges during the general season in 1991 and 1992. Hurley and Sargent (1991) and others have found that elk in roaded habitats responded to hunting pressure with a greater shift in activity centers than elk in closed road areas.

Both Brown (1985) and Pauley (1991) reported movements in the Sand Creek elk herd in response to hunting pressure prior to and during the general season. Brown (1985) found that elk summering in Harriman Park avoided areas open to hunting during the general season. Pauley (1991) reported that 7 radio-marked bulls moved into refuge areas prior to or during the general season, including 4 early migrations to the winter range. Pauley (1991) also reported 10 early migrations to the winter range by cow elk.

Home Range

Summer-fall home range areas for yearling elk in my study varied from 2.3 km² to 252.2 km² for 77 yearling elk. This exceeds the range of 36.7 km² to 97.5 km² summer-fall ranges reported by Brown (1985) for 52 cow elk. The average

summer-fall home range for yearling bulls in 1991-1992 was smaller than the summer-fall ranges of 52 cow elk in the same study area reported by Brown (1985). Part of this difference was probably due to differences in computer programs used to calculate home range size.

Elk whose home ranges included portions of refuge areas were more likely to move into refuge areas during the general season than those that did not. However, some yearlings may have used refuge areas during the summer undetected because few locations were obtained prior to general season.

Factor Influencing Survival

Behavior

Elk behavior can affect survival in several ways including habitat selection and response to the influx of hunters on opening day of the hunting season (Lyon and Canfield 1991). The lack of large habitat distinctions between elk that were killed and elk that survived the general season suggests that selection of habitat features, at least in categories I measured, was not an effective means of avoiding death.

Choosing an appropriate response to hunter presence was apparently more effective. Sixteen yearling bulls moved

into either a refuge or an area of lower hunter density immediately prior to or during the general season. Some of these 16 yearlings continued to move, and 2 were killed by day 3 of the general season when they returned to areas with high hunter densities. All of the yearling bulls that moved into, and remained in, areas of low hunter density from high hunter density areas survived. I was unable to detect any differences in habitat use on opening day between elk that moved and those that remained on prehunt ranges and survived.

Topography

Elk harvested in the Sand Creek area tended to use areas with lower elevation deviation than elk that survived the general hunting season while remaining on their pre-hunt summer range. This suggests that survivors were in more topographically diverse habitats than non-survivors. Elk that left their pre-hunt summer range during the general season did not differ significantly from harvested or sedentary elk. Topography has been identified as a factor in elk habitat use and vulnerability. Edge and Marcum (1991) found that topography influenced elk distribution relative to human disturbance. Unsworth et al. (1993) identified topography as a factor in elk vulnerability in north-central Idaho.

Vegetative Cover

Vegetative cover did not appear to influence the movements or survival of yearling bulls. Elk that survived the general season used areas with a greater proportion of seedling\clearcut timber stands than harvested elk, but this difference may be an artifact of the small sample, rather than a causal relationship. Although many elk management guidelines rely on vegetation to provide security cover for elk (Thomas et al. 1979, Lyon 1979, Lyon et al. 1985), the relationship between cover types and elk vulnerability remains largely unresolved (Lyon and Canfield 1991, Unsworth et al. 1993). Lyon and Canfield (1991) reported that large connected blocks of homogeneous canopy cover contributed positively to survival.

Roads

Roads contribute to increased elk vulnerability primarily by providing access to hunters. Although Basile and Lonner (1979) reported that densities of roads open to hunters influence elk behavior and survival, I was unable to identify a clear relationship between road densities and survival or behavior for my study area. All yearlings located on opening day more than 2 km from an open road survived the general season. This supports the hypothesis

that roads negatively impact survival. However, yearlings which were located in areas with the greatest total road densities also tended to survive the general season. For example, 91% of the 11 yearling bulls located in areas with greater than 1.4 km of roads per km² (all roads) on opening day survived the general season. Road densities were a poor predictor of either survival or behavior within the study area.

Elk react to people, not roads (Basile and Lonner 1979). In 1991 and 1992, some elk remained on their summer range despite high open road densities, while other elk abandoned areas with relatively low open road densities. Other investigators found that reductions in open road densities can increase or decrease elk vulnerability (Basile Lonner 1979, Hillis et.al. 1991). Elk which moved into lower road density areas did not necessarily move into an area with lower hunter densities since road densities and hunter densities were not correlated within the study area. This was especially the case in Unit 60 where the highest hunter densities occurred in the BBR area, the subunit with the lowest open road densities. Current road densities within Unit 60 area appear to exceed that level where hunter densities are influenced by road densities.

Hunter Densities

Hunter densities in areas occupied by harvested elk were greater than hunter densities in areas occupied by elk that survived the general season. Hunter densities were the dominant factor in elk vulnerability in north-east Oregon (Vales et al. 1991). Both hunter densities and road densities were much higher in the north-east Oregon study than hunter densities (hunter/km²) and road densities in my study area during 1991-1992.

Hunter Perceptions

Although I did not conduct a formal survey, the method of hunting appeared to vary among the management units and subunits. Hunters tended to be reluctant to leave vehicles in heavily roaded areas. This allowed elk to survive in areas with low relief, that were near heavily traveled roads, and that had been highly modified by timber management practices. The survival of these elk does not fit conventional wisdom. Habitat conditions and hunter density measurements were not sufficient to determine why these elk survived while others in "better" habitats did not. Because hunters did not perceive these areas as suitable elk habitat, they simply drove past legal bulls. Conversely, elk within Unit 60 which used areas with low

open road densities and a low proportion of seedling\ clearcut timber stands were especially vulnerable to hunters because hunters concentrated effort on areas with low open road densities and good security cover.

Season Length and Mortality

The influence of season length on vulnerability was not adequately identified in my study. Mortality of radio-marked yearlings did not increase significantly in 1992 with a 31% increase in hunter numbers, and a doubling of season length. Telephone survey harvest data, however, indicated that antlered elk harvest in the Sand Creek herd in 1992 was nearly double the antlered harvest in 1991. Additional data on a wider range of season lengths and hunter densities would be necessary to resolve this ambiguity.

