Responses of elk to a 500 kV transmission line on the North Boulder winter range, Montana
by Gerald Patrick Nelson

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

Abstract:
This study was an attempt to determine the effects that a 500 kV powerline had on a wintering population of elk in southwestern Montana. The positioning of the powerline corridor separated important security and thermal cover from open grassland feeding areas. Track surveys of corridor crossings by elk were used to determine any "turnback behavior" as a result of the powerline. Seven 24-hour telemetry sessions were conducted during the winter of 1984-85. Home ranges for 10 of the 13 elk wearing operating radio-collars could be computed and plotted for one or more of the 24-hour sessions. Visual observations and pellet group surveys were used to augment the other methods used in the study. No "turnback behavior" was detected from monitoring the track surveys. The absence of corridor crossings shortly after precipitation was observed twice. The absence of corridor crossings with no prior precipitation (4 days) was observed once. Telemetry and pellet group surveys showed the importance of open grasslands as feeding areas and timbered, areas as security and thermal cover. The majority of the feeding areas were south of the powerline, and the majority of the security cover was north. Visual observations helped ascertain the importance of travel avenues between bedding and feeding areas, especially during deep and drifting snow conditions. Elk displayed an alarm response while crossing the corridor on 3 occasions. In January of 1985 a crossing of the power line corridor during a snowstorm by a group of at least 14 elk was documented. Any hindrances or modifications of the elk populations use of the winter range could not be conclusively confirmed by any of the methods used in this study. It appears that the North Boulder elk herd uses all the winter range habitat available at this time.

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APPROVAL

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Gerald Patrick Nelson

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

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ABSTRACT

This study was an attempt to determine the effects that a 500 kV powerline had on a wintering population of elk in southwestern Montana. The positioning of the powerline corridor separated important security and thermal cover from open grassland feeding areas. Track surveys of corridor crossings by elk were used to determine any "turnback behavior" as a result of the powerline. Seven 24-hour telemetry sessions were conducted during the winter of 1984-85. Home ranges for 10 of the 13 elk wearing operating radio-collars could be computed and plotted for one or more of the 24-hour sessions. Visual observations and pellet group surveys were used to augment the other methods used in the study. No "turnback behavior" was detected from monitoring the track surveys. The absence of corridor crossings shortly after precipitation was observed twice. The absence of corridor crossings with no prior precipitation (4 days) was observed once. Telemetry and pellet group surveys showed the importance of open grasslands as feeding areas and timbered areas as security and thermal cover. The majority of the feeding areas were south of the powerline, and the majority of the security cover was north. Visual observations helped ascertain the importance of travel avenues between bedding and feeding areas, especially during deep and drifting snow conditions. Elk displayed an alarm response while crossing the corridor on 3 occasions. In January of 1985 a crossing of the powerline corridor during a snowstorm by a group of at least 14 elk was documented. Any hindrances or modifications of the elk populations use of the winter range could not be conclusively confirmed by any of the methods used in this study. It appears that the North Boulder elk herd uses all the winter range habitat available at this time.

INTRODUCTION

The final stage of the "Colstrip Project" (Colstrip EIS 1979) was to construct a 500 kilovolt (kV) powerline to conduct electricity from coal-fired electrical generators in Eastern Montana to consumers in the Pacific Northwest. This alternating current (ac) transmission line passes through the North Boulder River big game winter range on the east side of the Continental Divide. In addition to supporting a wintering herd of 450 to 500 elk (Cervus elaphus nelsoni), this portion of Hunting District 318 also provides winter range for mule deer (Odocoileus hemionus) and moose (Alces alces shirasi). The powerline passes through this winter range in a location which separates the upper-slope areas of timbered security cover from the lower-slope areas of open grasslands which are important foraging areas for elk. Since winter range is considered a limiting factor for elk in most northern temperate climates (Proceedings of Western States Elk Workshop 1973), it is essential, from a management standpoint, to know what effects construction and electrification of such a transmission line would have on a wintering elk population.

The powerline towers and access roads were completed in 1982. The corridor was cleared and the conductors were strung and energized in 1983. This study was a continuation and completion of a project that began in December of 1982. The main objective of the study was to determine if the presence of the powerline had any effect on the elk population's use of the winter range. I began on the project in March 1984 and conducted my first full field season in the winter of 1984-85. Two prior field seasons, conducted by another student (Canfield 1984), included the pre-energization winter of 1982-83 and the post energization winter of 1983-84. Each field season began in late December and concluded when snow conditions allowed elk to move off the winter range.

STUDY AREA DESCRIPTION

Location

The study area is located in southwestern Montana, about 26 kilometers (km) north of Butte and about 14 km west of Boulder (Figure 1). Originally the North Boulder River constituted the southern boundary of the study area, the 2100 meter (m) contour line the northern boundary, Basin Creek the eastern boundary, and Little Cottonwood Creek the western boundary. These boundaries were extended to include the 10 square (sq) km of the Lowland Creek Drainage directly south of the study area as some of the radio-collared elk used this area almost exclusively.

Climate

Average annual precipitation for the study area is 45 centimeters (cm) (Ross and Hunter 1976). This ranges from 40 to 50 cm with precipitation increasing as elevation increases. The average daily maximum and minimum temperatures for the period December 1984 to

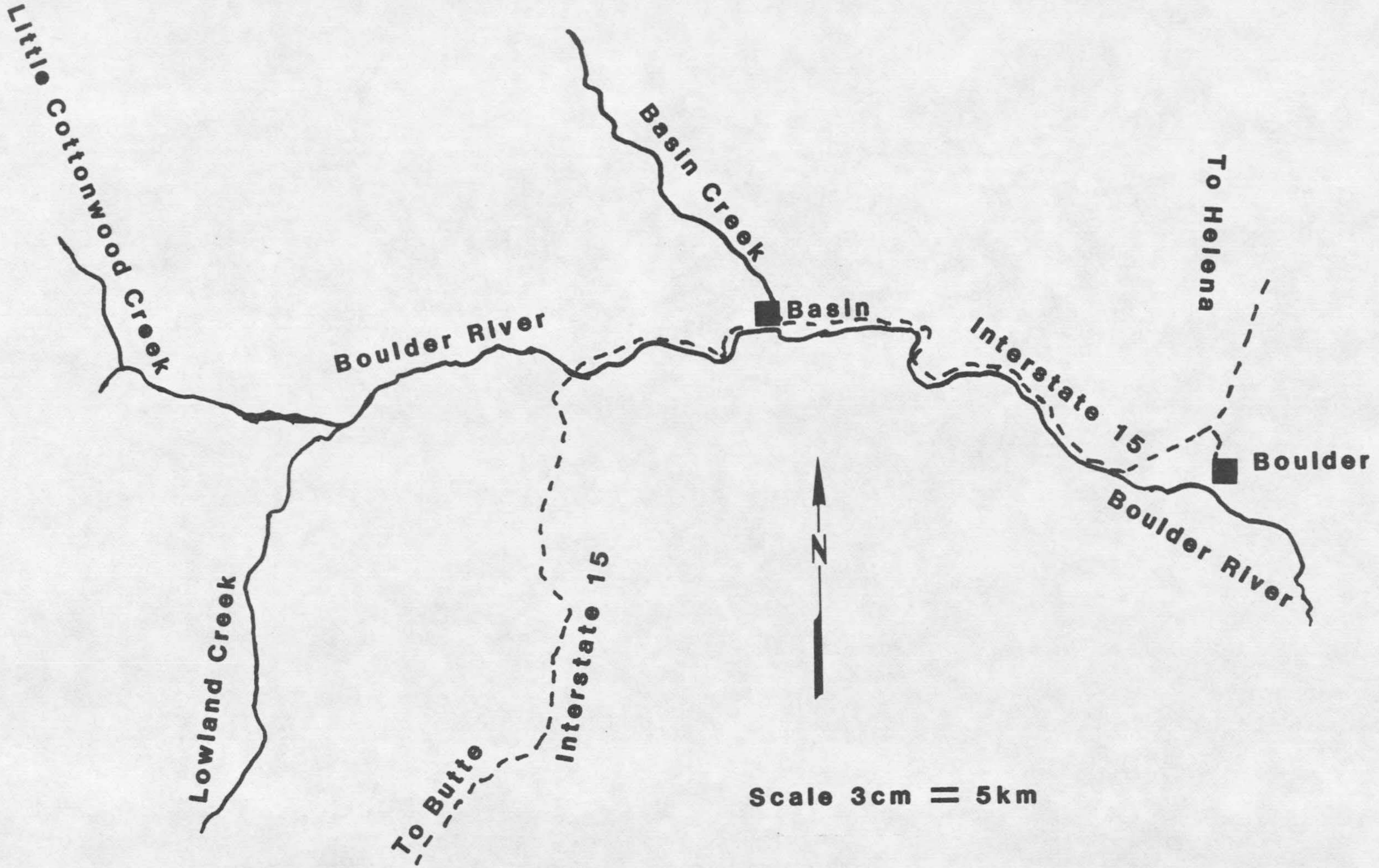


Figure 1. Map of study site and the surrounding area.

Table 1. Mean monthly temperatures (C) from weather stations at study site, Butte, and Boulder for the winter of 1984-1985.

Site	Year	Month	Avg. Max.	Avg. Min.	Monthly Average
Study Area	1984	Dec.	-3.46	-13.88	not available
Study Area	1985	Jan.	- .77	-11.60	na
Study Area	1985	Feb.	- .02	-10.66	na
Study Area	1985	Mar.	1.02	-11.08	na
Study Area	1985	Apr.	8.78	- 3.81	na
Butte	1984	Dec.	-4.22	-20.05	-12.11
Butte	1985	Jan.	-5.83	-20.61	-13.22
Butte	1985	Feb.	-2.89	-19.89	-11.39
Butte	1985	Mar.	5.11	-12.10	- 3.50
Boulder	1984	Dec.	- .78	-16.83	- 8.77
Boulder	1985	Jan.	-1.61	-16.44	- 9.00
Boulder	1985	Feb.	-1.28	-14.77	- 6.72
Boulder	1985	Mar.	6.49	8.71	- 1.11

April 1985 were 1.11 and -10.21 C respectively. Table 1 lists a comparison of mean monthly temperatures from Butte and Boulder weather stations (NOAA 1984-1985).

