



Elk habitat use and the impact of the construction and energization of a 500-KV ac powerline on the North Boulder Winter Range, Montana
by Jodie Ellen Canfield

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:

Elk habitat use, activity patterns, and winter distribution, before and after energization of a 500-kV AC powerline which crosses critical winter range in southwestern Montana, was studied during the mild winters of 1983 and 1984. Methods included 24 hour continuous radio-monitoring, track and pellet group counts, and direct ground and aerial observations. Habitat use by the elk herd, which apparently was at or above carrying capacity, was influenced by weather parameters, distribution of available forage (as influenced by snow conditions and cattle grazing), and population density. The powerline crosses a bunchgrass range at about the level where timber begins, and elk typically crossed the powerline corridor twice a day while traveling between bedding and feeding areas. Powerline construction in the spring of 1983 displaced radioed elk prior to spring migration. Four of 11 elk with functional radios did not return to the study area to winter in 1984 after the powerline was energized. The physical presence of the powerline did not alter elk distribution or activity patterns, however, noise generated from corona discharge off the conductors during precipitation caused elk to hesitate and show excitability before crossing a "noisy corridor", and may alter basic elk daily activity patterns during storms. It is not expected that elk will further acclimate to precipitation noise levels because the rate of animal exposure is low on the relatively arid North Boulder range, and the corridor itself is not an attractive forage source. The level of impact from corona noise may change with more severe winter conditions if elk are forced by deep snow to congregate on lower elevations entirely below the powerline corridor. The number of hunters declined from historical figures in the area after powerline access roads were built. Hunter distribution also changed, however, total harvest remained the same. Placement of future extra high voltage (EHV) lines should consider not only the effect of the physical presence of the corridor and towers on wildlife, but also the potential impacts of electro-magnetic fields and corona discharge. It is recommended that future EHV lines are not placed across concentrated big game use areas.

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A thesis submitted in partial fulfillment
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MONTANA STATE UNIVERSITY
Bozeman, Montana

November 1984

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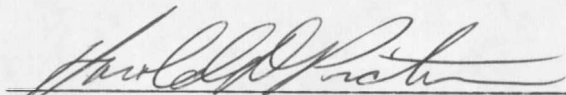
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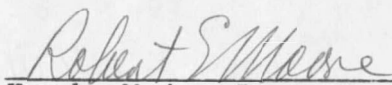
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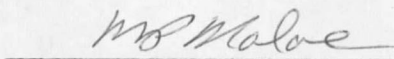
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ACKNOWLEDGEMENT

I wish to express my sincere appreciation to the following people for their valuable contributions to this study: Dr. H. D. Picton, Montana State University, major advisor, who invested time and energy in all phases of the study; Dr. R. J. Mackie and Dr. R. E. Moore, MSU, for review of the manuscript; Mr. D. Burkhalter, MSU computing services, for conducting the computerized statistical analyses and for assistance with TELDAY; Mike Paterni and Tina Crump, Deerlodge National Forest, for their tremendous contributions to the fieldwork; Mike Frisina, MDFWP area manager, for conducting the trapping operations and providing background information; Mr. Jack Lee and others of the Bonneville Power Administration for providing constructive criticism, technical publications, and weather and noise data; The Gallatin Flying Service for their expertise in aviation and locating elk; the many volunteers from the Deerlodge National Forest and Montana State University who made the 24 hour monitoring sessions and pellet group counts a success; Ron Spoon for field assistance, encouragement, and patience; my family for their support throughout my academic endeavors; and my dog Mac for his constant companionship in the field.

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ABSTRACT

Elk habitat use, activity patterns, and winter distribution, before and after energization of a 500-kV AC powerline which crosses critical winter range in southwestern Montana, was studied during the mild winters of 1983 and 1984. Methods included 24 hour continuous radio-monitoring, track and pellet group counts, and direct ground and aerial observations. Habitat use by the elk herd, which apparently was at or above carrying capacity, was influenced by weather parameters, distribution of available forage (as influenced by snow conditions and cattle grazing), and population density. The powerline crosses a bunchgrass range at about the level where timber begins, and elk typically crossed the powerline corridor twice a day while traveling between bedding and feeding areas. Powerline construction in the spring of 1983 displaced radioed elk prior to spring migration. Four of 11 elk with functional radios did not return to the study area to winter in 1984 after the powerline was energized. The physical presence of the powerline did not alter elk distribution or activity patterns, however, noise generated from corona discharge off the conductors during precipitation caused elk to hesitate and show excitability before crossing a "noisy corridor", and may alter basic elk daily activity patterns during storms. It is not expected that elk will further acclimate to precipitation noise levels because the rate of animal exposure is low on the relatively arid North Boulder range, and the corridor itself is not an attractive forage source. The level of impact from corona noise may change with more severe winter conditions if elk are forced by deep snow to congregate on lower elevations entirely below the powerline corridor. The number of hunters declined from historical figures in the area after powerline access roads were built. Hunter distribution also changed, however, total harvest remained the same. Placement of future extra high voltage (EHV) lines should consider not only the effect of the physical presence of the corridor and towers on wildlife, but also the potential impacts of electro-magnetic fields and corona discharge. It is recommended that future EHV lines are not placed across concentrated big game use areas.

INTRODUCTION

Rocky Mountain elk (Cervus elaphus nelsoni) and the hunting opportunities they create are a source of recreational wealth and economic benefit (Boyd 1978). As a species, elk provide the most days of hunter recreation in the state of Montana (Aderhold 1984). Rich coal deposits in Eastern Montana also generate economic benefits and provide energy for the needs of a growing human population.

The "Colstrip Project" was designed to use these coal resources in order to meet anticipated demands for electrical energy in the Pacific Northwest. The final phase of the project was to build a 500-kV AC electrical transmission line. The Montana Power Company built the line from Colstrip to Townsend, Montana, and from there the Bonneville Power Administration (BPA) continued the line west to integrate Colstrip power into the BPA transmission grid (Colstrip EIS 1979). The BPA portion of the line in Montana skirts the Elkhorn Mountains between Townsend and Boulder, continues up the North Boulder River drainage, and crosses the eastern foothills of the Continental Divide west of Basin.

The foothills, rising up from the North Boulder River, constitute the only major elk wintering area in hunting district 318 (Egan 1967). Mule deer (Odocoileus hemionus) and moose (Alces alces shirasi) also winter in the area.

The Colstrip EIS (1979) states that the impacts of the extra high voltage (EVH) transmission line on deer and elk range would be long-term, high, and direct in terms of cover removal, forage disturbances due to road and tower construction, increased stress on animals due to human activities and access roads, and potential fragmentation of habitat.