Distribution and Fate of 2-Year-Old Bulls

Those bulls that are saved by the spike-only regulation are not necessarily available to Idaho hunters in the future. In 1992 the annual mortality rate of 2-year-old bulls, which could not be legally harvested during the general season, in the Sand Creek herd was 11-28%. Bull elk are still subject to mortality in the absence of legal hunting. DeSimone and Vore (1992) reported a 29% annual

mortality rate for radio-marked bulls 2-years-old and older in the Elkhorn Mountains. Legal harvest accounted for 45% of this mortality. This is considerably higher than the annual mortality rate reported by Houston (1982) of 1.2-1.5% for bulls 2-4 years old in the northern Yellowstone elk herd.

Six percent of the bulls that survived the 1991 general season moved into Montana and Wyoming in 1992. Tagging records indicate that this is not unusual since similar proportion (4%) of the bulls marked on the Sand Creek Winter range from 1949-1992 were harvested in either Wyoming or Montana. In the Elkhorn Mountains, under a spike-only regulation, 5% of the radio-marked bulls moved into another area (DeSimone and Vore 1992).

Distribution Changes Over Time

If the distribution of radio-marked yearling bulls in this and 2 previous studies (Brown 1985, Pauley 1991) were representative of the distribution of the elk population at the time the studies were conducted, a major population shift occurred between 1987 and 1991. Elk use of Unit 62A and Unit 61 east of Highway 20 appears to have decreased. Both Brown (1985) and Pauley (1991) reported that over 20% of the elk captured and radio-collared on the Sand Creek winter range summered in this area. In 1991-1992, 2% of the

yearling bulls summered in this area. Telephone harvest data also support this trend. Since the mid 1980's, both hunter numbers and antlered elk harvest have declined in Unit 62A.

Elk use of Unit 60, especially the BBR area, appears to have increased since the mid 1980's. This could be due to changes in road management within these areas. Basile and Lonner (1979) reported that the implementation of motorized vehicle travel restrictions caused elk to remain in areas they would otherwise have abandoned during the hunting season. Road densities within the BBR area were higher than any other subunit of Unit 60 prior to the change in access management. The density of roads open to motorized vehicles was lower than the other subunits during the 1991 and 1992 general seasons.

MANAGEMENT IMPLICATIONS

The spike-only regulation was successful in increasing bull elk survival in the Sand Creek study area, however application of this regulation to other areas may not produce a similar increase in bull survival. Refuge areas and the decrease in hunter numbers contributed substantially to bull survival in the Sand Creek area under the spike-only regulation.

Implementation of the spike-only regulation in the Sand Creek area resulted in increased hunter participation in nearby any-antlered bull Idaho Fish and Game big game management units. However, implementation of the spike-only regulation in areas where hunters are restricted by permits may decrease hunting pressure in neighboring any-antlered bull units.

Both land management decisions and hunting regulations influence the ability of bull elk to remain and survive in areas open to hunting during the general season. Maintaining areas in which bull elk vulnerability is low through restrictive hunting regulations may encourage road building and timber harvest on lands managed by federal and state agencies. Creating areas where bull elk remain despite high levels of roading and timber harvest may facilitate elk harvest by tribal members. Despite the reduction in hunter numbers under the spike-only regulation,

some elk responded to hunting pressure by moving into refuge areas.

Although some points of my study area had relatively low road density and high availability of cover, elk mortality in these areas was high. This was at least partially due to road availability and timber harvest in adjacent areas. Elk inhabiting areas with low road densities and moderate levels of timber harvest may be subject to high mortality and hunting pressure where the surrounding area has been subjected to intensive road building and timber harvest. Land management practices that result in a more even distribution of both elk and hunters throughout the study area may reduce the tendency of elk to abandon their summer range during the general season.

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APPENDICES

APPENDIX A

APPENDIX TABLES

Table 8. Mortality Causes of radio-collared elk, 1991-1992

	Radio	Ear Tag	Status Change	Mortality Agent
1	150.070	US 872	10/10/91	General Hunt
2	150.571	US 868	10/10/91	General Hunt
3	150.671	US 864	10/10/91	General Hunt
4	151.121	US 861	10/10/91	General Hunt
5	151.261	US 776	10/10/91	General Hunt
6	151.470	US 780	10/10/91	General Hunt
7	151.511	US 778	10/10/91	General Hunt
8	150.101	US 911	10/10/92	General Hunt
9	150.190	US 1043	10/10/92	General Hunt
10	150.201	US 928	10/10/92	General Hunt
11	150.360	US 1003	10/11/92	General Hunt
12	150.612	US 933	10/10/92	General Hunt
13	151.411	US 923	10/10/92	General Hunt
14	151.471	US 932	10/12/92	General Hunt
15	150.311	US 883	11/23/91	Controlled Hunt
16	151.411	US 784	11/02/91	Controlled Hunt
17	150.611	US 781	09/24/91	Archery Hunt WL
18	151.740	US 887	09/21/91	Archery Hunt
19	150.691	US 889	10/30/92	General Hunt MT
20	150.176	US 886	11/23/92	General Hunt MT
21	150.210	US 762	10/12/92	Illegal Mortality
22	150.122	US 861	07/09/91	Unknown Fate
23	150.030	US 951	12/23/91	Unknown Fate
24	150.541	US 874	12/23/91	Unknown Fate
25	151.081	US 977	10/14/91	Unknown Fate
26	151.271	US 871	12/23/91	Unknown Fate
27	150.291	US 925	10/08/92	Mortality Unknown Cause
28	150.790	US 958	09/04/91	Shoshone-Bannock Harvest
29	150.380	US 1051	09/--/92	Rifle Kill
30	150.571	US 1013	08/01/92	Rifle Kill
31	150.710	US 960	07/05/91	Cast Collar
32	150.710	US 1001	07/08/92	Vehicle Kill
33	151.010	US 980	02/02/93	Train Kill
34	150.370	US 1021	04/--/92	Winter Mortality
35	150.490	US 1068	04/--/92	Winter Mortality
36	150.740	US 1070	04/--/92	Winter Mortality
37	150.090	US 779	02/06/93	Translocated
38	151.071	US 977	02/06/93	Translocated
WL	Wounding loss			MT Montana