Figure 2 shows the location of Soil Conservation Service (SCS) snow course sites in relation to the study area. Table 2 lists snow depths and elevations for these SCS sites. Winter winds were primarily out of the west-

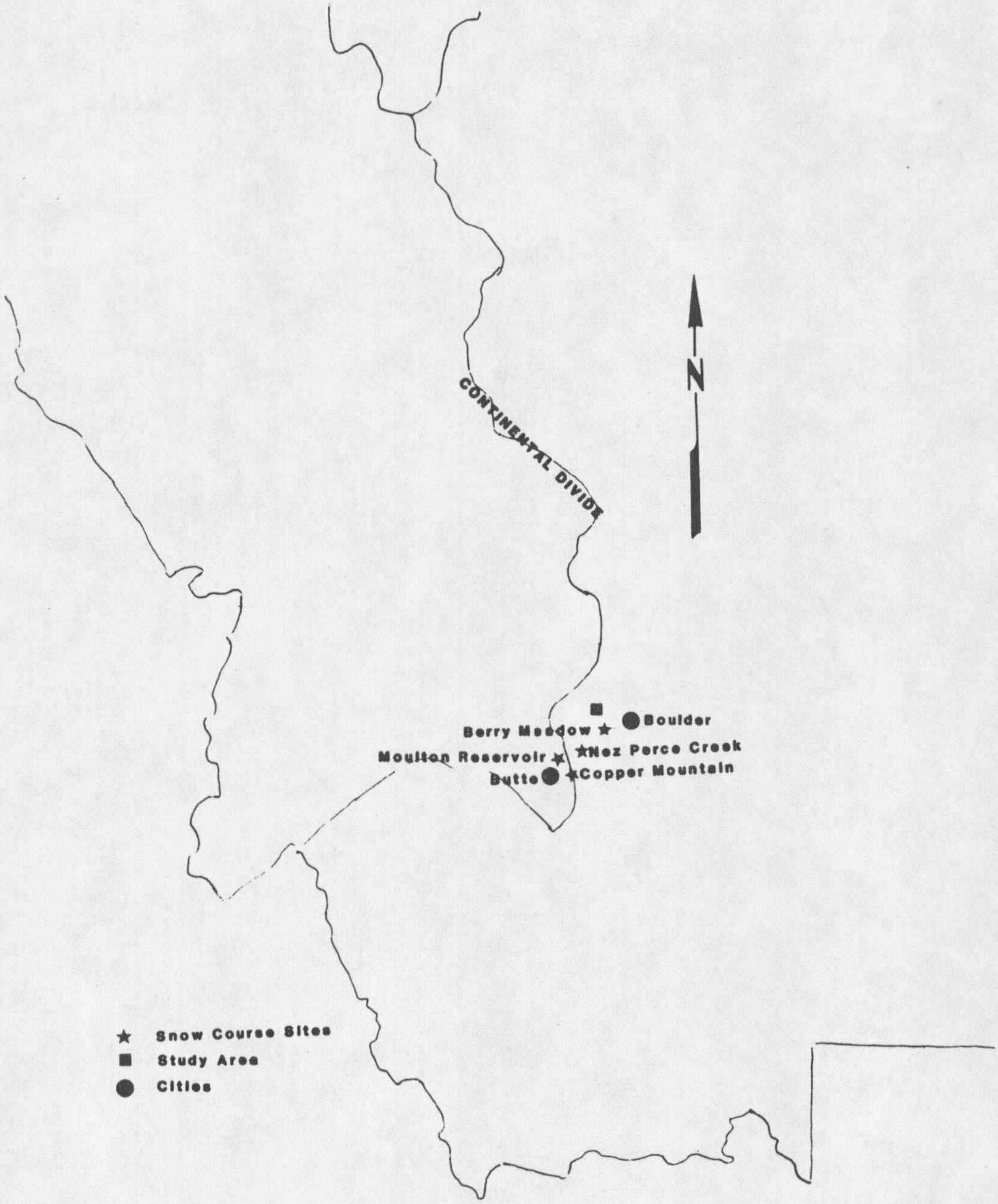


Figure 2. Location of SCS snow course sites near the study area.

Table 2. Snow depths (inches) from various Soil Conservation Service snow course sites near the study area.

Site	Year	Jan.1	Feb.1	Mar.1	Apr.1	Elev.(m)
Copper Mtn	Avg.*	not available	31	36	41	2347
Copper Mtn	1983	na	27	33	45	
Copper Mtn	1984	na	24	32	44	
Copper Mtn	1985	na	30	36	42	
Nez Perce Creek	Avg.*	na	23	26	26	2012
Nez Perce Creek	1983	na	18	20	22	
Nez Perce Creek	1984	na	16	20	32	
Nez Perce Creek	1985	na	18	24	23	
Picnic Grounds	Discontinued 1983					
	Avg.*	na	16	19	18	1981
Moulton Reserv.	Avg.*	20	27	33	28	2088
Moulton Reserv.	1983	19	22	26	26	
Moulton Reserv.	1984	18	18	26	36	
Moulton Reserv.	1985	20	21	28	36	
Berry Meadow	Avg.*	na	na	28	30	2134
Berry Meadow	1983	na	na	22	30	
Berry Meadow	1984	na	na	18	31	
Berry Meadow	1985	na	na	24	30	
Uncle Sam Gulch	Discontinued 1973					
	Avg.*	20	29	30	28	1950

* 20 year average for the years 1961 to 1980.

southwest. Winds interacting with topography are a factor in the distribution of snow on the study area.

Physiography

The study area is a grassland region on the east front of the Continental Divide. Southern, open exposures are prominent, as would be expected for a big game winter range. Most of the drainages that terminate at the North Boulder River run north to south and have formed steep sided gulches. Elevations range from 1764 m (5880 feet {ft}) at the North Boulder River to 2100 m (7000 ft) at the northern border of the study area.

Geology and Soils

The study area is situated on the Boulder Batholith, a series of intrusions of granitic magma and related volcanic material (Alt and Hyndman 1972). Parent material of this nature usually weathers to a soil with loamy sand or sandy loam texture (Veseth and Montagne 1980). The soils in this area are classified as either Inceptisols or Alfisols, moderately sloping to very steep when occurring on mountains (Montagne et al. 1982).

The Boulder Batholith is a source of valuable mineral deposits such as gold, silver and copper. Mining activity has taken place in and around the area since 1865 (Ruppel 1963). Although no longer a major land use, some mining claims are still maintained in the region.

History of the Herd

The North Boulder elk herd probably originated from elk transplanted in the Brown's Gulch area north of Butte (Chrest and Peterson 1979, Egan 1968). From 1939 to 1968, 506 elk were released in the area. All of the elk came from Yellowstone National Park except for 27 released in 1967 which came from the Big Hole River region. Data from tag returns and direct observations showed that some of these elk made their way down the Lowland Creek drainage and lived on or near the present day study area. Remnants of native elk herds may have been present in the region but this is not verifiable.

Vegetation

Douglas fir (*Pseudotsuga menziesii*) is the primary timber species on the study area. Quaking aspen (*Populus* tremuloides) stands occur in the gulches with adequate moisture. Two known stands of Ponderosa pine (Pinus ponderosa), both on dry, southern exposures, were present on the study area. Lodgepole pine (Pinus contorta) becomes more prevalent above the arbitrary 2100 m (7000 ft) northern boundary.

Major grass species on the area included bluebunch wheatgrass (Agropyron spicatum) and Idaho fescue (Festuca idahoensis) and to a lesser extent, rough fescue (Festuca scabrella). Species found as part of the grassland habitat included big sagebrush (Artemisia tridentata), green rabbitbrush (Chrysothamnus viscidiflorus), fringed sagewort (Artemisia frigida), and Wood's rose (Rosa woodsii).

Willow (Salix sp.) is the dominant, but certainly not the only, riparian species in the area. A more complete list of plant species appears in Canfield (1984).

Transmission Line

The transmission line has the capacity for 500 kV of alternating current. Its route runs east to west across the study area for approximately 16 km. The corridor required for this powerline is 42.6 m wide. The metal towers are 53.6 m tall and 17.2 m wide.

Recreational and Commercial Use

In addition to the minimal mining activity previously mentioned, this area also receives a variety of recreational and commercial demands. Its proximity to the communities of Butte and Boulder make it a popular area for hunting, fishing, camping, and snowmobiling. Three campgrounds are located on the North Boulder Road. Other picnic and camping areas are situated on the Lowland Creek Road closer to Butte.

The multiple use plan of the Deerlodge National Forest includes logging and grazing in addition to recreation. Active logging occurs on the northwestern portion of the study area within the boundaries of the elk winter range. Five-hundred and thirty-seven head of cattle were grazed in the area from mid-June to mid-October in 1985. Private lands occurring on or adjacent to the study area are used mainly for grazing and hay production.

METHODS

Direct Observations

Observations were made as often as possible at dawn, dusk, and during the daylight hours in conjunction with other field activities. Elk were most visible while feeding at first light and at dusk. A vantage point on the Lowland Creek Road provided the best position to observe elk using the south and west-facing slopes of the study area. Elk were observed with 7 X 35 binoculars and a 32 X spotting scope. Most daylight observations were made at or near timbered security cover. The number of animals, activity, location, time, weather conditions, and presence of radio-collared elk were recorded for each observation. The use of direct observations in conjunction with track observations and biotelemetry data aided in determining the elk population's daily routine.

Track Survey

Six sets of three transects each along the powerline right-of-way were monitored while snow was on the ground to determine if elk showed any avoidance or "turn-back" behavior due to the powerline. Each set consisted of a transect under the powerline, a transect 100 m north, and a transect 100 m south of the powerline. All transects were parallel to the line. This arrangement was designed to show if elk came within 100 m of the powerline and then turned back instead of crossing the corridor. The sets of transects were monitored daily after a snow storm until tracks were observed. Occasionally this method had to be abandoned until the next snow storm because wind-blown areas would make it impossible to determine the age or number of individual tracks in older snow.

Telemetry

Fifteen cow elk were radio-collared in January 1983 (Canfield 1984) and an additional seven cow elk were radio-collared in March 1984. Each collar was made of molded PVC pipe with a transmitter sealed inside and marked with an identifiable symbol or color combination.

Three stationary triangulation stations were erected on the study site. Their locations approximated the optimum locations for triangulation (White 1985), while still taking advantage of the topography of the study area (Figure 3). In this case the optimum locations were found by using a rectangular area, within the study area, with the dimensions 2 by 4 units. Each station consisted of a Telonics TAC-5 precision direction-finding array with dual three-element antennae (Telonics Inc., Mesa, AZ). A compass rose, calibrated to true north, was used for orientation. The stations were calibrated by using a fixed, beacon transmitter set at a known location and predetermined compass bearing. Calibration was checked by using a compass and the angle of declination.

Two tests were conducted to test the accuracy of the system. In each test, volunteers manned the three stations and attempted to locate a specified transmitter at 15 minute intervals for 3 hours. During this period, I hiked through the study area carrying the transmitter. Stops were made every 15 minutes to allow the stations to get a fix on the location. Each stop was marked on a map. The map was then sealed in an envelope and sent to