Other phenomena associated with EHV lines include electrical fields, magnetic fields, and corona discharge which results in foul weather audible noise and ozone production. Sheppard (1983) suggested that there are significant biological interactions with electric fields in the "high voltage transmission line" environment. However, it was beyond the scope of this study to investigate these aspects as they relate to elk in a field situation.

Responses of big game to EHV powerlines and the use of associated corridors were evaluated by Goodwin (1975) and Griffith (1977). Relative to these studies, the current study is unique in that it provided the

opportunity to gather data both before and after energization of the line, during the years of greatest habitat disruption, and at altitudes above 1500 m.

Elk winter range in the N. Boulder drainage is limited by excessive snow accumulations to the north, west, and south, and by human settlement to the east. The amount and quality of winter range is, in turn, limiting to the elk population (Chrest and Herbert 1980, Chrest and Childress 1976). Therefore, any reduction in habitat or changes in patterns of elk use associated with the transmission line, will directly affect the future populations.

There is potential for impacts of the powerline to be masked or compounded by climatic conditions, availability of forage and cover, and man's activities. It is recognized that future changes in land management on this winter range, in terms of timber harvest, cattle grazing, or recreational uses, may potentiate or ameliorate powerline effects.

Because elk are large mobile animals, it can be expected they will respond to change in their environment by adjusting behavior in regard to distribution, movement, and use of specific habitats (Mackie pers. comm. 1984).

The general objective of this ongoing study is to evaluate factors influencing elk habitat use and movements

on the North Boulder River winter range before and after energization of the powerline. The specific objectives are to (1) evaluate elk habitat selection and movement patterns on winter range in relation to climatic variables, forage availability, animal activity, the transmission line, and human activities and (2) determine if elk avoid or show distinct behavioral responses to any activity or phenomena associated with construction and operation of the powerline.

The original proposal recommended 3 years of baseline data collection and an additional 3 years to study the impacts of powerline construction and energization. Delays in funding precluded fieldwork until the winter of 1982-1983. By that time, the transmission line towers and access roads had been completed. Clearing of the corridor was completed and the lines strung in spring and summer 1983. The line was energized in October 1983, thus the second field season (1983-1984) represents the post-energization period. My field studies were conducted from late December 1982 to June of 1983 and from mid-December 1983 to late March of 1984. The overall study will continue through the spring 1985.

This study was funded by the Bonneville Power Administration (U.S. Department of Energy), and by the United States Forest Service. Mike Frisina, Montana Department of Fish, Wildlife, and Parks (MDFWP), provided assistance in capturing and marking elk.

STUDY AREA DESCRIPTION

Location and Access

The study area is in the North Boulder River drainage of southwest Montana, approximately 26 km (16 mi) north of Butte. The area includes approximately 52 km² (20 mi²), of the Deerlodge National forest and a small portion of private holdings. Boundaries are Basin Creek on the east, Little Cottonwood Creek on the west, the North Boulder River on the south, and the 2100 m (7,000 ft) contour line on the north.

Vehicular access is provided by three principal gravel roads: the Red Rock Creek road extending north off Interstate 15 near the eastern study area boundary; the Boulder River road following the valley floor from I-15 west to headwaters along the Continental Divide; and the Saratoga road running north from the river bottom along the western margin of the study area (Figure 1). In addition, there is a variety of jeep trails, logging and mining roads, and newly built BPA powerline access roads which penetrate every drainage in the area, but which are closed to motorized vehicles between December 1 and May

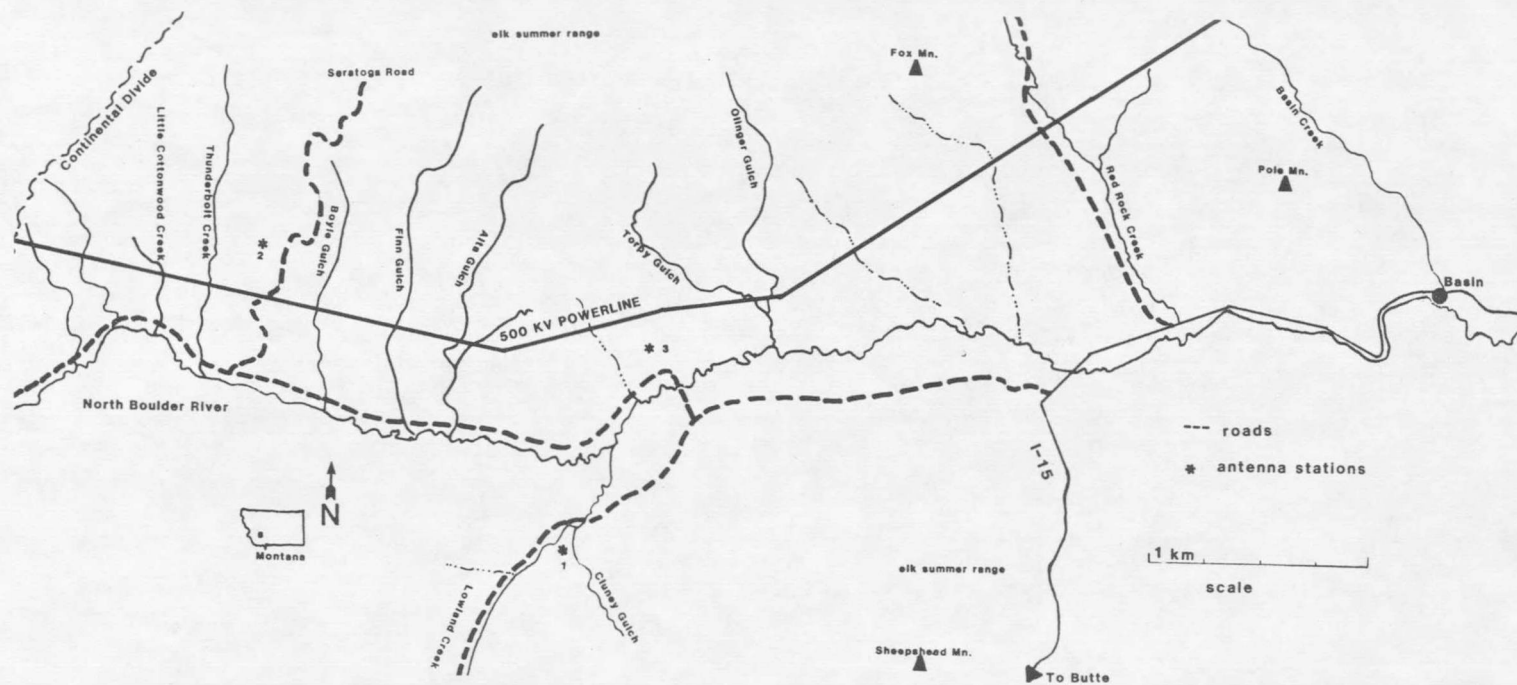


Figure 1. Map of the N. Boulder range showing location of the powerline, antenna stations, and open winter roads.