Table 9. Winter composition counts for Sand Creek elk herd

Year	Total Count	Bulls/ 100 Cows	Calves/ 100 Cows	Total Cows	Total Calves	Bulls Age			Total
						1.5	2.5	Adult	Bulls
1992	3679	68	44	1729	767	266	575	342	1183
1991	3049	56	43	1529	660	369	333	158	860
1990	2603	28	37	1459	542	146	103	160	409
1989	2979	19	34	1926	669	142	126	103	371
1988	2441	--	--	--	--	--	--	--	--
1987	2815	24	54	--	--	--	--	--	--
1986	2269	--	60	--	--	--	--	--	--
1985	2553	--	44	--	--	--	--	--	--
1984	1803	--	53	--	--	--	--	--	--
1983	2959	--	65	--	--	--	--	--	--
1982	2327	--	--	--	--	--	--	--	--
1981	2310	--	--	--	--	--	--	--	--
1980	-----	--	44	--	--	--	--	--	--
1979	1892	--	--	--	--	--	--	--	--
1978	1484	--	49	--	--	--	--	--	--
1977	-----	--	45	--	--	--	--	--	--
1976	-----	--	--	--	--	--	--	--	--
1975	1228	--	--	--	--	--	--	--	--
1974	-----	--	--	--	--	--	--	--	--
1973	-----	--	--	--	--	--	--	--	--
1972	-----	--	--	--	--	--	--	--	--
1971	908	--	--	--	--	--	--	--	--
1970	-----	--	--	--	--	--	--	--	--
1969	-----	--	--	--	--	--	--	--	--
1968	-----	--	--	--	--	--	--	--	--
1967	981	--	--	--	--	--	--	--	--
1966	-----	--	--	--	--	--	--	--	--
1965	-----	--	--	--	--	--	--	--	--
1964	-----	--	--	--	--	--	--	--	--
1963	823	--	--	--	--	--	--	--	--
1962	----	--	--	--	--	--	--	--	--
1961	----	--	--	--	--	--	--	--	--
1960	----	--	--	--	--	--	--	--	--
1959	539	--	--	--	--	--	--	--	--

* estimates for 1989-1991 include sightability index

* cow/calf ratio in 1963 and 1985-86 estimated from ground

Table 10. Locations and fate of radio-marked bulls which survived the 1991 hunting season

Radio	1991		1992 Locations						Status
	Activity	Center	7/10	8/3	8/13	10/12	10/20	11/27	
50010	YNP		*	YNP	*	*	*	WR	Alive
50040	YNP		*	YNP	*	*	*	*	Alive
50060	YNP		*	YNP	*	HSP	*	*	Alive
50591	YNP		*	YNP	*	*	*	WR	Alive
50622	YNP		*	YNP	*	*	*	*	Alive
51010	YNP		*	YNP	*	*	*	WR	Train kill
51451	YNP		*	YNP	YNP	*	*	WR	Alive
50050	HSP		*	HSP	*	*	*	*	Alive
50731	HSP		*	YNP	*	*	*	BBR	Alive
50851	HSP		*	BSH	*	*	*	*	Alive
51021	HSP		*	BSH	*	*	*	*	Alive
51080	HSP		*	*	*	*	*	*	Unknown
51651	HSP		*	HSP	*	*	*	*	Alive
51673	HSP		*	HSP	*	*	*	*	Alive
50090	BSH		*	BSH	*	*	CAMAS	*	Translocated
50210	BSH		*	BSH	*	*	GH-illegal kill	*	Alive
50476	BSH		*	CENT	*	*	*	*	Unknown
50541	BSH		*	*	*	*	*	*	Alive
50551	BSH		*	CENT	*	*	*	*	Alive
51071	BSH		*	HSP	*	*	BBR	*	Translocated
50691	BBR		*	*	*	*	MT	GH MT	Alive
51300	BBR		*	BBR	*	*	*	*	Alive
51361	BBR		*	BBR	*	*	*	*	Alive
50030	CENT		*	*	*	*	*	*	Unknown
50176	CENT		*	*	*	*	*	GH MT	Alive
50450	CENT		*	CENT	*	*	*	*	Alive
51001	CENT		*	CENT	*	*	*	*	Alive
51060	CENT		*	CENT	*	*	*	*	Alive
51271	CENT		*	*	*	*	*	*	Unknown
51381	CENT		CENT	CENT	*	*	*	*	Alive
51421	CENT		*	CENT	*	*	*	*	Alive
51441	CENT		*	CENT	*	*	*	*	Alive
50250	ATF		*	62A	*	*	*	WR	Alive
50580	ATF		*	HSP	*	*	*	*	Alive
51101	ATF		HSP	HSP	HSP	*	*	*	Alive
50020	62A		*	62A	*	*	*	WR	Alive

ATF Antelope Flat
 BSH Bishop Mountain
 BBR Big Bend Ridge
 CENT Centennial Range
 CAMAS Camas Creek Wildlife Refuge
 GH MT General Hunt, Montana

HSP Harriman State Park
 Translocated 1993
 YNP Yellowstone National Park
 WR Winter Range
 * No location
 62A Unit 62A