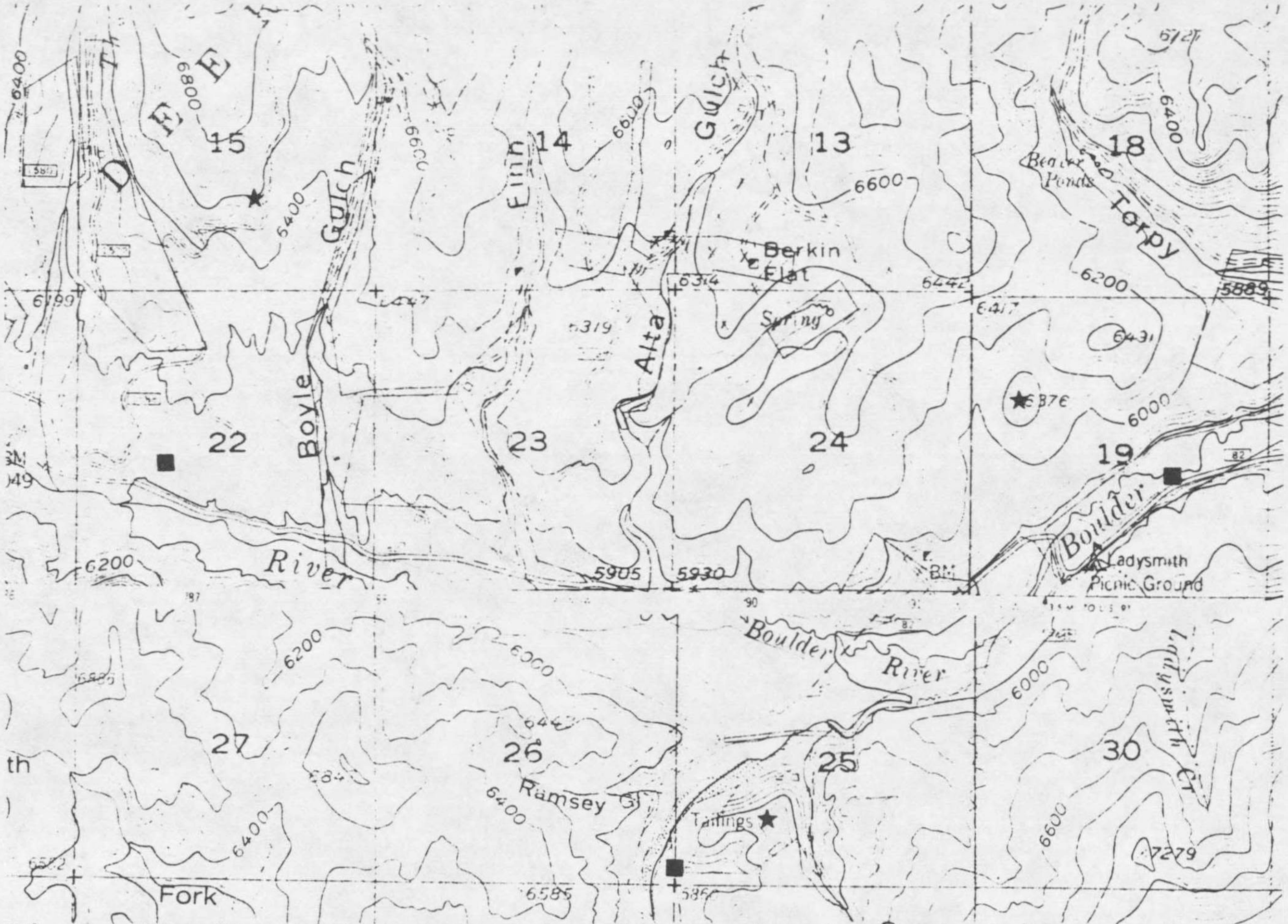


Figure 3. Stars show actual locations of telemetry stations. Squares show optimal locations for stations when using a rectangular study area with dimensions of 2 by 4 units (White 1985).

a neutral party. The locations from the three stations were triangulated and compared with the actual locations on the map. This made it possible to insure that relocation error in the vicinity of the powerline was held to near the theoretical minimum.

Seven 24-hour periods were monitored during the winter of 1984-85. Each session consisted of three stations simultaneously attempting to locate all radio-collared elk every 2 hours. Two people were assigned to each station when possible. An attempt was made to assign at least one person with telemetry experience to each of the stations. Locations were triangulated on United States Geological Survey orthophotoquad maps. Locations were entered into a computer data file, and the computer program TELDAY (Burkhalter and Lonner 1983) was used for plotting and analysis.

Pellet Group Survey

Using the methods outlined by Cole (1975), routes that meandered throughout the study area were walked in the late spring of 1984 and 1985. The density of pellet groups was recorded at 0.25 mile intervals and each site was ranked as being a high, medium, low, or no-use area.

The intensity of use along these routes was compared with surveys conducted in 1975 and 1983.

Ten sets of pellet transects along the powerline corridor were monitored in the spring. Each set consisted of nine 50 m transcts. One transect ran under the centerline of the powerline. The remaining 8 transects, all parallel to the line, were located north and south of the corridor at distances of 15, 50, 100, and 200 m from the outer conductors. "Fresh" pellet groups occurring within 1 m on either side of the transect were counted. This information was compared with data collected in 1983 and 1984.

Weather Data

Weather and noise data were provided by the Bonneville Power Administration weather monitoring station located on the study area. Additional information was obtained from the weather stations in Butte and Boulder.

Hunter Survey

A hunter checking station was operated on the study area on the opening day of the 1984 big game season, one weekend at mid-season, and the final weekend. The number of vehicles and their origin were recorded. Hunters were questioned about the type and amount of game they saw. All game brought through the station was recorded and a location of the kill site was obtained. Hunters were also asked to comment on the closure of some of the study area access roads.

RESULTS AND DISCUSSION

Climate and Habitat

Using a climate index developed by Picton (1979), an average study area winter would receive a ranking of 0. A milder than average winter would have a positive value, and a harsher than average winter would have a negative value. The winter of 1982-83 had a ranking of +6, the winter of 1983-84 had a ranking of +9 making them two of the three mildest winters in a 17 year period. The winter of 1984-85 had a ranking of -2, which falls within the limits of what would be considered a biometerological normal winter (67% of the winters).

During a winter of normal precipitation, the northern boundary of the elk winter range is approximately 1980 m (6600 ft). Canfield (1984) reported the upper limit for the winter range for the period November to March was 2040 m (6800 ft). My data suggested the northern boundary of the winter range fluctuated between 1950 m (6500 ft) and 2010 m (6700 ft). This is slightly less than the arbitrary 2100 m boundary (Picton et al. 1984) initially chosen for the restricting elevation. By mid-

April the radio-collared elk seemed to be at or slightly beyond the arbitrary 2100 m boundary and by the end of April were moving off the winter range.

Using a Linear Measuring Set (LMS), aerial photographs were digitized through a process called "density slicing". Figure 4 shows 29 sq km of the study area and adjoining land along the Lowland Creek drainage. Results from this analysis (Figure 5) show that 54.4 % of this portion of the study area is timbered habitat, 40.9 % untimbered, "open" habitat, and 4.6 % is part of the North Boulder River flood plain. In a closer look at the central part of the study area, Figure 6 shows that most of the timbered security cover lies north of the powerline, although timber does occur along some of the gulches in the moister areas south of the line. Important untimbered feeding areas, including the river's flood plain, lie primarily south of the powerline. Open areas north of the powerline are often unsuitable foraging areas in the winter due to snow cover, although this may vary between winters and sites depending upon aspect, topography, wind action, and amount of precipitation.

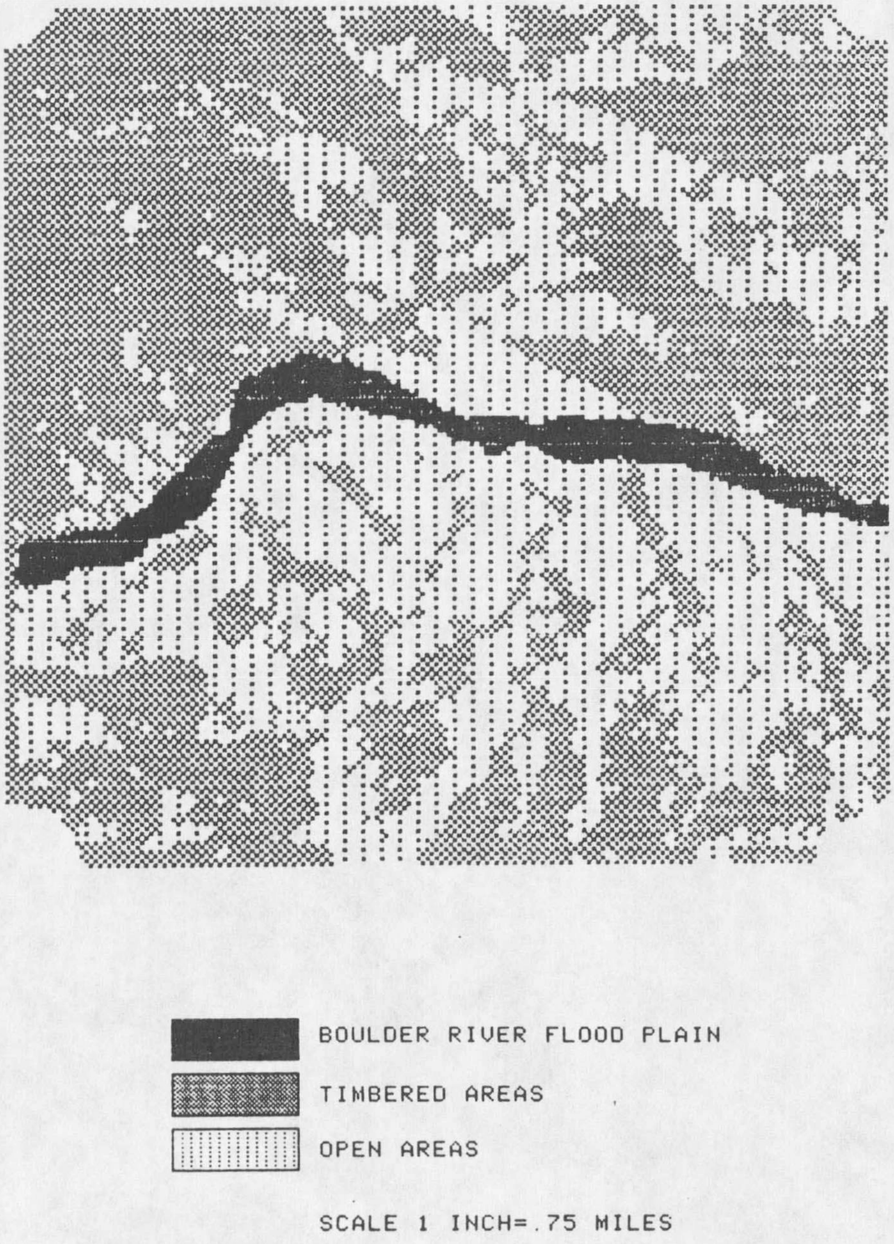


Figure 4. Linear measuring set printout showing 29 square kilometers of the study area.

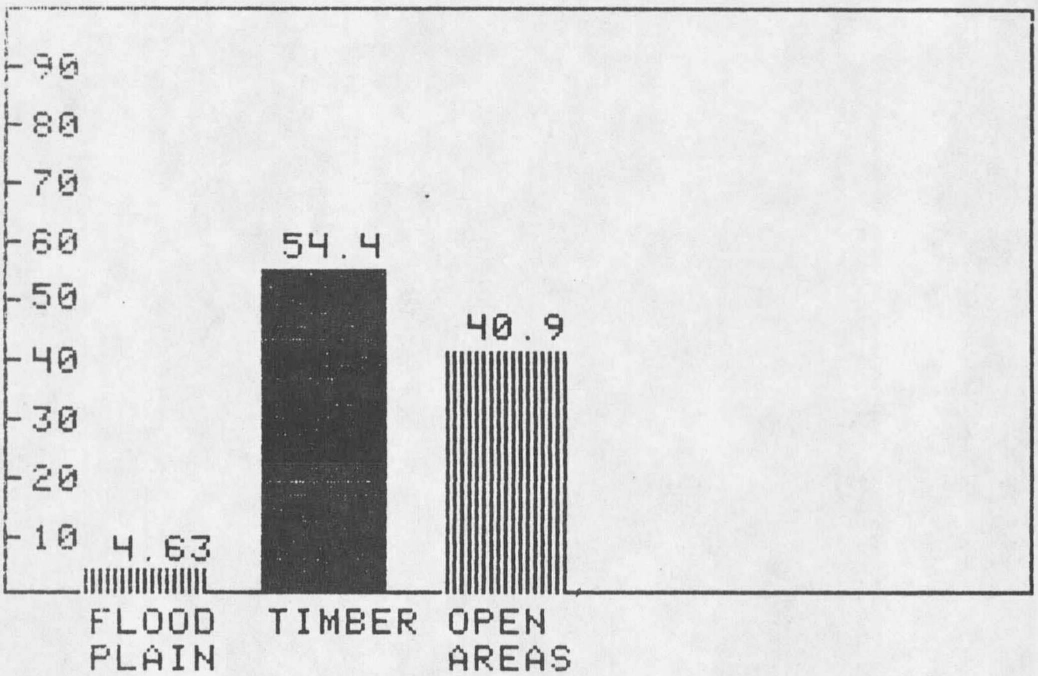


Figure 5. Linear measuring set area results. A percentage is given for each habitat type.