15. The road closures were implemented in 1973 by the USFS in recognition of the area as critical winter elk range.

Physiography

The area can be generally classified as a foothills region east of the Continental Divide. Ruppel (1963) described the area as the northern part of the Boulder mountains which are low and rounded. Elevations range from 1644 m (5480 ft) to 2220 m (7400 ft). The general exposure is southerly, but many small deep gulches dissect the range in a north/south direction, thus giving the area a diversity of aspects. The predominant landform is a series of ridges running north/south. Flat rolling areas and steep sided knolls are superimposed.

Geology and Soils

The area is part of the Boulder Batholith, an extensive outcropping of igneous granitic material that was formed by several small molten magma intrusions during the Cretaceous Period (Alt and Hyndman 1972). During the Tertiary, the inter-mountain valleys filled with gravels and sediments, and were later eroded and moved by the Pleistocene glaciers to create the foothills. The study area was additionally influenced by volcanic activity during the Tertiary (Ruppel 1963). Thus the parent

materials from which the area soils were derived include granitics, glacial deposits, volcanics, alluvial deposits, and noncalcareous sedimentary rocks. Stream erosion, frost churning, glacial deposition, and mass wasting are the primary processes inferred to be responsible for the geomorphology of the area (Ruppert 1980).

Soils are generally well-drained, shallow, rocky loams and sandy loams of the taxonomic order Inceptisol. Severe late summer moisture stresses occur in most of the soils on the winter range. In contrast, the summer range to the north has poorly drained soils and remains lush and green for most of the summer. More detailed information on landtypes, soils, and geology of the study area are found in Ruppert (1980), Montagne et al. (1982), and Ruppel (1963), respectively.

Climate

The area has a montane continental climate with limited precipitation and extreme temperatures. Table 1 lists the average precipitation and temperatures for Boulder, and Butte, Montana--the nearest weather recording stations to the study area (USDC-NOAA 1983).

Table 1. Climatic data summary from Butte and Boulder weather stations.

Elevation(m) at station	Mean annual precip. (1941-1970 base)	Mean July temp.	Mean Jan. temp.
Butte (1658)	30.67 cm	17.2 ⁰ C	-9.17 ⁰ C
Boulder (1471)	27.60 cm	18.6 ⁰ C	-5.78 ⁰ C

Table 2 is derived from Montana snow course records (Farnes and Shafer 1975) for Elk Park, 9 km south of the study area, and for Uncle Sam Gulch, on the eastern boundary of the study area. The elevation at both sites is 1950 m (6500 ft).

Table 2. Averages and ranges of snow depths by month at Elk Park and Uncle Sam's Gulch, Montana, 1941-1974 and 1968-1973 base respectively.

Date	Average snow depth(cm)		Range (cm)	
	Elk Park	U.S. Gulch		
January 1	----	50.9	----	33-81
February 1	39.5	73.1	20-75	58-76
March 1	46.0	74.3	23-80	43-113
April 1	40.3	70.6	18-73	55-88
May 1	23.0	46.0	00-75	00-83

The North Boulder River valley normally receives southwesterly chinook winds consistently throughout the winter and spring. These winds keep south and west slopes on the winter range relatively free of snow. Based on a

climate index for the period November to March, which used Boulder data for precipitation and temperatures, the winter of 1982-83 rated a +6, and the winter of 1983-84 rated a +9 on a scale ranging from -10 to +10 (Figure 28, Appendix A).

Vegetation

As determined by a LMS (light metering system), which computes areas of contrasting shades from aerial photographs, 54 % of the study area is timbered, 41 % is open parks, and the remaining 5 % represents riparian vegetation of the North Boulder River floodplain (Figure 2). Table 3 lists the scientific and common names of the major plant species or genera found on the study area following the classification of Hitchcock and Cronquist (1973).

Douglas fir is the predominant overstory in timber stands at lower elevations. The usual understory consists of creeping juniper, pinegrass, and kinnickinick. This association is found primarily in drainages and on north and east exposures. Ponderosa pine is present on one southern exposure with sandy soil. At higher elevations, Lodgepole Pine forms thick "doghair" stands on all but the dry southerly exposures. Old clearcuts, as well as currently active cutting units, are present above 2100 m (7,000 ft).