Table 11. Summer-Fall home range of radio-collared yearling elk

Area	Radio	km ²	mi ²	Fixes	Area	Radio	km ²	mi ²	Fixes	
Y	50040	33.6	12.9	7	H	50050	11.5	4.5	10	
E	50060	21.9	8.5	5	A	50731	22.7	8.7	10	
L	50311	43.7	16.9	4	R	50851	4.3	1.7	9	
L	50591	52.2	20.1	5	R	51021	2.3	0.9	8	
O	50622	9.9	3.8	5	I	51080	6.2	2.4	9	
W	51010	64.8	25.0	6	M	51651	2.3	0.9	8	
S	51411	8.7	3.4	5	A	51673	4.9	1.9	9	
T	51451	64.3	24.8	6	N	50140	11.4	4.4	9	
O	51121	7.3	2.8	7		50311	12.1	4.7	9	
N	51261	5.3	2.0	8		50671	11.6	4.5	9	
E						50930	10.1	3.9	9	
	Average	31.7	12.2	6		51511	8.4	3.3	9	
						Average	9.8	3.8	9	
B	50090	7.1	2.7	9		50030	32.1	12.4	11	
I	50210	15.2	5.9	10	C	50176	11.8	4.6	11	
S	50476	9.6	3.7	9	E	50450	10.1	3.9	9	
H	50541	44.3	17.1	9	N	50612	11.4	4.4	5	
O	50551	10.0	3.8	9	T	51001	33.4	12.9	10	
P	50790	12.8	4.9	4	E	51060	13.2	5.1	10	
	51071	5.9	2.3	8	N	51271	31.1	12.0	5	
	51511	25.2	9.7	7	N	51381	35.6	13.7	10	
	50110	31.9	12.3	8	I	51421	27.2	10.5	10	
	50340	42.7	16.5	9	A	51441	40.6	15.7	11	
	50350	43.0	16.6	9	L	51471	7.6	2.9	5	
	50360	8.1	3.1	5	A	51740	12.5	4.8	4	
	50511	76.8	29.7	9	N	50190	2.1	0.8	5	
	50612	10.8	4.1	6	G	50219	20.8	8.0	9	
	50790	55.0	21.2	10	E	51641	40.0	15.4	8	
	51050	12.7	4.9	9		Average	22.0	8.5	8	
	Average	25.7	9.9	8						
A	50250	47.3	18.3	9		50070	3.5	1.3	6	
N	50580	252.2	97.4	6	B	50570	15.2	5.9	6	
T	51101	67.3	26.0	10	I	50670	33.7	13.0	8	
E	50241	13.0	5.0	9	G	50691	20.7	8.0	8	
L	50261	35.9	13.8	10	B	51121	45.3	17.5	6	
O	50280	32.1	12.4	9	E	51261	15.4	6.0	7	
P	50300	40.0	15.5	10	N	51300	11.9	4.6	10	
E	50331	23.9	9.2	9	D	51361	8.9	3.4	9	
	51471	93.8	36.2	8		R	50101	33.5	12.9	6
	Average	67.3	26.0	9		I	50201	14.4	5.6	6
						D	50231	128.2	49.5	9
62A	50020	31.7	12.2	8		G	50291	22.6	8.7	4
	50391	42.4	16.4	8		E	51411	9.5	3.7	7
	Average	37.1	14.3	8		Average	27.9	10.8	8	

Table 12. Locations of radio-marked yearling elk using Harriman State Park (HSP), 1991-1992

91 MAY 31	JULY 09	AUG 08	AUG 22	SEPT 12	SEPT 26	OCT 8	OCT 10	OCT 12	OCT 14	OCT 18	OCT 20	
150.050	150.050	150.050	150.050	150.050	150.050	150.050	150.050	150.050	150.050	*	*	
150.210	150.210	150.210	150.210	BSH	BSH	BSH	BSH	BSH	150.210	*	*	
WR	150.250	150.250	150.250	150.250	ATF	ATF	ATF	ATF	ATF	*	*	
WR	BBR	150.551	BSH	BSH	BSH	BSH	BSH	BSH	BSH	*	*	
150.581	150.581	150.581	ATF	ATF	ATF	ATF	ATF	150.581	ATF	*	*	
BBR	150.710	Cast Collar										
150.731	150.731	150.731	150.731	150.731	150.731	150.731	150.731	150.731	150.731	*	*	
WR	150.851	150.851	150.851	BSH	BSH	BSH	150.851	150.851	BSH	*	*	
ATF	ATF	ATF	ATF	ATF	ATF	151.101	ATF	ATF	62A	*	*	
WR	*	151.021	151.021	151.021	151.021	151.021	151.021	151.021	151.021	*	*	
WR	151.080	151.080	151.080	151.080	151.080	151.080	151.080	151.080	151.080			
*	*	151.651	151.651	151.651	151.651	151.651	151.651	151.651	151.651	*	*	
151.673	151.673	151.673	151.673	151.673	151.673	151.673	151.673	151.673	151.673	*	*	

92 MAY 27	JULY 10	AUG 13	*	*	SEPT 21	OCT 9	OCT 10	OCT 12	OCT 15	OCT 18	OCT 20
BBR	150.140	150.140	*	*	150.140	150.140	150.140	150.140	150.140	150.140	150.140
150.261	150.261	150.261	*	*	ATF	ATF	ATF	ATF	ATF	150.261	150.261
BBR	ATF	ATF	*	*	ATF	ATF	BBR	150.280	150.280	150.280	150.280
150.300	150.300	150.300	*	*	ATF	ATF	ATF	ATF	150.300	150.300	150.300
WR	150.311	150.311	*	*	150.311	150.311	150.311	150.311	150.311	150.311	150.311
BBR	150.331	150.331	*	*	ATF	ATF	ATF	ATF	ATF	ATF	ATF
BBR	150.571	150.571M									
BBR	150.671	150.671	*	*	150.671	150.671	150.671	150.671	150.671	150.671	150.671
WR	150.930	150.930	*	*	150.930	150.930	150.930	150.930	150.930	150.930	150.930
ATF	ATF	ATF	*	*	ATF	ATF	ATF	151.471M			
BBR	151.511	151.511	*	*	151.511	151.511	151.511	151.511	151.511	151.511	151.511

Elk was located in (ATF) Antelope Flat Area
 Elk was located in (BBR) Big Bend Ridge Area
 Elk was located in (BSH) Bishop Mountain Area
 Elk was located on (WR) Winter Range
 * Elk was not located
 M Mortality

Table 13. Locations of radio-marked yearling elk using the Bishop Mountain area (BSH), 1991-1992