Figure 6. Linear measuring set printout of a portion of the study area near the powerline.

Track Transects

All but one of the corridor crossings recorded at the transect sets crossed all three transects (Table 3). This one exception consisted of four sets of tracks that crossed the northern and middle transects of set 6. The tracks and feeding craters showed that the elk fed in a down-slope fashion, spent some time in a young aspen grove occurring in a shallow gulley, and then travelled back up-slope to timbered security cover. This was not considered a turnback (i.e. a decision not to cross the corridor at a distance of 100 m or less north or south of the powerline) as the majority of the feeding craters occurred within the northern (up-slope) transect as well as under the powerline itself.

Four instances were reported in which corridor crossings did not occur on the day immediately following a storm, but did occur on the second or third day after the storm (Canfield 1984). I observed this same absence of crossings three times in the winter of 1985. Two of these occasions occurred on the first or second days following a storm. In the third instance, however, no precipitation had fallen for the previous 4 days.

Table 3. Track transect set crossings for 1985. Numbers in table are distinguishable tracks for individual elk unless otherwise noted.

Set	Date	North	Transect Center	South
1	Jan.9	120*	120*	120*
2	Jan.9	25*	25*	25*
3	Jan.9	7	no estimate(a)	9
1	Jan.30	13	13	13
2	Jan.30	0	0	0
3	Jan.30	0	0	0
4	Feb.15	0(b)	0(b)	9
5	Feb.15	0	0	0
6	Feb.15	4	4	0
1	Feb.17	0	0	0
2	Feb.17	0	0	0
3	Feb.17	0	0	0
1	Feb.28	10	10	10
2	Feb.28	ne(a)	ne(a)	ne(a)
3	Feb.28	0	0	0
1	Mar.2	10	10	10
2	Mar.2	0	0	0
3	Mar.2	0	0	0
1	Mar.11	0	0	0
2	Mar.11	0	0	0
3	Mar.11	0	0	0
4	Mar.12	ne(a)	ne(a)	ne(a)
5	Mar.12	ne(a)	ne(a)	ne(a)
1	Mar.29	0	0	0
2	Mar.29	0	0	0
3	Mar.29	0	0	0

* Estimate made on tracks forminga trail.
(a) Tracks formed a trail, no estimate was made.
(b) Tracks crossed powerline but missed transect.

Snow cover definitely affected the travel habits of the elk. Some of the track transects were rendered useless when deep and drifting snow caused elk to seek out other avenues for crossing the powerline corridor. In some instances when other travel routes were not available, one trail was maintained through the deep snow and very little deviation from that trail occurred.

In some areas adjacent to the corridor, trails of several groups of elk would funnel out of the timber and higher grasslands and converge into two or three "crossing trails" as they passed under the powerline; they then "fanned out" into many trails as elk foraged on the grassland. This behavior was also observed when groups of elk would cross a fence, especially when the footing on the far side of the fence was obscured due to snow cover.

Direct Observations

During the spring of 1984 and the winter of 1984-85, 1,167 direct observations of elk were recorded. Characteristics of actual crossings of the corridor by elk depended on varying circumstances. Elk that were disturbed by the observer crossed the corridor with little or no regard for the powerline. Undisturbed elk crossed at varying speeds depending upon the presence or absence of feeding activity. On the morning of January 19, three elk were observed crossing the powerline in a posture that was similar to the "alarm gait" reported by McCullough (1969) and Murie (1951). Each animal crossed the corridor trotting with its neck held erect and its head tilted over its back. All three were part of a larger group of elk, but each animal crossed the line alone. These elk were observed from a distance with a spotting scope. No cause for this alarm response, other than the powerline, was noted. The average, A-weighted, audible noise for this time period (0700 to 0830) was 43.7 decibels. The elk could not be observed after they had crossed the corridor because of topography.

The typical 24-hour routine for the North Boulder elk herd began and ended in the timbered security cover north of the powerline. Elk were observed at dusk moving south from the timber to the open grassland areas where they presumably fed for most of the night. At dawn elk were observed feeding up-slope toward the timber. During the day, in addition to the resting and ruminating activity, some feeding and movement occurred in and around the smaller parks and open areas of the predominantly forested habitat north of the powerline. At dusk this cycle began again.

Variations observed in this routine were attributed to weather conditions, time of the year (i.e. late winter), or human activity in the area. During evenings with cold and windy or snowy and windy conditions, elk would not often move out into the open areas, and those feeding in open grassland habitat would retreat to smaller, isolated patches of timber in response to advancing storm fronts. In March elk were occasionally observed on the open grasslands and Boulder River flood plain as late as 0900.

On the afternoon of January 29, during a light snowstorm, I observed two groups of elk (14 and 30) feeding on two points 0.3 and 0.5 km south of the powerline, respectively. The group of 14 was on a hillside that was commonly used as a feeding area, and elk often crossed track transect set 1 to reach this area. It had been snowing lightly but steadily from 1630 until past 1715 when the elk were sighted. The A-weighted, mean audible noise caused by the powerline on this date was about 50 decibels. Unless the elk had bedded south of the powerline earlier in the day, they would have had to cross the corridor during the snowstorm. A check of transect set 1 on January 30 confirmed that this group of elk moved out of the timber north of the powerline, crossed the corridor and moved onto the open hillside to feed. Thirteen discernable sets of tracks were recorded crossing all three transects of set 1. The area under the powerline that was crossed by the elk is a potential feeding area in the fall and spring, but on this date, a minimal amount of forage was available due to snow cover.

Telemetry

By the winter of 1984-85, the signals from 13 of the radio-collared elk could be received from one or more of the three stationary triangulation stations. The same 13 animals were located during an aerial survey conductedin mid-February. A visual observation of an elk wearing a non-functional collar was also made at this time. For 1985, 317 telemetry relocations were compiled. Figure 7 shows a general distribution of radio-collared elk for the winter of 1984-85. The total area used by radio-collared elk for this winter was 84.3 sq km with a standard diameter of 5.9 km. The standard diameter is the diameter of a circle which is centered on the geographic activity center. This circle encloses 68 % of

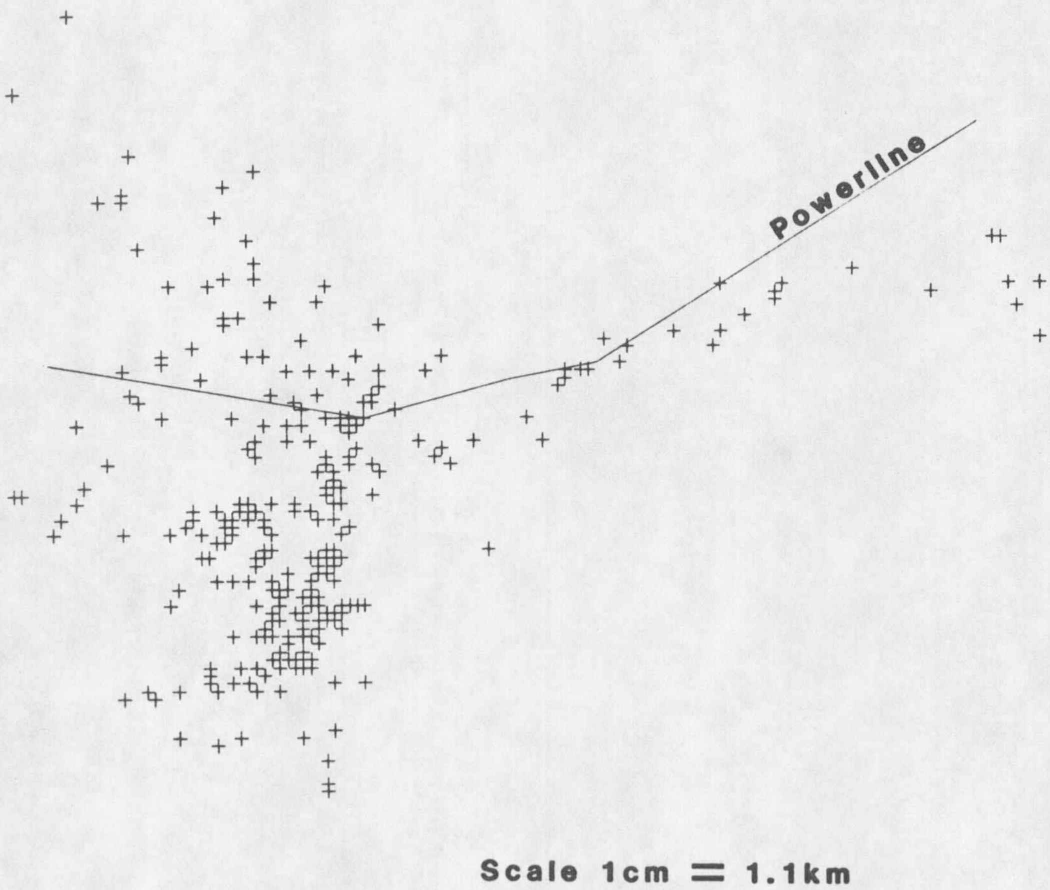


Figure 7. Distribution of all radio relocations for the winter of 1984-85.

the relocations. Ten of the animals were located on a map a minimum of four times for a given 24-hour period. This is the minimum number of relocations per time period required by the computer program to compute and plot a home range. In 1985 the average area for a 24-hour period for 10 animals was 0.8 sq km with a range of 0.03 to 2.6 sq km. This is approximately 1/3 the average area Canfield (1984) reported for the winters of 1982-83 and 1983-84. The average cumulative winter home range for 10 elk in 1985 was an area of 6.8 sq km with a range of 1.1 to 14.8 sq km and a mean standard diameter of 2.9 km. The average cumulative winter home range for the five animals with the most relocations (more than 30 each) was an area of 10.7 sq km with a range of 4.3 to 14.8 sq km and a mean standard diameter of 2.9 km. In 1983 an average winter home range of 22.4 sq km with a range of 12.5 to 35 sq km and a mean standard diameter of 4.0 km was reported. In 1984 the average winter home range was 23.5 sq km with a range of 14 to 44.3 sq km and a mean standard diameter of 3.8 km (Canfield 1984). Table 4 lists the home ranges from the previous seasons and the winter of 1984-85. The reduction in home range size for 1984-85 could be a result of closer to normal amounts of snow cover.

Table 4. Winter home ranges of radio-collared elk for 1983, 1984, and 1985. Locations for 1983 and 1984 are from Canfield (1984).

	1983			1984			1985		
Elk	SD	Max. Area	Fixes	SD	Max. Area	Fixes	SD	Max. Area	Fixes
5	3.2	17.4	52	2.8	14.0	62	3.3	13.8	31
6	2.8	13.0	63	3.7	33.0	47	1.9	4.1	18
7	3.6	34.0	74	3.7	23.2	64	1.7	4.3	62
9	3.2	18.7	64	3.7	29.9	50	3.3	10.1	47
12	4.1	22.6	74	4.9	44.3	52	3.4	14.8	56
14	3.6	17.6	67	3.6	17.5	61	2.8	4.0	16
15	3.6	12.5	62	3.6	33.4	75	2.6	10.5	55
17		NA(a)			NA		1.8	1.1	7
20		NA			NA		4.2	4.0	8
21		NA			NA		3.5	1.3	6

SD=the standard diameter measured in kilometers.