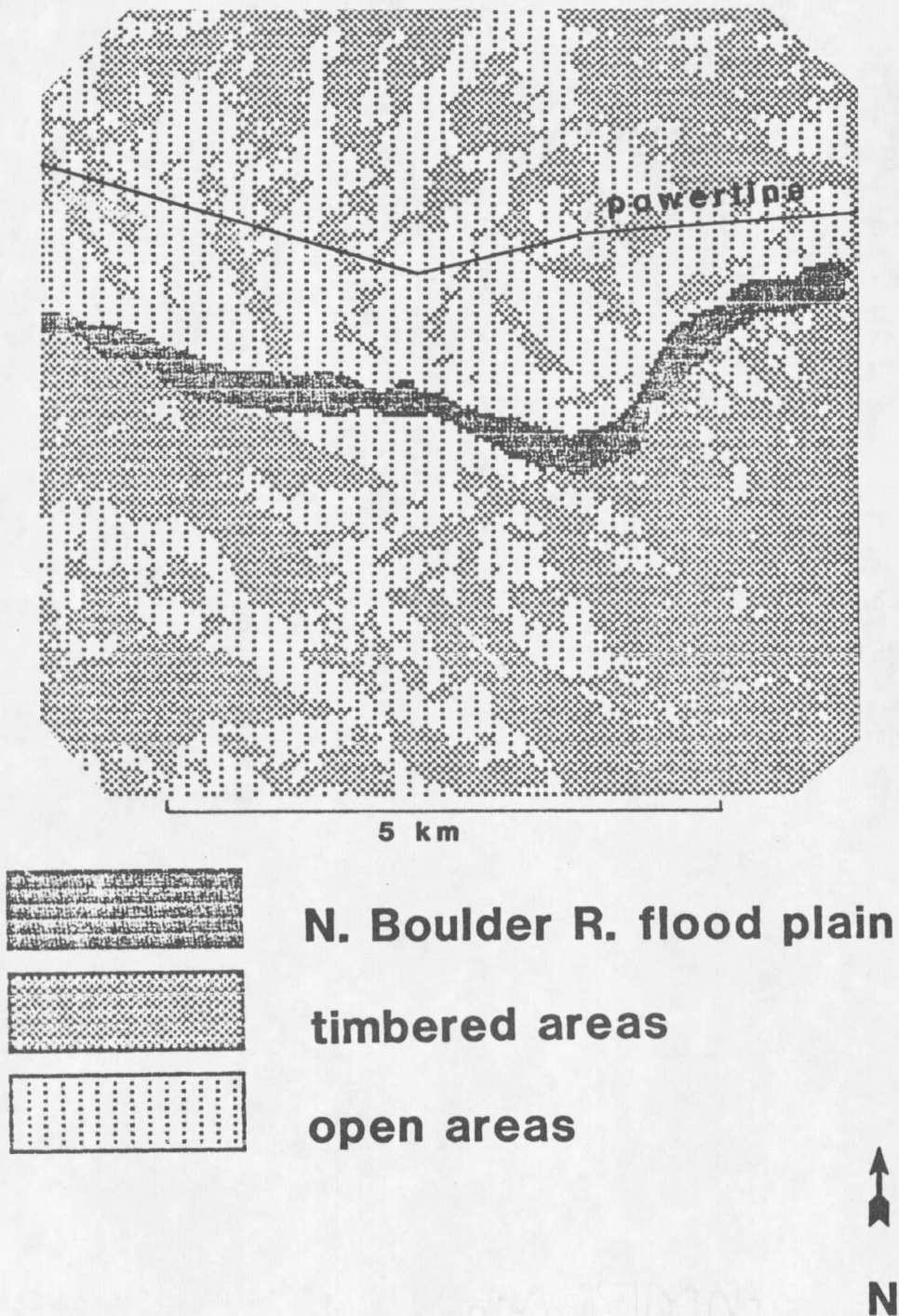


Figure 2. Map of the western two thirds of the study area and Lowland Creek showing distribution of major vegetation types.

Table 3. Major plant species or genera represented on the study area.

Genus	Species	Common name
TREES:		
<u>Pseudotsuga</u>	<u>menziesii</u>	Douglas fir
<u>Pinus</u>	<u>contorta</u>	Lodgepole pine
<u>Pinus</u>	<u>ponderosa</u>	Ponderosa pine
<u>Populus</u>	<u>tremuloides</u>	Quaking aspen
SHRUBS:		
<u>Juniperus</u>	<u>horizontalis</u>	Creeping juniper
<u>Juniperus</u>	<u>scopulorum</u>	Rocky Mn. juniper
<u>Artemesia</u>	<u>tridentata</u>	Big sagebrush
<u>Chrysothamnus</u>	<u>viscidiflorus</u>	Green rabbitbrush
<u>Artemesia</u>	<u>frigida</u>	Fringed sagewort
<u>Purshia</u>	<u>tridentata</u>	Bitterbrush
<u>Artostaphylos</u>	<u>uva-ursi</u>	Kinnickinick
<u>Douglasia</u>	<u>montana</u>	Mountain douglasia
<u>Amelanchier</u>	<u>alnifolia</u>	Serviceberry
<u>Rosa</u>	<u>woodsii</u>	Wood's rose
<u>Potentilla</u>	<u>fruticosa</u>	Cinquefoil
<u>Prunus</u>	<u>virginiana</u>	Chokecherry
<u>Berberis</u>	<u>repens</u>	Oregon grape
<u>Salix</u>		Willow
FORBS:		
<u>Lomatium</u>	<u>cous</u>	Mountain lomatium
<u>Lupinus</u>		Lupine
<u>Astragalus</u>		Milkvetch
<u>Phlox</u>		Phlox
<u>Arenaria</u>		Sandwort
<u>Antennaria</u>		Pussytoes
<u>Taraxacum</u>		Dandelion
<u>Selaginella</u>		Clubmoss
GRAMINOIDS:		
<u>Agropyron</u>	<u>spicatum</u>	Bluebunch wheatgrass
<u>Festuca</u>	<u>idahoensis</u>	Idaho fescue
<u>Festuca</u>	<u>scabrella</u>	Rough fescue
<u>Bromus</u>		Bromegrass
<u>Koeleria</u>	<u>cristata</u>	Junegrass
<u>Danthonia</u>		Oatgrass
<u>Poa</u>	<u>sandbergii</u>	Sandberg's bluegrass
<u>Carex</u>	<u>filifolia</u>	Threadleaf sedge
<u>Carex</u>	<u>geyerii</u>	Elksedge
<u>Calamagrostis</u>	<u>rubescens</u>	Pinegrass

Grasslands extend from the valley bottom to about 1950 m (6500 ft) on southerly aspects. The predominant association is bluebunch wheatgrass and Idaho fescue. Rough fescue occurs on much of the area and appears to be heavily used by both cattle and elk. Big sagebrush is found in dense stands on a few local sites in the study area, typically on southerly exposures. Bunchgrasses are often abundant under individual sagebrush plants.

Aspen stands are found throughout the study area in swales and creek bottoms. Elk browsing has severely curtailed reproduction, and some bark stripping is evident. Bluegrasses are the usual understory.

Riparian communities occur in all the drainages in the area. Willows are the dominant vegetation, but a variety of other shrubs and sedges are found. Beaver activity has resulted in extensive willow development on parts of the valley floor. However, other areas of the North Boulder River valley produce a dense tall stand of grasses which are harvested annually for hay to feed wintering livestock.

Land Use

Historically, the Boulder Batholith has been the source of many valuable deposits of copper, silver, and

gold. The remnants of mining activities, including dredging and exploratory adits, are currently visible on the study area.

Current multiple use activities on National Forest lands include timber harvest, cattle grazing, and recreational uses. There are three campgrounds and two trailheads on the N. Boulder road. Hunting, fishing, and snowmobiling attract many people to the area year round.

History of the Herd

Reports of elk using the N. Boulder winter range date back to the 1940's. Between 1939 and 1968, over 500 elk were planted in the vicinity of the study area (hunting district 318) from Yellowstone Park. Tag returns through the years revealed that most of the transplanted elk were harvested in hunting district 318 (Egan 1967).

The Transmission Line

The powerline essentially divides northern timbered areas from southern grasslands across most of the elk winter range (Figure 2).

Between Pole Mountain and Torpy Gulch (Figure 1), the line follows an abandoned telephone line corridor; between Torpy Gulch and Thunderbolt Creek, it was placed on open ridgetops and across steep gulleys. This placement

resulted in minimal forest clearing. The major vegetative disturbance was for tower bases and access roads. Approximately 1% of the study area was disturbed by powerline construction.

The right-of-way width for a double circuit 500-kV AC transmission line is 42.6 m. Towers are of a stack configuration design, 53.6 m tall and 17.2 m wide.