91 MAY 31	JULY 09	AUG 08	AUG 22	SEPT 12	SEPT 26	OCT 8	OCT 10	OCT 12	OCT 14	OCT 18	OCT 20
ATF	BBR	150.090	150.090	150.090	150.090	150.090	150.090	ATF	*	*	*
HSP	HSP	HSP	HSP	150.210	150.210	150.210	150.210	150.210	HSP	*	*
WR	150.476	150.476	150.476	150.476	150.476	150.476	150.476	150.476	150.476	*	*
150.541	150.541	150.541	150.541	150.541	150.541	150.541	150.541	150.541	150.541	*	*
WR	150.551	HSP	150.551	150.551	150.551	150.551	150.551	150.551	150.551	*	*
ATF	BBR	150.671	BBR	BBR	BBR	BBR	BBR				
150.790	150.790	150.790	150.790M								
WR	HSP	HSP	HSP	150.851	150.851	150.851	HSP	HSP	150.851	*	*
WR	151.071	151.071	151.071	151.071	151.071	151.071	151.071	151.071	151.071	*	*
WR	151.471	151.471	CENT	CENT	CENT	CENT	MT				
WR	151.511	151.511	151.511	151.511	151.511	151.511	151.511M				
92 MAY 27	JULY 10	AUG 13	*	*	SEPT 21	OCT 9	OCT 10	OCT 12	OCT 15	OCT 18	OCT 20
BBR	150.101	150.101	*	*	BBR	BBR	BBR				
WR	150.110	150.110	*	*	150.110	150.110	150.110	150.110	150.110	150.110	150.110
BBR	BBR	BBR	*	*	BBR	BBR	BBR	BBR	150.231	150.231	150.231
150.340	150.340	150.340	*	*	150.340	150.340	150.340	150.340	150.340	150.340	150.340
WR	150.350	150.350	*	*	150.350	150.350	150.350	CENT	150.350	150.350	150.350
WR	150.360	150.360	*	*	150.360	150.360	ATF				
150.511	150.511	150.511	*	*	150.511	150.511	150.511	150.511	CENT	CENT	CENT
150.612	150.612	150.612	*	*	150.612	150.612	150.612M				
150.790	150.790	150.790	*	*	150.790	150.790	150.790	150.790	CENT	CENT	MT
WR	151.050	151.050	*	*	151.050	151.050	151.050	151.050	151.050	151.050	151.050

Elk was located in (ATF) Antelope Flat Area
 Elk was located in (BBR) Big Bend Ridge Area
 Elk was located in (BSH) Bishop Mountain Area
 Elk was located in (CENT) Centennial Range
 Elk was located in (HSP) Harriman Park
 Elk was located on (WR) Winter Range
 M Mortality
 * Elk was not located

Table 14. Locations of Radio-marked yearling elk using the Big Bend Ridge (BBR) area, 1991-1992

91 MAY 31	JULY 09	AUG 08	AUG 22	SEPT 12	SEPT 26	OCT 8	OCT 10	OCT 12	OCT 14	OCT 18	OCT 20
150.070	150.070	150.070	150.070	150.070	150.070	150.070	150.070M				
ATF	150.090	BSH	BSH	BSH	BSH	BSH	BSH	ATF	*	*	*
ATF	150.572	ATF	ATF	150.572	150.572	150.572	150.572M				
ATF	150.671	BSH	150.671	150.671	150.671	150.671	150.671M				
150.691	150.691	150.691	150.691	150.691	150.691	150.691	150.691	ATF	*	*	*
ATF	ATF	ATF	ATF	ATF	151.101	151.101	ATF	ATF	62A	*	*
151.121	151.121	151.121	151.121	151.121	151.121	151.121	151.121M				
151.261	151.261	151.261	151.261	151.261	151.261	151.261	151.261M				
151.300	151.300	151.300	151.300	151.300	151.300	151.300	151.300	151.300	151.300	*	*
151.361	151.361	151.361	151.361	151.361	151.361	151.361	151.361	151.361	151.361	*	*
92 MAY 27	JULY 10	AUG 13	*	*	SEPT 21	OCT 9	OCT 10	OCT 12	OCT 15	OCT 18	OCT 20
150.101	BSH	BSH	*	*	150.101	150.101	150.101M				
150.140	HSP	HSP	*	*	HSP	HSP	HSP	HSP	HSP	HSP	HSP
150.201	150.201	150.201	*	*	150.201	150.201	150.201M				
150.231	150.231	150.231	*	*	150.231	150.231	150.231	150.231	BSH	BSH	BSH
150.241	ATF	ATF	*	*	ATF	ATF	ATF	ATF	ATF	ATF	ATF
150.280	ATF	ATF	*	*	ATF	ATF	150.280	HSP	HSP	HSP	HSP
WR	WR	150.291	*	*	150.291M						
150.331	HSP	HSP	*	*	ATF	ATF	ATF	ATF	ATF	ATF	ATF
150.380M											
151.411	151.411	151.411	*	*	151.411	151.411	151.411M				
ATF	ATF	ATF	*	*	ATF	ATF	ATF	151.471M			

Elk was located in (ATF) Antelope Flat Area
 Elk was located in (BBR) Big Bend Ridge Area
 Elk was located in (BSH) Bishop Mountain Area
 Elk was located in (CENT) Centennial Range
 Elk was located in (HSP) Harriman Park
 Elk was located on (WR) Winter Range
 M Mortality
 * Elk was not located

Table 15. Locations of radio-marked yearling elk using the Antelope Flat (ATF) area, 1991-1992

91 MAY 31	JULY 09	AUG 08	AUG 22	SEPT 12	SEPT 26	OCT 8	OCT 10	OCT 12	OCT 14	OCT 18	OCT 20
150.090	BBR	BSH	BSH	BSH	BSH	BSH	BSH	150.090	*	*	*
WR	HSP	HSP	HSP	HSP	150.251	150.251	150.251	150.251	150.251	*	*
WR	BBR	150.572	150.572	BBR	BBR	BBR	BBR				
HSP	HSP	HSP	150.581	150.581	150.581	150.581	150.581	HSP	150.581	*	*
150.671	BBR	BSH	BBR	BBR	BBR	BBR	BBR				
BBR	BBR	BBR	BBR	BBR	BBR	BBR	BBR	150.691	*	*	*
151.101	151.101	151.101	151.101	151.101	151.101	HSP	151.101	151.101	62A	*	*
151.300	BBR	BBR	BBR	BBR	BBR	BBR	BBR	BBR	BBR	*	*
151.381	MT	MT	MT	MT	CENT	CENT	CENT	CENT	CENT	*	*
92 MAY 27	JULY 10	AUG 13	*	*	SEPT 21	OCT 9	OCT 10	OCT 12	OCT 15	OCT 18	OCT 20
BBR	150.241	150.241	*	*	150.241	150.241	150.241	150.241	150.241	150.241	150.241
HSP	HSP	HSP	*	*	150.261	150.261	150.261	150.261	150.261	HSP	HSP
BBR	150.280	150.280	*	*	150.280	150.280	BBR	HSP	HSP	HSP	HSP
HSP	HSP	HSP	*	*	150.300	150.300	150.300	150.300	HSP	HSP	HSP
BBR	HSP	HSP	*	*	150.331	150.331	150.331	150.331	150.331	150.331	150.331
WR	BSH	BSH	*	*	BSH	BSH	150.360M				
151.471	151.471	151.471	*	*	151.471	151.471	151.471	HSP			