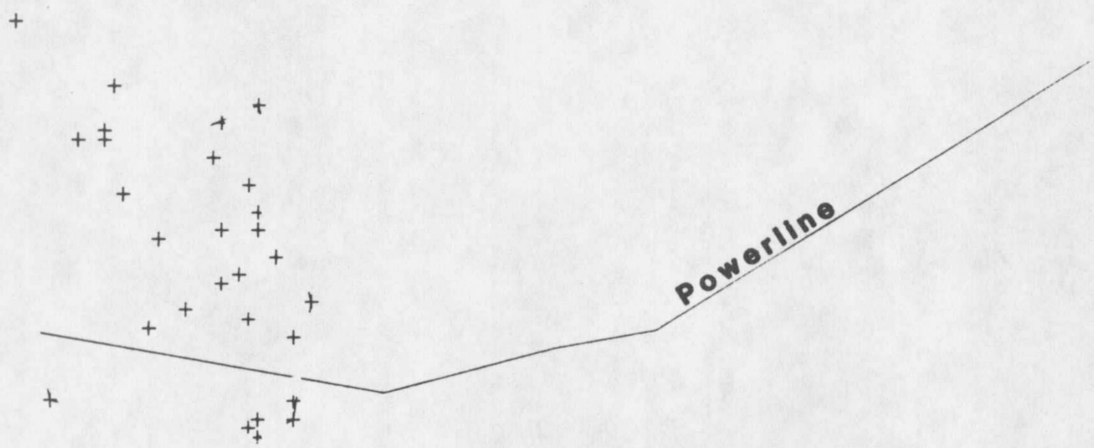
Maximum area is measured in square kilometers.

(a) Not available. These elk were collared in March 1984.

Elk that used the central portion of the study area routinely showed relocations north and south of the powerline. The majority of these home range plots showed core areas of activity north and south of the powerline with some relocations at or near the line (Figures 8-17). Figure 18 shows the distance from the powerline during daylight, dusk, dark, and dawn time periods for radio relocations occurring within 1000 m of the powerline. Figure 19 shows the distance from the powerline for these same relocations with and without precipitation.

Location of winter home ranges for radio-collared elk were fairly constant for all three winters. An area of 10 to 12 sq km that was used each winter showed high fidelity between winters and could be identified for each radio-collared animal. The major expansions and reductions in home range took place on the fringes of these areas.

In 1985 some of the radio-collared elk travelled back and forth two or three times from the central part of the study area near the powerline to the Lowland Creek drainage south of the powerline on the other side of the North Boulder River. Three of these elk (Nos. 12,14, and 15) had used summer range northeast of the powerline the previous summer in the Basin Creek and Red Rock Creek



Scale 1cm = 0.9km

Figure 8. Radio relocations for elk number 5 for the winter of 1984-85.

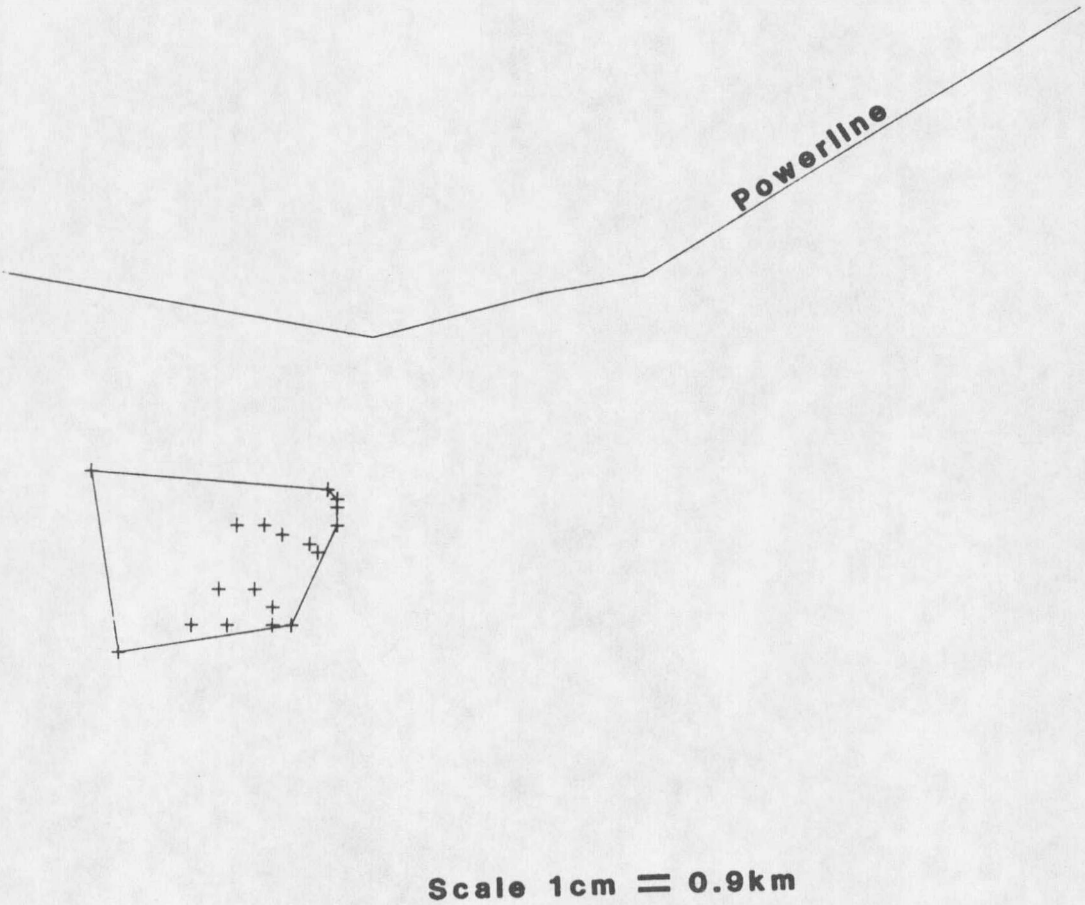


Figure 9. Radio relocations for elk number 6 for the winter of 1984-85. Polygon encloses the home range computed from these relocations.

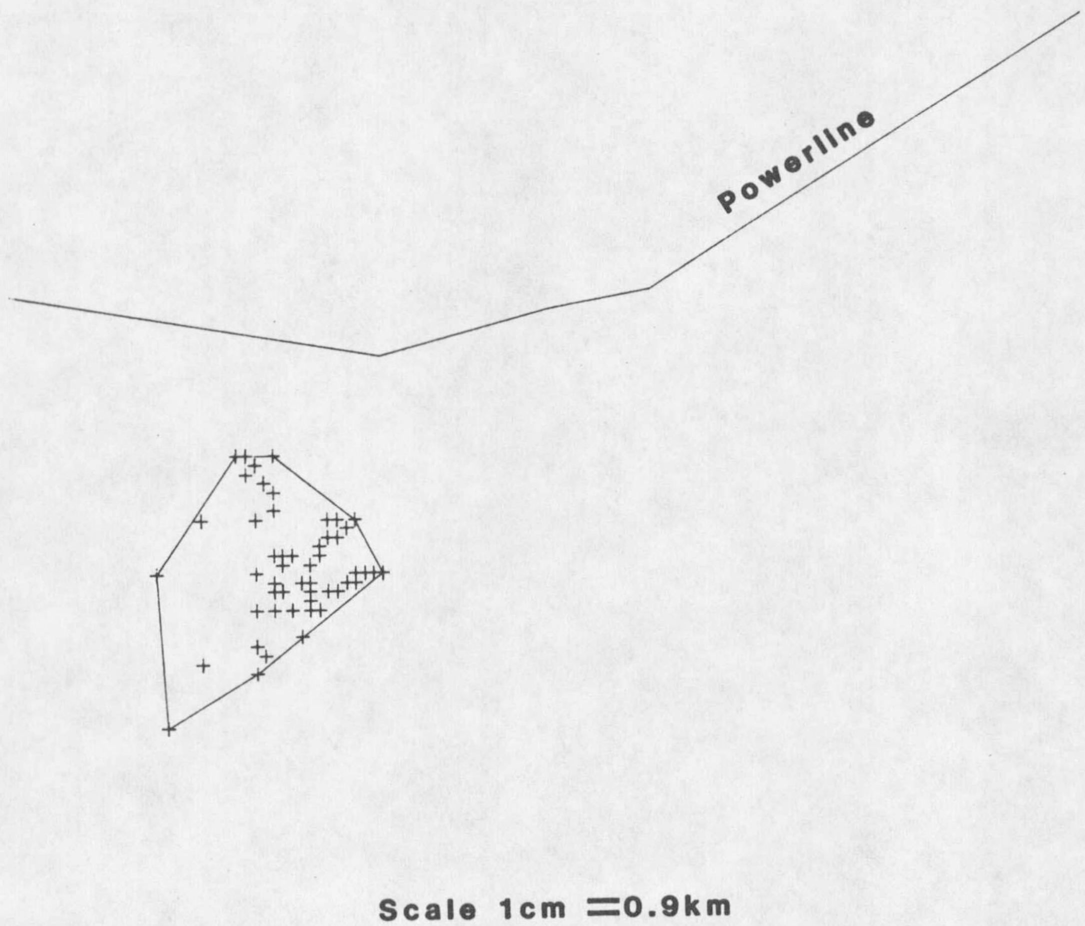


Figure 10. Radio relocations for elk number 7 for the winter of 1984-85. Polygon encloses the home range computed from these relocations.

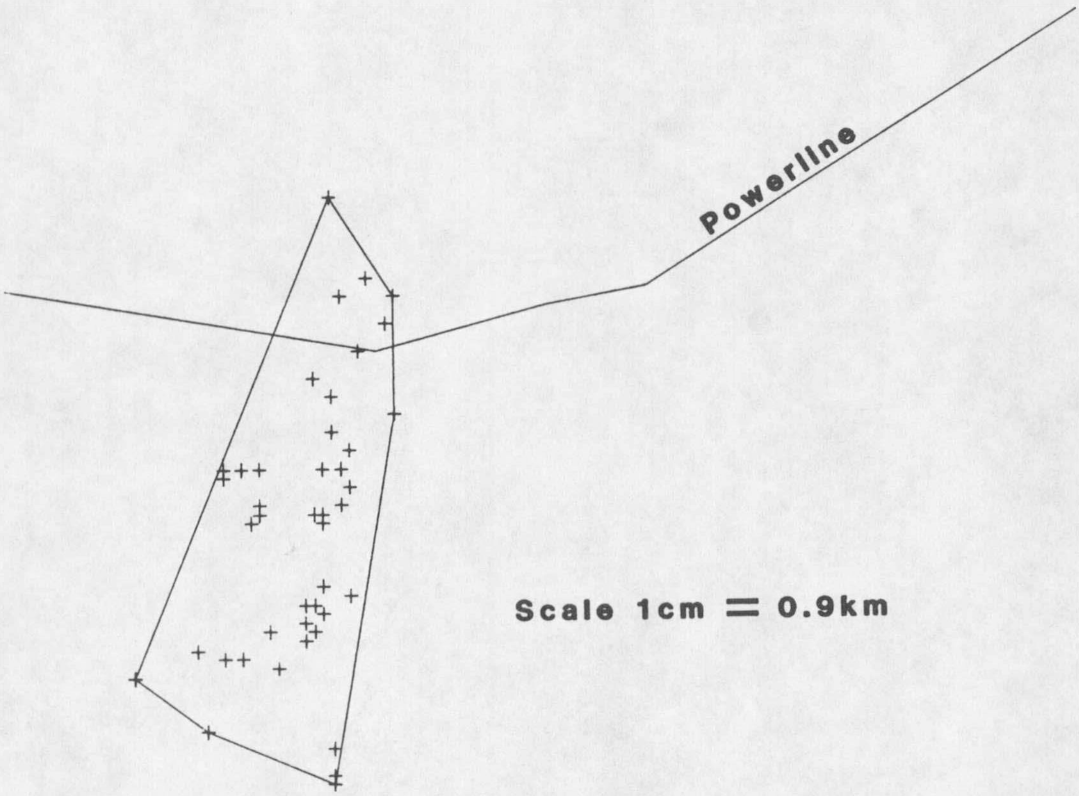


Figure 11. Radio relocations for elk number 9 for the winter of 1984-85. Polygon encloses the home range computed from these relocations.