METHODS

Radiotelemetry

Individual radiocollared elk were used to study general distribution of elk on winter range, winter movements, seasonal movements, and daily home ranges. From this data base, inferences were made about the following: habitat selection in relation to activity periods, elk distribution in relation to the transmission line, elk response to powerline energization and to human disturbances (hunting, construction activities), and elk distribution and movement patterns in relation to climatic factors. Radiocollars consisted of AVM transmitters inserted into molded PVC plastic pipe. A unique symbol or color combination identified each collar.

Fifteen cow elk were collared and eartagged in January 1983. Elk were captured using a dart gun from a helicopter. M-99 was the immobilizing drug. While the cow was immobilized, age was estimated from tooth replacement and wear, pregnancy status was determined by uterine palpation, and fecal and blood samples were collected. Fecal samples were later analyzed by Wayne Kasworm (MDFWP) for food habit information.

Aerial relocations were made bimonthly in winter and spring and once a month for the remainder of the year (weather permitting) from a Piper Supercub with a belly mounted three element Yagi antenna and an AVM model LA12 receiver. The general distribution of all elk observed on the winter range was also recorded during each flight.

Three permanent ground triangulation stations were established in locations such that bearings from any two stations to heavy elk use areas on the winter range formed an angle as close to 90^0 as possible (Figure 1). Each station employed a Telonics TAC-5 precision direction-finding array with dual three element antennas. A compass rose provided direction from each antenna. It was calibrated from true north using a compass and the angle of declination. These calibrations were then checked using stationary transmitters (beacons) at known locations and compass bearings from the stations. Stationary beacons were also used to test the accuracy of the system.

Stations were manned (2 people per station) twice a month by student volunteers from MSU and personnel from the Deerlodge National Forest. Placement of at least 1 person (per station) experienced in interpreting signal characteristics yielded the most accurate information (as Pac (1978) also suggested). An attempt was made to locate all radioed animals (simultaneously from all stations) every 2 hours over a 24 hour period. Compass bearings

from each station were compiled, and the elk locations triangulated on photo-orthoquad maps. Questionable locations were disregarded (evaluations were made from observer comments). Each elk location was described and converted into the computer format given in Table 21, Appendix B. Data were plotted and analyzed using the computer program TELDAY (MDFWP). Statistical analyses, using the SPSS software package and a programmable calculator, included means, standard deviations, ranges, frequency distributions, Student's t-tests, linear regression, and two-way analysis of variance.

The availability of habitat components was determined through systematic random point descriptions of the study area from a photo-orthoquad map. A total of 334 points were described using the following variables: distance to the main road, distance to the powerline, distance to timbered cover, elevation, topography, slope, aspect, and vegetation type (Table 21, Appendix B). Discriminate Analysis (SPSS) was used to determine statistical differences between habitat components at elk 24 hour locations and random habitat points. This procedure weights and combines the variables measured in a linear fashion in order to maximize the differences between the two groups being compared (Klecka 1975). In this case, it

gives an indication of elk habitat selection for any measured variable relative to its availability on the winter range.

Direct Observations

Visual observations were made on a daily basis when possible from topographic high points (often the antenna stations) and from on foot in the field. Because elk were only visible at dawn and dusk, observations were made at these times using 7 X 35 binoculars and a 32 X spotting scope. Due to bias of these observations toward open habitats and feeding activity periods, these data were used only to compare the distribution of unmarked groups of elk between years. Observations were recorded in the computer format given in Table 21, Appendix B, and plotted relative to the powerline using the program TELDAY.

Pellet and Vegetation Transects

General distribution of elk on the winter range during the period 1982-1984 was also examined using pellet group counting routes which sampled the entire study area. These routes were marked on aerial photograph overlays and walked each year in late spring. The observer recorded the change in relative density of pellet groups according to the method described by Cole (1975). Similar information was collected in 1975 for this area.

Ten permanently marked pellet transects were used to measure elk distribution in relation to the powerline right-of-way. Each transect consisted of 9 lines, each 50 m in length, layed out under the centerline and at parallel distances of 15, 50, 100, and 200 m north and south from the outer conductor of the powerline. In the spring of 1983, the total number of pellet groups within one m on either side of the line was counted on each line of each transect. This procedure was repeated in 1984, including only "fresh" pellet groups.

Concurrent with pellet counts, vegetation utilization was measured on 7 of the 10 transects. The nearest bluebunch wheatgrass, Idaho fescue, or rough fescue plant to each 1 m mark on a 50 m tape was recorded as grazed or ungrazed, and its height was measured. Slope, aspect, and vegetative cover were recorded for each line of each transect. This procedure was followed in spring 1983 and 1984, and in fall 1983 after cattle were removed from the study area allotments. Cattle utilization on bunchgrasses was calculated using the percent of plants grazed and USFS height/weight curves. Transect data were analyzed using multiple regression (SPSS). The number of pellet groups (representing elk use) and total plant utilization were entered as dependent variables in two separate analyses; slope, aspect, vegetative type, distance from the powerline, and direction from the powerline were

entered as independent variables. In the 1984 regression, cattle utilization (as measured in the fall of 1983) was entered as an additional independent variable. Stepwise multiple regression gives an indication of which independent variable or set of variables best explains the variation in the dependent variable.

Track Transects

During the winter, elk use of the powerline right-of-way was examined using track count transects. Four transects, each consisting of a 100 m line under the powerline and a parallel line 100 m both north and south of the corridor, were examined after every snow storm. After the powerline was energized in 1983, transects were measured more frequently to investigate possible elk avoidance of the powerline during precipitation noise levels.

Climatic Measurements

Snow Depths

In January 1983, ten snow stakes were stratified in one drainage on the study area by elevation, slope, aspect, and cover type. In March 1983, an additional

eight stakes were placed at higher elevations. In both 1983 and 1984, snow depths were monitored once a week from first snowfall to snowmelt for use in estimating snow depths at elk locations and monitoring general snow conditions over time. Wind speeds and directions were also estimated at each stake.

Temperature

In January 1983, a transect consisting of six min/max thermometers, placed every 50 m in elevation up a steep north timbered slope, was read once a week to document temperature extremes and the presence of inversions. It was removed in 1984 because there was no indication of any inversions in this area and because the Bonneville Power Administration established a weather and noise monitoring station on the study area in May 1983. I continued to record daily temperature extremes and the occurrence of precipitation from one location on the study area in 1984.

The BPA Monitoring Station provided weather and audible noise data for the days in which elk were monitored for 24 hour periods in 1984. BPA also provided graphical monthly summaries of audible noise for the 1984 field season. Technical information on audible noise emission from EHV powerlines was obtained from BPA publications.

Boulder and Butte weather station data were used to determine long-term climatic trends and to gather additional weather data relevant to the study period.