Elk was located in (ATF) Antelope Flat Area
 Elk was located in (BBR) Big Bend Ridge Area
 Elk was located in (BSH) Bishop Mountain Area
 Elk was located in (CENT) Centennial Range
 Elk was located in (HSP) Harriman Park
 Elk was located on (WR) Winter Range
 M Mortality
 * Elk was not located

Table 16. Locations of radio-marked yearling elk using big game management Unit 62A, 1991-1992

91 MAY 31	JULY 09	AUG 08	AUG 22	SEPT 12	SEPT 26	OCT 8	OCT 10	OCT 12	OCT 14	OCT 16	OCT 20
150.020	*	150.020	150.020	150.020	150.020	150.020	150.020	150.020	150.020	*	*
150.060	YNP	*	YNP	YNP	YNP	YNP	YNP	YNP	YNP	YNP	*
*	150.122	*	*	*	*	*	*	*	*	*	*
150.311	150.311	*	YNP	YNP	YNP	YNP	YNP	YNP	YNP	YNP	*
150.622	*	*	YNP	YNP	YNP	YNP	YNP	YNP	YNP	YNP	*
ATF	ATF	ATF	ATF	ATF	BBR	BBR	ATF	ATF	151.101	*	*
92 MAY 27	JULY 10	AUG 13	*	*	SEPT 21	OCT 9	OCT 10	OCT 12	OCT 15	OCT 18	OCT 20
*	150.391	150.391	*	*	150.391	150.391	150.391	150.391	*	150.391	150.391

Elk was located in (ATF) Antelope Flat Area
 Elk was located in (BBR) Big Bend Ridge Area
 Elk was located in (BSH) Bishop Mountain Area
 Elk was located in (CENT) Centennial Range
 Elk was located in (HSP) Harriman Park
 Elk was located in (YNP) Yellowstone Park
 Elk was located on (WR) Winter Range
 M Mortality
 * Elk was not located

Table 17. Locations of radio-marked yearlings using the Centennial Mountains (CENT), 1991-1992

91 MAY 31	JULY 09	AUG 08	AUG 22	SEPT 12	SEPT 26	OCT 8	OCT 10	OCT 12	OCT 14	OCT 16	OCT 20
150.030	150.030	150.030	150.030	150.030	150.030	150.030	150.030	150.030	150.030	150.030	*
150.176	150.176	150.176	150.176	150.176	MT	MT	MT	150.176	150.176	150.176	*
150.450	MT	MT	MT	MT	MT	MT	MT	MT	MT	MT	*
WR	150.612	150.612	150.612	150.612	150.612M						
151.001	151.001	MT	151.001	151.001	151.001	151.001	151.001	151.001	151.001	151.001	*
*	151.060	151.060	MT	151.060	151.060	151.060	151.060	151.060	151.060	151.060	*
151.270	MT	MT	MT	MT	MT	151.270	151.270	MT	MT	MT	*
ATF	MT	MT	MT	MT	151.381	151.381	151.381	151.381	151.381	151.381	*
151.421	151.421	151.421	151.421	151.421	151.421	151.421	151.421	151.421	151.421	151.421	*
151.441	151.441	151.441	151.441	MT	MT	MT	MT	MT	MT	MT	*
WR	BSH	BSH	151.471	151.471	151.471	151.471	MT				
151.740	151.740	151.740	151.740	151.740M							
92 MAY 27	JULY 10	AUG 13	*	*	SEPT 21	OCT 9	OCT 10	OCT 12	OCT 15	OCT 18	OCT 20
WR	150.190	150.190	*	*	150.190	150.190	150.190M				
WR	150.219	MT	*	*	150.219	150.219	150.219	150.219	150.219	150.219	150.219
WR	BSH	BSH	*	*	BSH	BSH	BSH	150.350	BSH	BSH	BSH
BSH	BSH	BSH	*	*	BSH	BSH	BSH	150.790	150.790	150.790	MT
BSH	BSH	BSH	*	*	BSH	BSH	BSH	BSH	150.511	150.511	150.511
WR	151.641	151.641	*	*	151.641	151.641	151.641	151.641	MT	MT	151.641

Elk was located in (ATF) Antelope Flat Area
 Elk was located in (BBR) Big Bend Ridge Area
 Elk was located in (BSH) Bishop Mountain Area
 Elk was located in (CENT) Centennial Range
 Elk was located in (HSP) Harriman Park
 Elk was located in (MT) Montana
 Elk was located on (WR) Winter Range
 M Mortality
 * Elk was not located

Table 18. Locations of radio-marked yearlings using Yellowstone Park (YNP), 1991-1992

91 MAY 31	JULY 09	AUG 08	AUG 22	SEPT 12	SEPT 26	OCT 8	OCT 10	OCT 12	OCT 14	OCT 16	OCT 20
Two Top	Two Top	*	*	150.010	150.010	150.010	*	*	*	*	*
Two Top	Two Top	*	150.040	150.040	150.040	Two Top	150.040	*	*	Two Top	*
62A	150.060	*	150.060	150.060	150.060	150.060	*	*	*	*	*
62A	150.311	*	150.311	150.311	150.311	150.311M	*	*	*	*	*
*	150.591	*	150.591	150.591	150.591	150.591	*	*	*	*	*
62A	*	*	150.622	150.622	150.622	150.622	*	*	*	150.622	*
Two Top	MT	*	151.010	151.010	151.010	151.010	*	*	*	151.010	*
*	*	*	151.410	151.410	151.410	151.410	*	151.410M	*	*	*
*	151.451	*	151.451	151.451	151.451	151.451	*	*	*	151.451	*
92 MAY 27	JULY 10	AUG 13	*	*	SEPT 21	OCT 9	OCT 10	OCT 12	OCT 15	OCT 18	OCT 20
*	151.121	*	*	*	151.121	151.121	151.121	151.121	*	151.121	151.121
WR	151.261	151.261	*	*	151.261	151.261	151.261	151.261	*	151.261	151.261

Elk was located in (ATF) Antelope Flat Area
 Elk was located in (BBR) Big Bend Ridge Area
 Elk was located in (BSH) Bishop Mountain Area
 Elk was located on (Two Top) Two Top Mountain
 Elk was located in (MT) Montana
 Elk was located on (WR) Winter Range
 M Mortality
 * Elk was not located