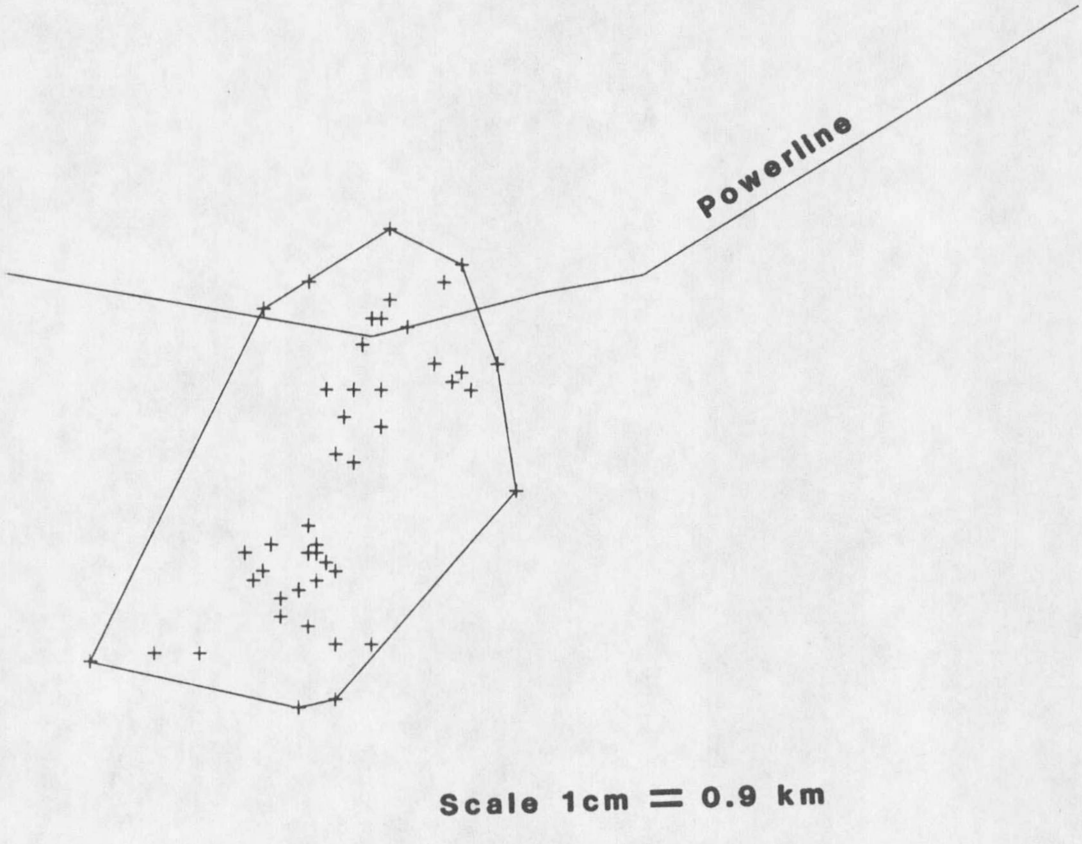


Figure 12. Radio relocations for elk number 12 for the winter of 1984-85. Polygon encloses the home range computed from these relocations.

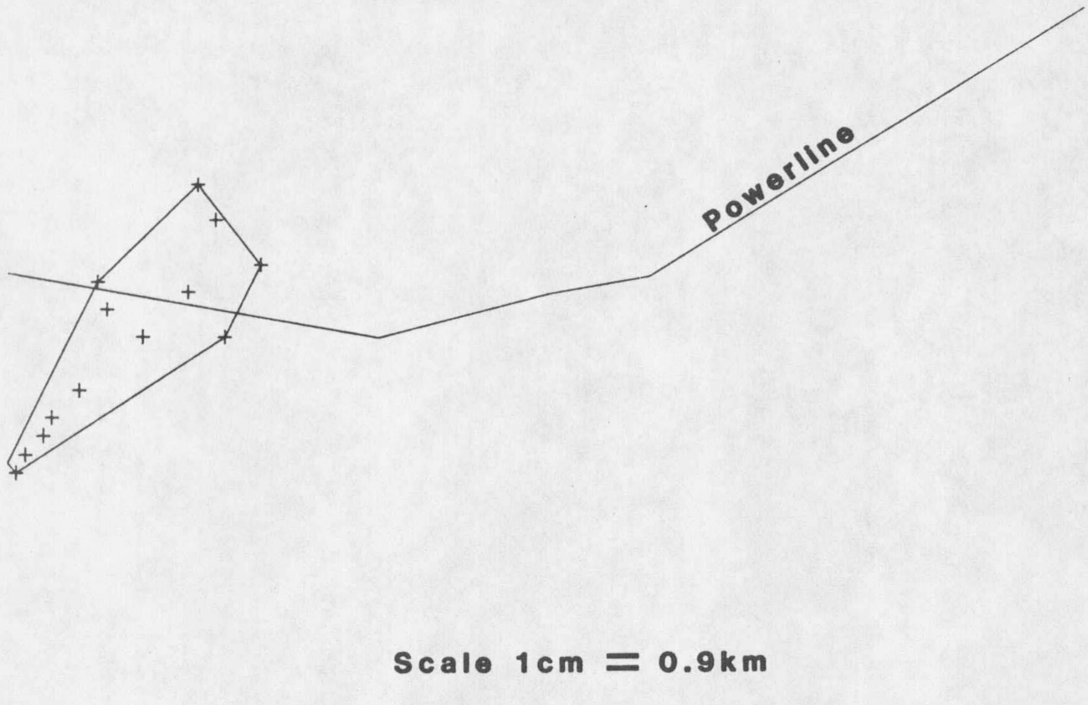


Figure 13. Radio relocations for elk number 14 for the winter of 1984-85. Polygon encloses the home range computed from these relocations.

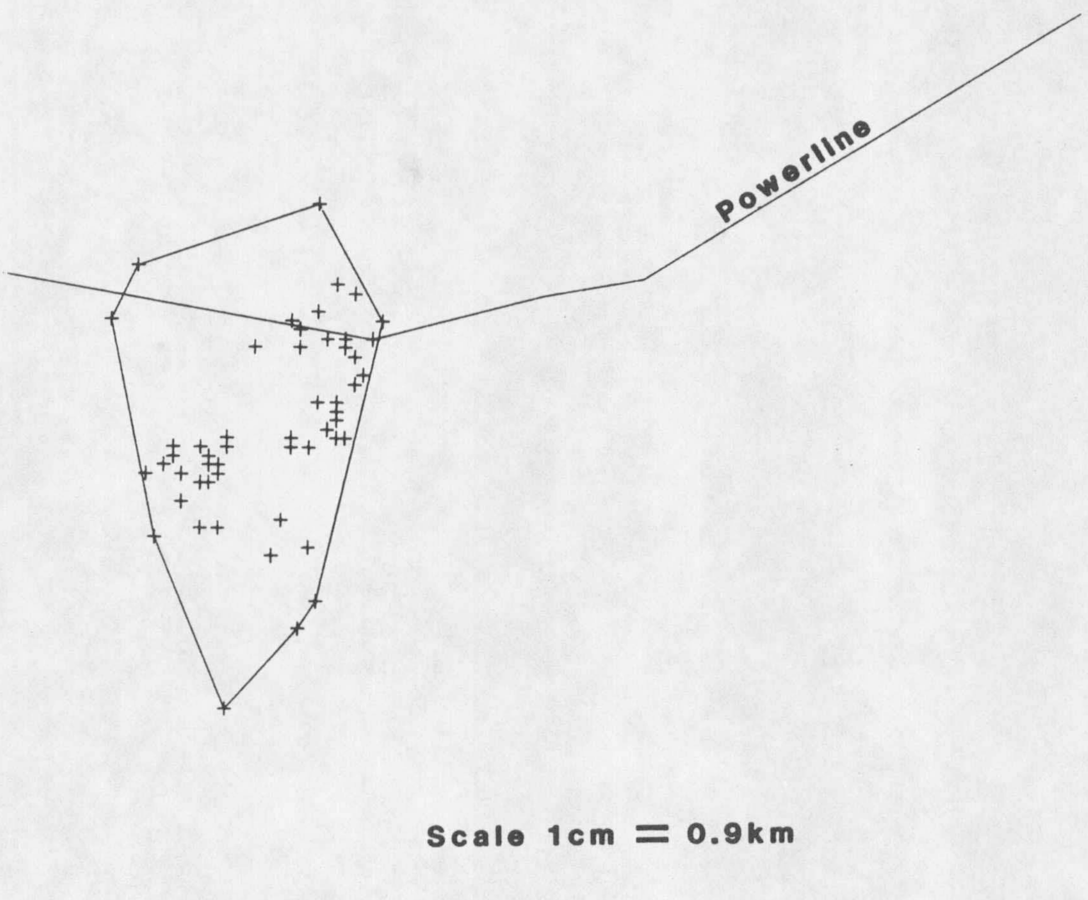


Figure 14. Radio relocations for elk number 15 for the winter of 1984-85. Polygon encloses the home range computed from these relocations.

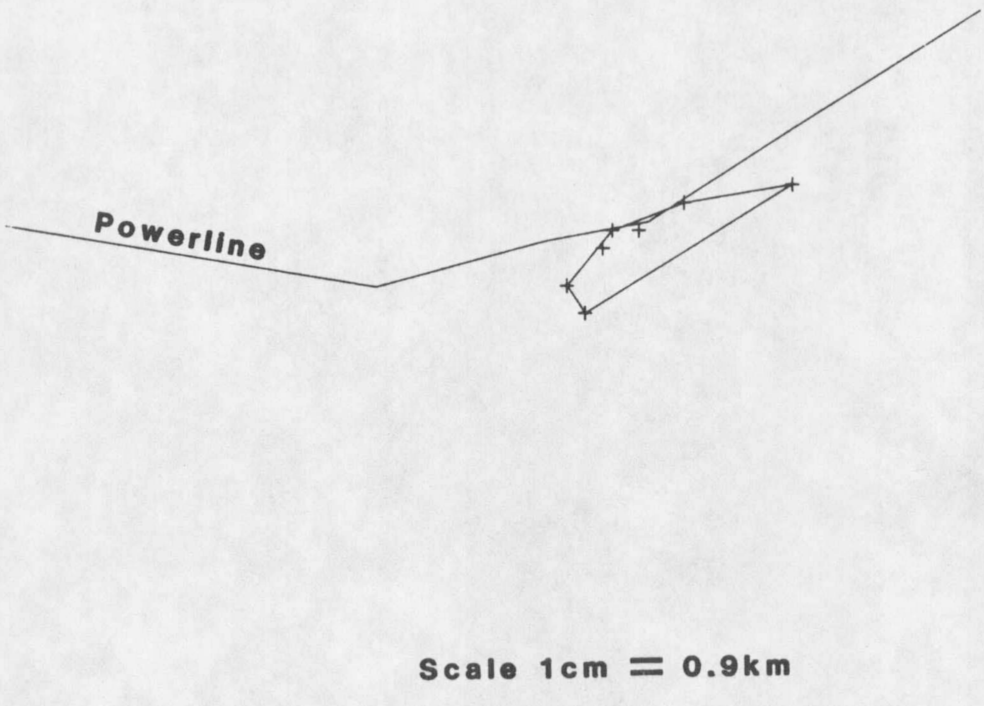


Figure 15. Radio relocations for elk number 17 for the winter of 1984-85. Polygon encloses the home range computed from these relocations.