Hunter Surveys

For two weekends during the general big game hunting season both years, hunter checking stations were operated on the study area. Hunters were asked to answer a questionnaire concerning how they hunted the area and the number and location of animals seen or killed. Although not specifically requested, some offered their opinion about the new BPA transmission line and access roads.

Historical Information

Ten years of baseline data concerning hunting pressure and success, elk population trends, productivity, and distribution of the elk herd on the study area was available from MDFWP reports. Other historical information was collected from the files of MDFWP biologist Mike Frisina.

Historical information concerning cattle grazing on the study area allotments and previous elk/cattle forage allocation conflicts was gathered from USFS records (Deerlodge National Forest) and from the files of Mike Frisina.

RESULTS

Population Dynamics

The North Boulder winter range is used almost exclusively by cows, calves, and yearling bulls. The size of the wintering population has increased an average of 7 % per year between 1964-1984 (Figure 3). Herd productivity (calves per 100 cows) has fluctuated between a high of 70 in 1974 to a low of 29 in 1982. Ratios for the winters of 1983 and 1984 were 37 and 45 respectively. Of the 15 cow elk palpated for pregnancy in January 1983, 11 were pregnant, including one of two yearlings. The number of calves per 100 cows was negatively correlated with the number of cows (from trend counts) on winter range ($r = -.65$), but the absolute number of calves was positively correlated with the total number of cows ($r = .79$), and the total number of elk counted during winter trend counts ($r = .91$).

Trapping and Telemetry

Table 4 summarizes the data on capture and fate of the radiocollars put out in 1983. A total of 1301 radiolocations and 713 visual observations were compiled

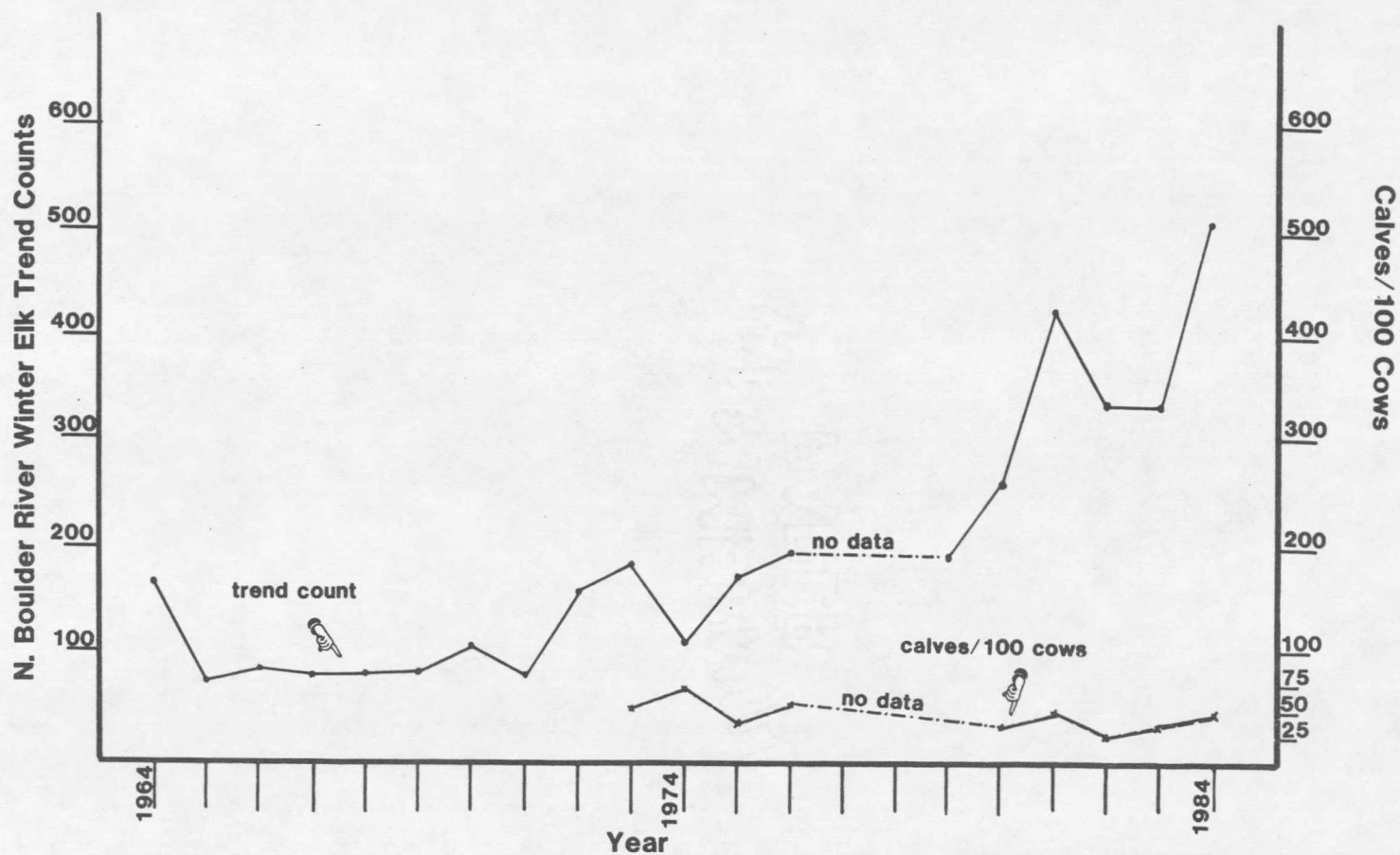


Figure 3. Calf/cow ratios and total number of elk during MDFWP winter trend flights on the N. Boulder winter range, Mt.

Table 4. Summary of elk capture data and fate of the radiocollars put out in January 1983.

Elk ID	Age	Trap location	Fate of collar
1	8-10	lower Alta Gulch	elk legally shot in 1983; put out again in 3/84.
2	2	w. of Finn Gulch	transmitter malfunction in February 1983; collar never recovered.
3	4-6	upper Alta Gulch	transmitter on original elk and functioning in June 1984.
4	2	n. of Berkin Flat	transmitter malfunction in June 1983; collar never recovered.
5	3	lower Boyle Gulch	transmitter on original elk and functioning in June 1984.
6	2	lower Finn Gulch	transmitter on original elk and functioning in 6/84.
7	4-6	w. of Finn Gulch	transmitter on original elk and functioning in 6/84.
8	5-7	w. of Alta Gulch	transmitter on original elk and functioning in 6/84.
9	5-6	w. of Alta Gulch	transmitter on original elk and functioning in 6/84.
10	6	Torpy Gulch	signal traced to ridge on summer range; collar buried under snow and not on an elk.
11	Ad.	w. of Torpy Gulch	transmitter on original elk and functioning in 6/84.
12	1	Berkin Flat	transmitter on original elk and functioning in 6/84.
13	1	w. of Torpy Gulch	transmitter on original elk and functioning in 6/84.
14	3-4	lower Finn Gulch	transmitter on original elk and functioning in 6/84.
15	6-8	upper Alta Gulch	transmitter on original elk and functioning in 6/84.

over 2 years fieldwork. The average ground telemetry system error, determined from stationary radios at known locations, was less than .2 km. This error is less than reported by Biggins and Pitcher (1978) and Lonner and Hammond (1980), and possibly due to shorter triangulation distances and improved accuracy of the TAC-5 system over a standard null-peak system. The stationary transmitters were also used to test for possible distortion of triangulated locations by the powerline. No influence was detected.