Table 19. Location, sex, and age of elk marked on the Sand Creek Winter Range and harvested in either Montana and Wyoming, 1949-1992

	Kill Location	Age Male	Age Female	Year Marked	Year Killed
1	Blacktail Cr		Adult	1949	1950
2	Cherry Cr		calf	1950	1954
3	Unknown, MT		Adult	1950	1962
4	Horse Canyon	year		1950	1953
5	West Yellowstone	calf		1952	1955
6	Mile Creek	calf		1954	1959
7	Hellroaring Cr	year		1959	1964
8	Ledford Cr	calf		1960	1961
9	Fridley Cr		calf	1960	1964
10	Ruby River	year		1964	unknown
11	Elk Mtn	calf		1985	1985
12	Odell Cr	Adult		1987	1992
13	Odell Cr	Adult		1987	1987
14	Blacktail Cr		calf	1991	1992
15	Meadow Cr	calf		1991	1992
16	Timber Cr	calf		1991	1992
17	Teton County, WY		calf	1968	1969
18	Huckleberry Sp, WY	calf		1981	1984
19	Hominy Peak, WY	calf		1987	1988

Table 20. Classification of cover types from USDA Targhee Forest Service digital database

USFS Code	Vegetation Type	Cover Class
1DF6	Douglas Fir Seedling Stand	Seedling\Clearcut
1DF9	Douglas Fir Mature Stand	Mature Stand
AS5	Aspen Cut	Seedling\Clearcut
AS6	Aspen Seedling Stand	Seedling\Clearcut
AS7	Aspen Sapling Stand	Sapling\Polestand
AS8	Aspen Polestand	Sapling\Polestand
AS9	Aspen Mature Stand	Mature Stand
BLP9	Lodgepole Pine Burned	Open\Grasslands
DF5	Douglas Fir Cut	Seedling\Clearcut
DF6	Douglas Fir Seedling Stand	Seedling\Clearcut
DF7	Douglas Fir Sapling Stand	Sapling\Polestand
DF8	Douglas Fir Polestand	Sapling\Polestand
DF9	Douglas Fir Mature Stand	Mature Stand
FILL	Unclassified	Unclassified
GR	Grass	Open\Grasslands
GRB	Grass Brush	Open\Grasslands
GRF	Grass Forb	Open\Grasslands
GRS	Grass Sagebrush	Open\Grasslands
LP5	Lodgepole Pine Cut	Seedling\Clearcut
LP6	Lodgepole Pine Seedling Stand	Seedling\Clearcut
LP7	Lodgepole Pine Sapling Stand	Sapling\Polestand
LP8	Lodgepole Pine Polestand	Sapling\Polestand
LP9	Lodgepole Pine Mature Stand	Mature Stand
MB	Mountain Brush	Tall Shrublands
MX35	Mixed Conifer Cut	Seedling\Clearcut
MX36	Mixed Conifer Seedling Stand	Seedling\Clearcut
MX37	Mixed Conifer Sapling Stand	Sapling\Polestand
MX38	Mixed Conifer Polestand	Sapling\Polestand
MX39	Mixed Conifer Mature Stand	Mature Stand
MX5	Mixed Conifer Cut	Seedling\Clearcut
MX6	Mixed Conifer Seedling Stand	Seedling\Clearcut
MX7	Mixed Conifer Sapling Stand	Sapling\Polestand
MX8	Mixed Conifer Polestand	Sapling\Polestand
MX9	Mixed Conifer Mature Stand	Mature Stand
NAS9	Aspen Mature Stand	Mature Stand
NDF9	Douglas Fir Mature Stand	Mature Stand
NLP9	Lodgepole Pine Mature Stand	Mature Stand
NMX	Mixed Conifer Noncommercial	Mature Stand
NUS	NOT USFS	Unclassified
R	Rock	Open\Grasslands
SF6	Spruce Fir Seedling Stand	Seedling\Clearcut
SF7	Spruce Fir Sapling Stand	Seedling\Clearcut
SF8	Spruce Fir Polestand	Sapling\Polestand
SF9	Spruce Fir Mature Stand	Mature Stand
TSG	Tall Sagebrush	Tall Shrublands
TSM	Tall Sagebrush	Tall Shrublands
WA	Water	Open\Grasslands
WB9	Whitebark Pine	Mature Stand

APPENDIX B

APPENDIX FIGURES



Figure 10. Road map produced from USDA Targhee National Forest digital database (unpublished data, 1993) for the Sand Creek elk herd Study area.