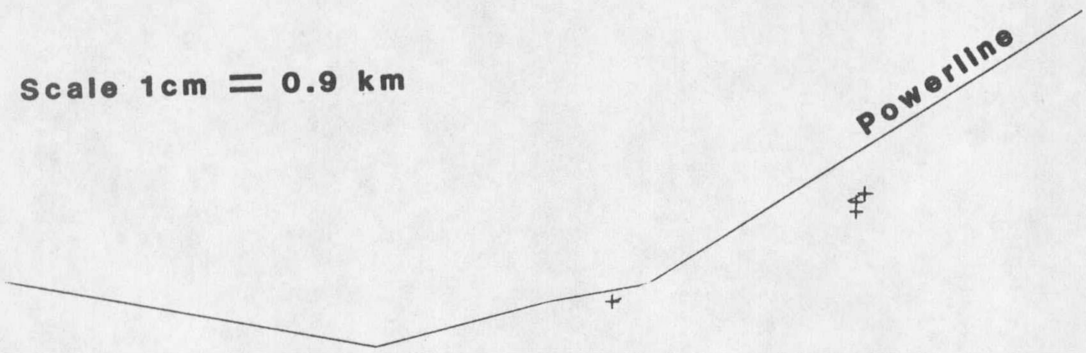


Figure 16. Radio relocations for elk number 20 for the winter of 1984-85.

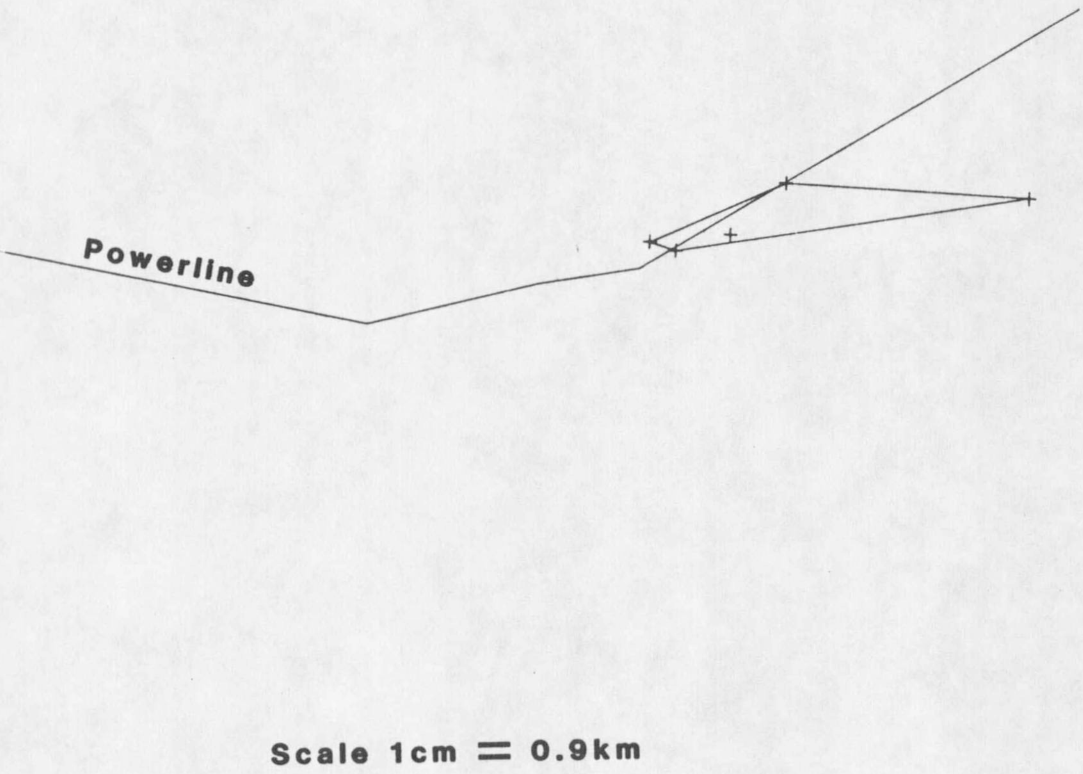


Figure 17. Radio relocations for elk number 21 for the winter of 1984-85. Polygon encloses the home range computed from these relocations.

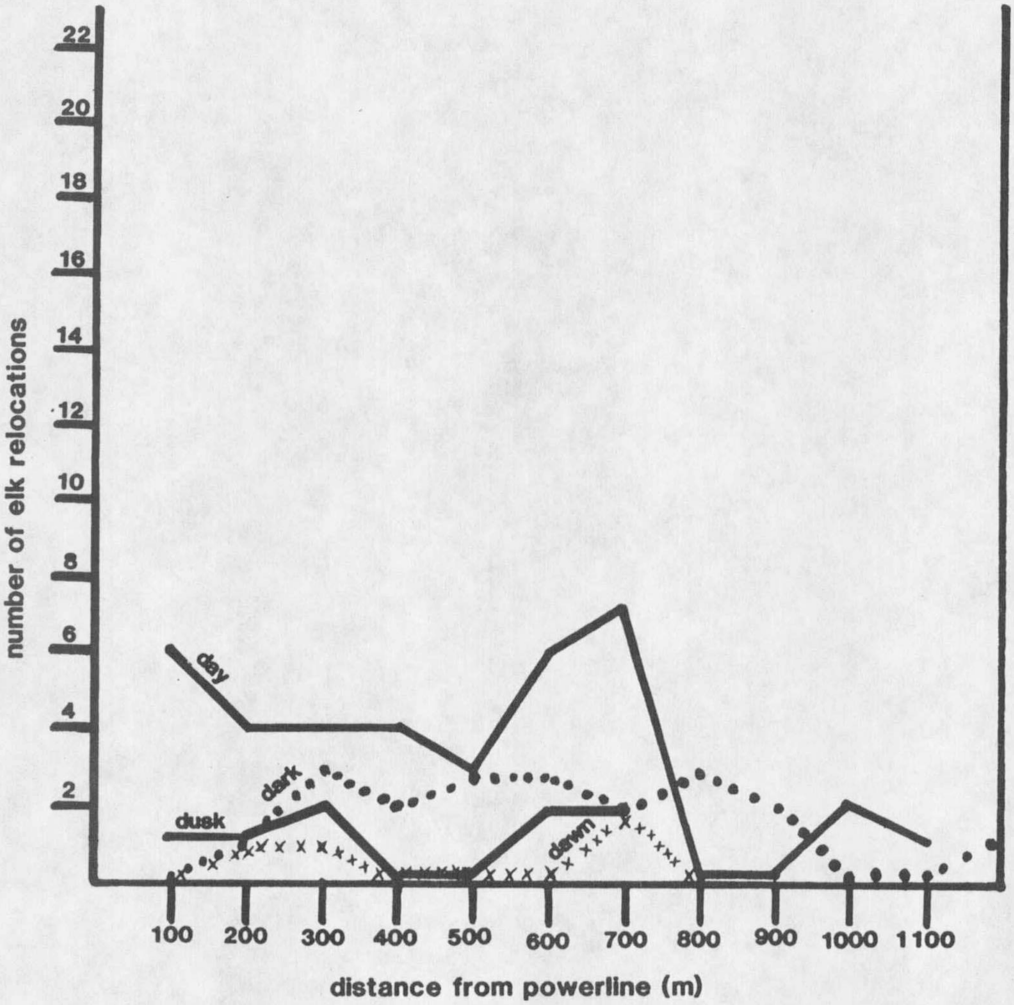


Figure 18. Distance of radio relocations to the powerline during day, dusk, dark, and dawn periods for the winter of 1985.

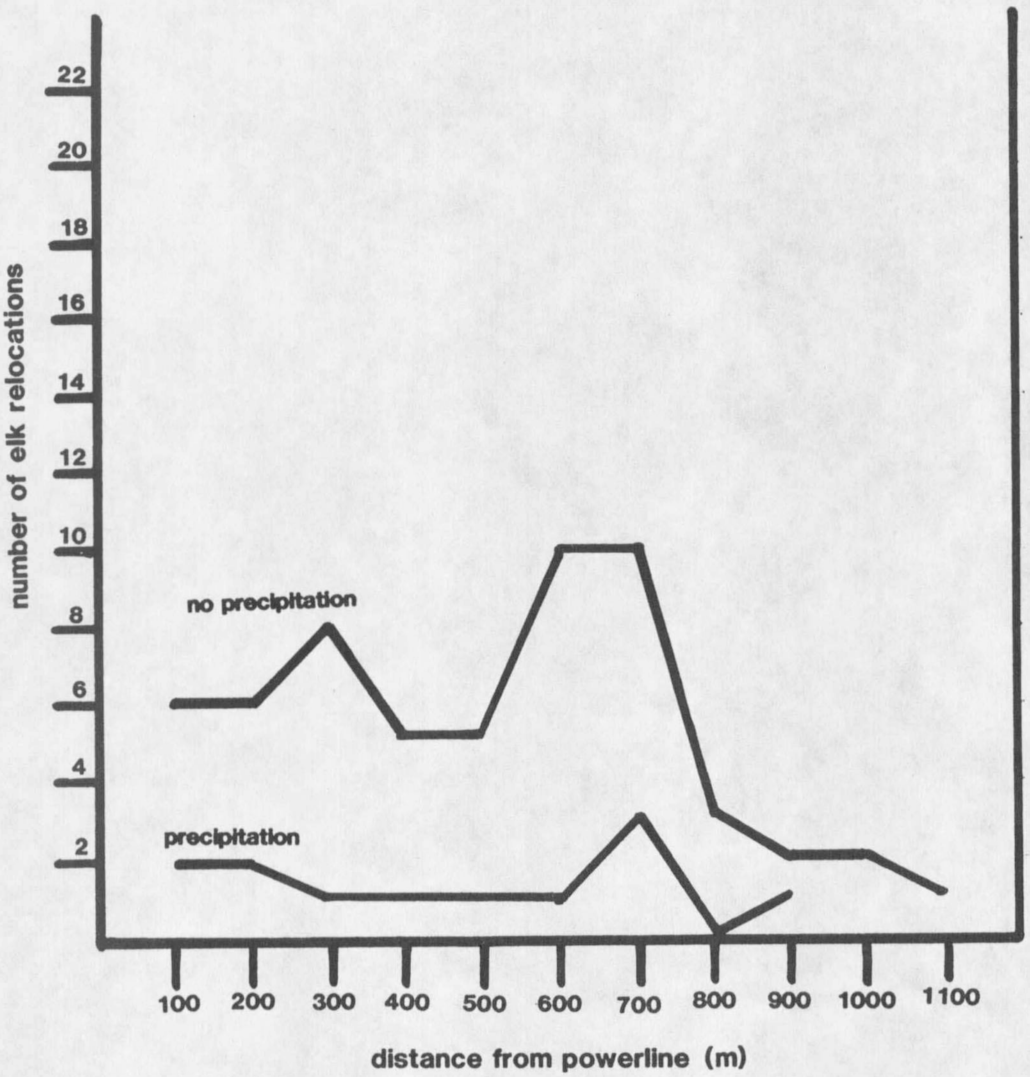


Figure 19. Radio relocations within 1000 meters of the powerline during periods with and without precipitation during the winter of 1985.

drainages near the Continental Divide. These same elk were located along the Lowland Creek drainage in late March and mid-April in 1985. These three animals began the winter in the central part of the study area near the powerline. By early February they were in the Lowland Creek area. In late February they were back in the central part of the study area near the powerline. In late March they were back along the Lowland Creek drainage and were located there again in mid-April. If these elk remained loyal to their 1984 summer range they would have to cross the North Boulder River, the main dirt road, and the powerline at least one more time in the spring. Such variability in travel could be an important component in the presence or absence of corridor crossings.