General Elk Distribution

High Use Areas

Winter aerial surveys (Figure 4), relative pellet group density (Figures 5 and 6), and total winter elk radiolocations (Figure 7) show general elk distribution on the N. Boulder winter range. Heavy use areas have in common moderately steep bunchgrass parks with nearby timber patches. Lower use areas are those with dense timber having little or no understory.

Influence of Snow Cover

The correlation between the distribution of available forage in an average snow year (Frisina et al. 1976) and the percent of marked and unmarked elk relocations (for

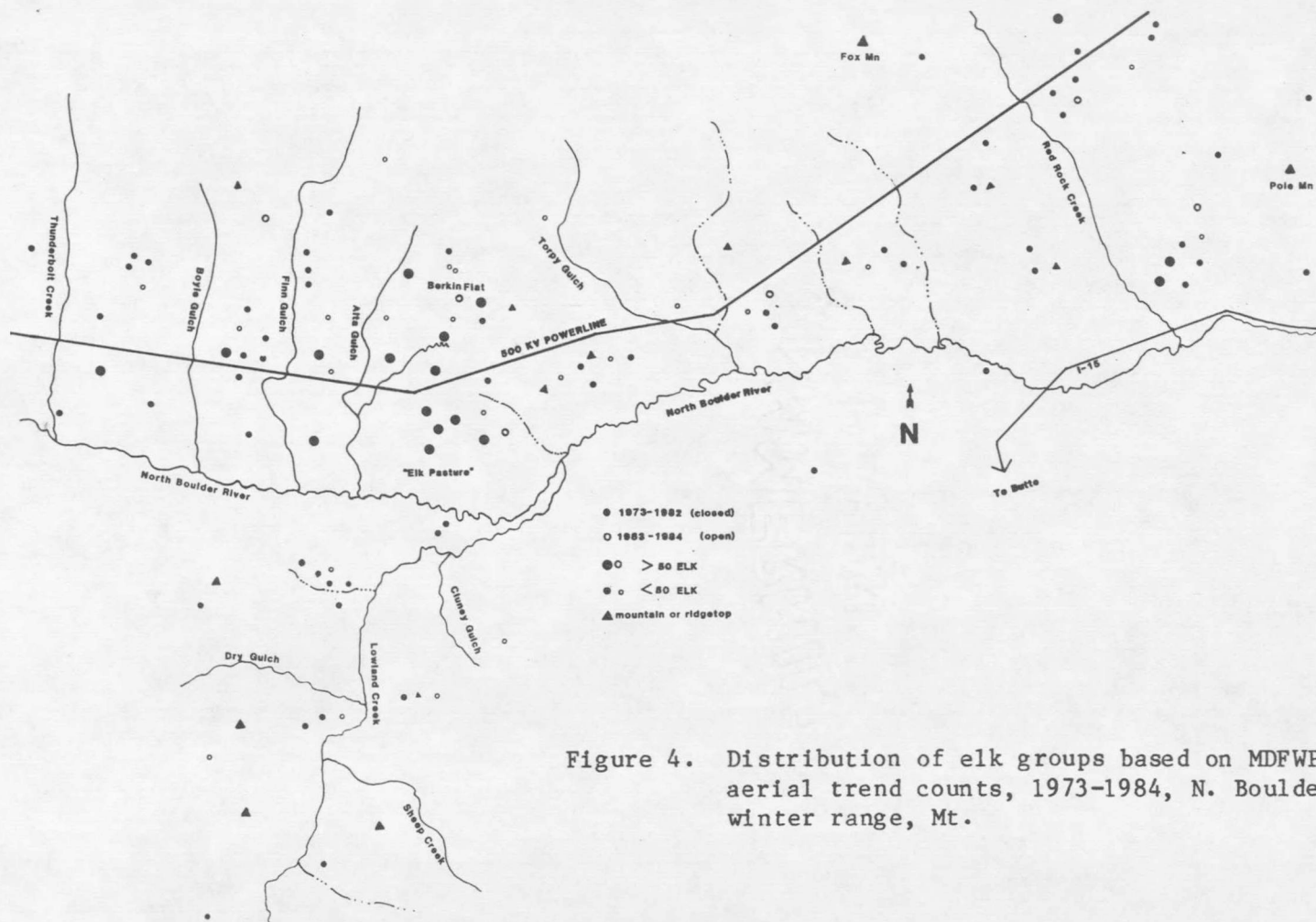


Figure 4. Distribution of elk groups based on MDFWP aerial trend counts, 1973-1984, N. Boulder winter range, Mt.