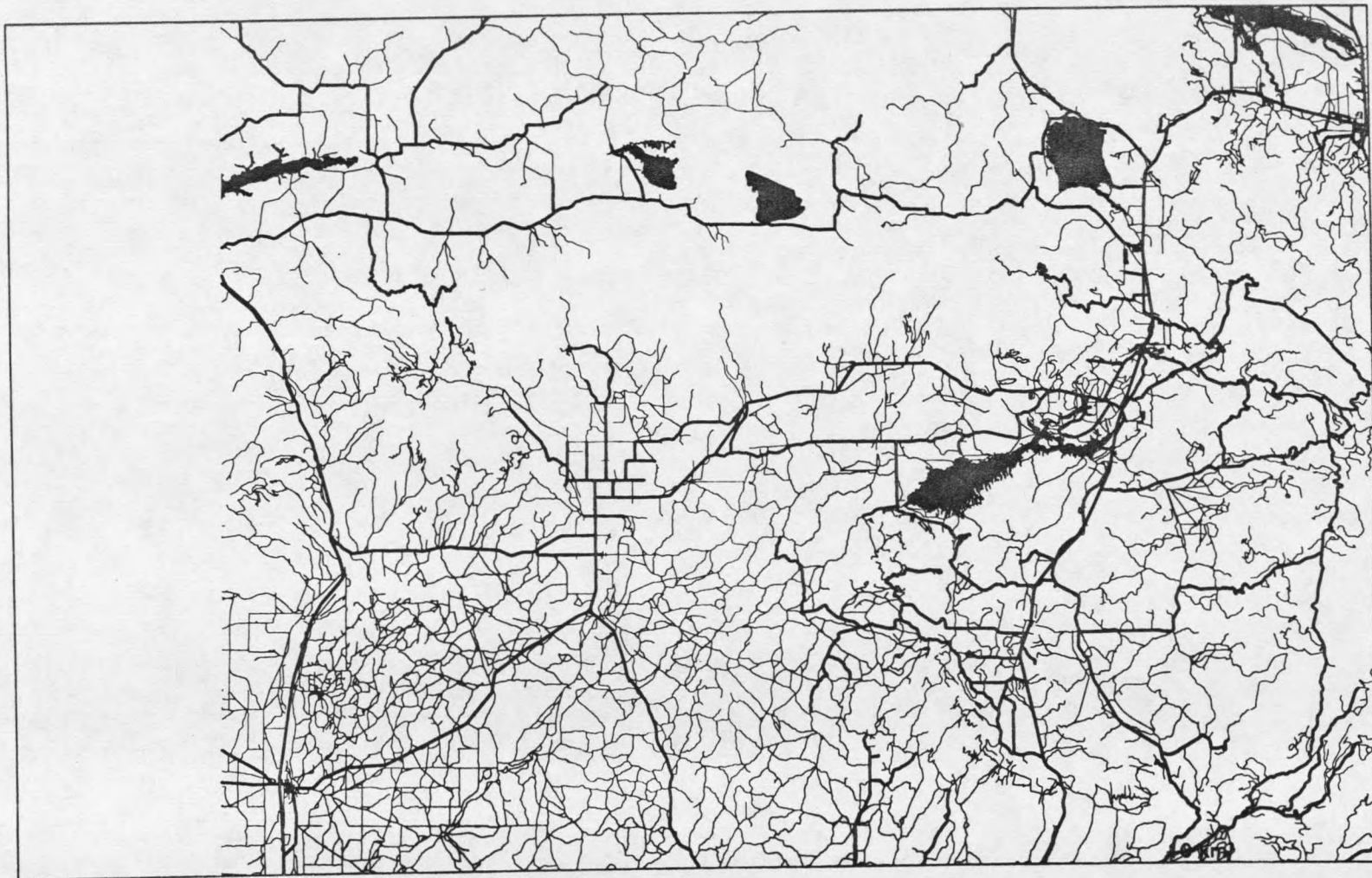


Figure 11. Road map produced from the TIGER (1990) database for the Sand Creek elk herd study area.

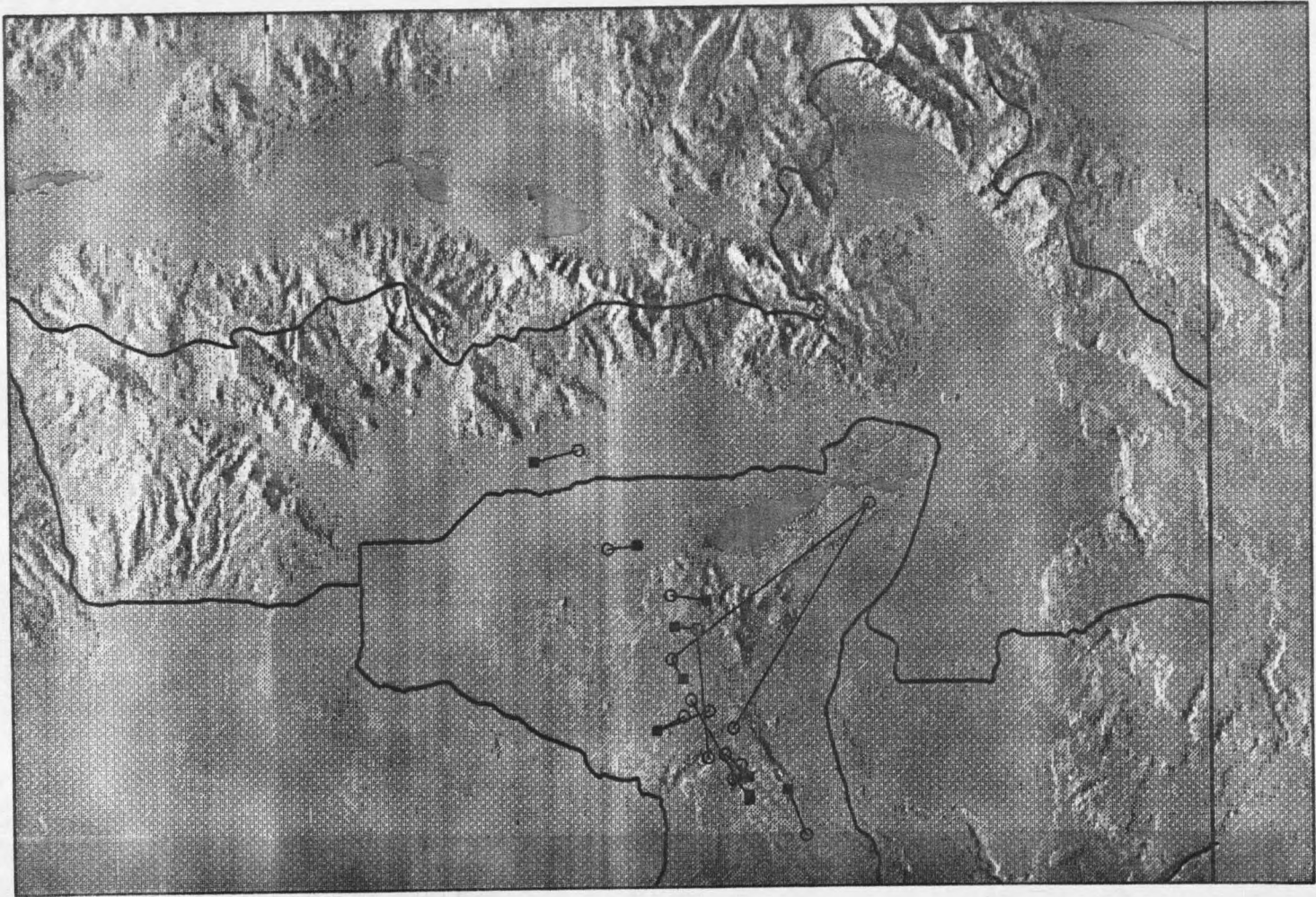


Figure 12. Movements of yearling bulls that were harvested during the general season 1991 and 1992. A ■ indicates location prior to the general season.

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