Three elk (Nos. 8, 12, and 15) showed a major change in summer range use. In the summer of 1983, all three occupied summer range south of the study area in the Lowland Creek drainage area near Elk Park. In the summer of 1984, these elk were located northeast of the study area in the upper reaches of both the Basin Creek and Red Rock Creek drainages. Numbers 12 and 15 did, however, remain loyal to their winter range. I was unable to locate elk number 8 in the winter of 1984-85. Of the remaining thirteen elk that were located in the summer of 1984, seven animals occupied the same summer range that they did in 1983, and three were collared in March of 1984 so no comparison could be made. Of the seven elk that were collared in March of 1984 (Canfield 1984), four returned to the same winter range in the Pole Mountain area in 1985, and three were not located during the winter of 1984-85.

A large number of relocations were not used due to conflicting signals, insufficient bearings, or plotted triangles that were too large to be accurate. Topography was felt to induce the biggest source of error in the telemetry relocations. On the bearings that were used, error was similar in magnitude to that found by Lee et al. (1985). Relocations along the powerline showed minimal error. For six test relocations within 350 m of the line, the average north-south error was 50 m. Interference from the powerline was not considered a major factor in telemetry error. Winds in excess of 18 km/hr did not seem to affect telemetry error. Radio frequency noise at 74.5 MHz and precipitation explained 45 percent of the variation in the ability to find the good null signal essential to determining an acceptable bearing.

Pellet Group Surveys

Relative intensity of use, measured by Cole's (1975) pellet group survey methods, was influenced by climate. The steeper, south-facing slopes along the North Boulder Road received more intense use in 1985 than they did in the previous two winters. This was probably a result of tougher foraging conditions and less access to foraging areas elsewhere on the study site due to greater snow cover. The results from the Cole pellet group surveys conducted in 1985 are similar to the results from data collected in 1975 by the Forest Service. The winter of 1974-75 was climatically ranked (Picton 1979) as -3. This ranking falls in the normal range for severity as does the winter of 1984-85.

Data from the pellet group transects that paralleled the powerline could have been affected by the closer to normal snow cover that existed in the winter of 1985, cattle use the previous summer, the powerline, or a combination of all three. Areas that were known to have higher counts for the previous two winters did not receive as much use by elk in 1985. The majority of transects showed some reduction in pellet groups each season (Figure 20). Cattle use in the summer seemed to negatively affect the number of pellet groups occurring on the parallel transects (Canfield 1984). The same areas that would be heavily grazed by cattle in the summer have a tendency to accumulate snow cover during an average winter. This combination of livestock use and snow cover tends to discourage elk from grazing in these areas and forces them to seek out areas where forage is more accessible. As a result the elk would move farther from the powerline in a southerly direction and concentrate on the steeper slopes with southern and western aspects. On 70 % of the transects, a major reduction (50 % or more) in the number of pellet groups occurred between the two post-energization seasons of 1984 and 1985. This suggests that the powerline might also have affected the distribution of pellet groups along the corridor. Data collected in 1983 (Canfield 1984) from these pellet transects is biased (Figure 20) due to an accumulation of pellet groups from previous winters before this study began. Unfortunately, I was unable to distinguish between the effects of the snow cover, cattle grazing, and the powerline when examining pellet group surveys which are close to the powerline.

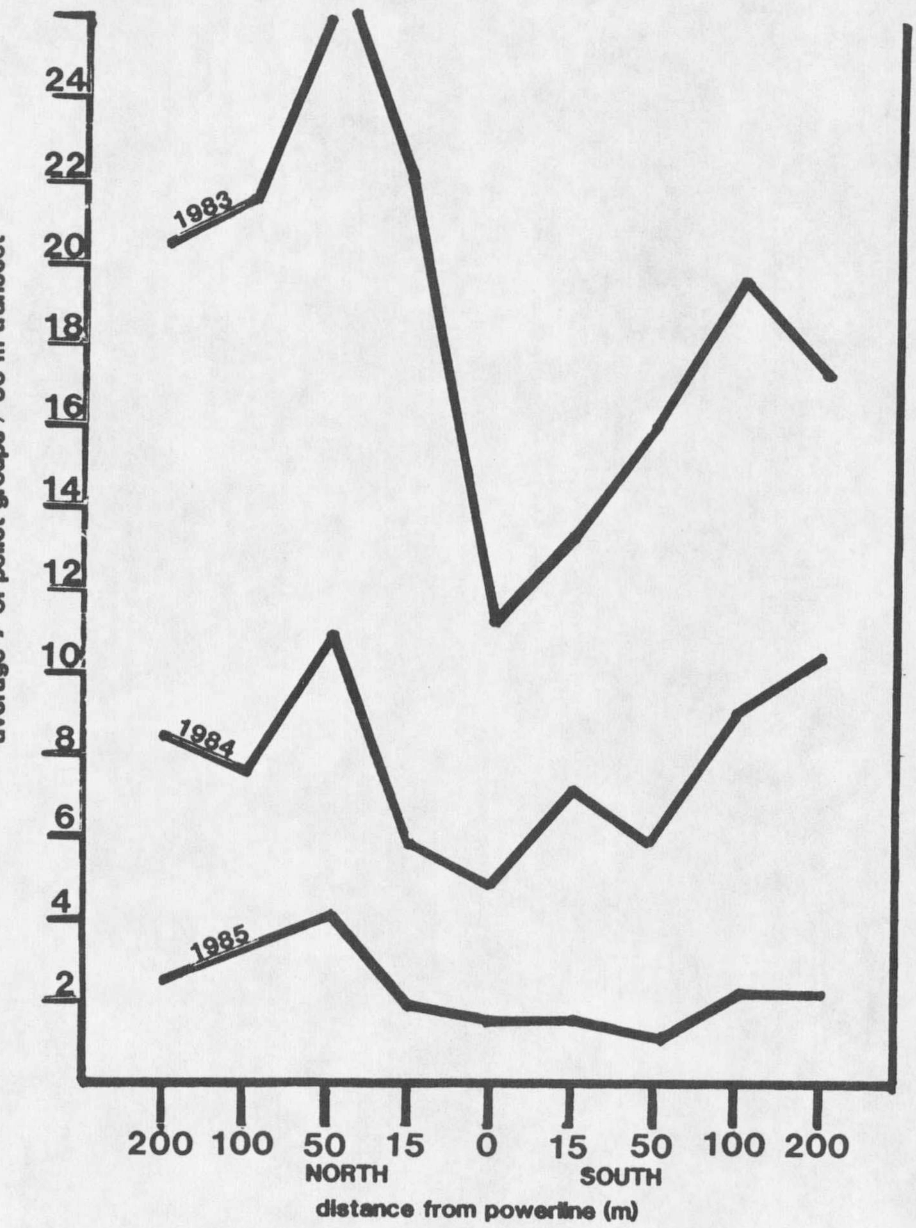


Figure 20. Average number of pellet groups per 50 meter transects parallel to the powerline.

Hunter Surveys

During the 5 days in which a hunter checking station was manned on the study area, 199 cars were checked. Of these, 138 were from Butte, 24 were from Helena, and 37 were from various other communities. Eighty-one responses to the road closure questions were recorded. Sixty-two % of the responses were in favor of the closures, 23 % were against the existing closures and 15 % were indifferent. Nineteen elk carcasses were examined during the survey. One elk examined was wearing a radio-collar, however the collar was no longer functioning.

SUMMARY

A substantial portion of the North Boulder elk herd has the potential to be directly exposed to the 500 kV powerline twice a day on any given day from early December to late April. Thus the question becomes "To what degree are the elk affected, and are these effects beneficial or detrimental to the population?".

No "turnback behavior" could be inferred from the monitoring of the track transects. Canfield (1984) found no "turnbacks" either, although she felt that the presence of well-used crossing trails on two of the four sets of transects caused the data to be too variable. The important point is that elk were crossing the powerline corridor instead of turning back.

The lack of corridor crossings one or two days following a storm was offered as being the result of elk avoiding the powerline due to increased audible noise during precipitation (Canfield 1984). Other explanations for this phenomenon, such as travel variability and weather affecting both elk habits and tracking conditions, should not be discounted.

Inclement weather should be considered a factor when trying to explain the absence of corridor crossings during the 48 hour period after precipitation. Elk were observed several times seeking shelter or unwilling to forego shelter during cold and windy, or snowy and windy weather conditions. The winter of 1985 had a greater potential for windchill effects than did the two previous winters due to colder temperatures. The weather conditions both before and after winter storms may be severe enough to cause elk to seek thermal shelter (Clutton-Brock et al. 1982, Skovlin 1982). Low barometric pressure disrupted daily routines of Roosevelt elk and caused a higher degree of nervousness (Harper 1962), while tule elk acted "wild and nervous" during windy days and quite relaxed and unconcerned during calm days (McCullough 1969).

In the winter of 1984-85, a crossing of the corridor by elk during a snowstorm was documented. The audible noise (Lee and Griffith 1978) produced by the powerline during precipitation was not sufficient to prevent this group of elk from crossing the corridor and reaching preferred feeding areas.

Canfield (1984) observed four occasions in which tracks did not cross transects along the powerline. All of these instances occurred one or two days following precipitation. I observed an absence of track crossings under similar weather constraints on two occasions. Conversely, the absence of tracks crossing the powerline with no previous precipitation having fallen for at least four days was also observed on one occasion. This suggests that the absence of powerline crossings may be caused by something other than, or in addition to, noise caused by precipitation. A confirmed powerline crossing during a snowstorm and the absence of track crossings without previous precipitation do not support the hypothesis of audible noise during precipitation discouraging elk from crossing the powerline (Canfield 1984). If a conditional response is involved, these occurrences do not necessarily refute this hypothesis.

Monitoring the sets of track transects gave me the impression that elk regarded the powerline as an obstacle to be crossed, much as they would a fence. I was unable to determine if the obstacle becomes a barrier during certain times (e.g. during precipitation), changing the behavior patterns of the elk population (Geist 1982).

Measuring the amount of stress experienced by elk crossing the powerline was beyond the limits of this study, however observing some crossings in which elk showed an alarm response indicated that in some cases elk considered the powerline a threat (McCullough 1969, Murie 1951).

Telemetry and pellet group surveys both showed the importance of core activity areas north and south of the powerline. Direct observations documented the importance of travel avenues between these core areas. These avenues were generally underrated using other methods. The majority of the travel routes crossed a segment of the powerline at some point.

The observations made to date suggest that elk are using all parts of the winter range within the limits of terrain, snow cover, available forage, and human disturbance that was present before the construction of the powerline, although there may be some differences in intensity of use for some areas.

During the 1984 big game hunting season, some road closures were implemented and enforced by the Forest Service. Hunters' comments in favor of the road closures cited less hunters and less game harassment as benefits. Hunters not in favor of the road closures felt that closures made it difficult to retrieve game, discriminated against hunters that were older and less physically able, and made it impossible to kill the number of elk that would reduce the population to the desired level. A majority (69 %) of the hunters that came through the checking station were from Butte.

No beneficial effects for the elk population were documented. Unlike the study by Goodwin (1975), open areas are not at a premium on the North Boulder winter range. The powerline corridor is situated in a manner that separates the timbered security cover from the open feeding areas, but it does not create new feeding habitat for the elk.

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