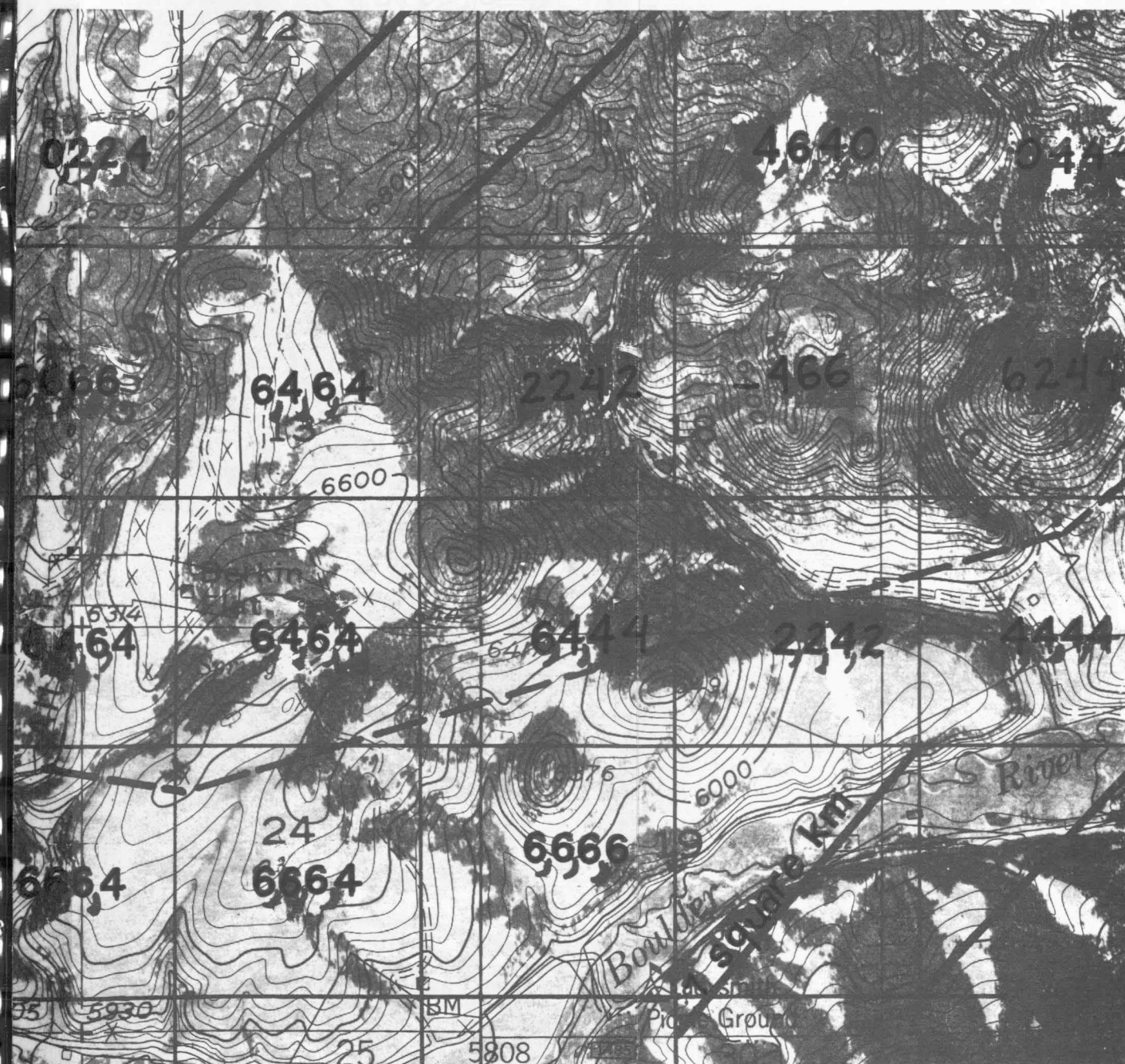
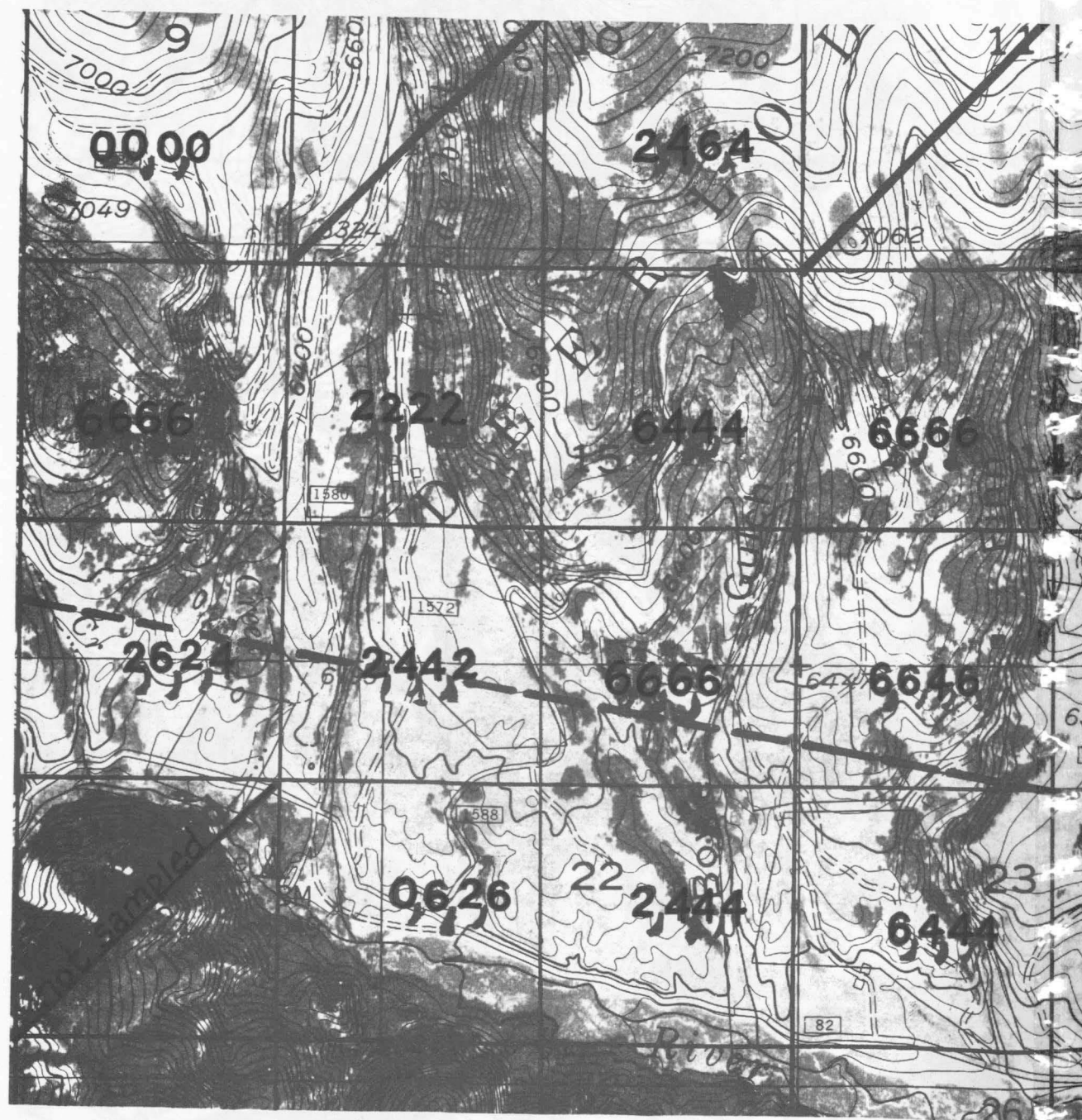


Figure 5. Relative densities of pellet groups per square km on the western end of the N. Boulder winter range in 1975, 1982, 1983, and 1984. High=6, medium=4, low=2 (Cole 1975).

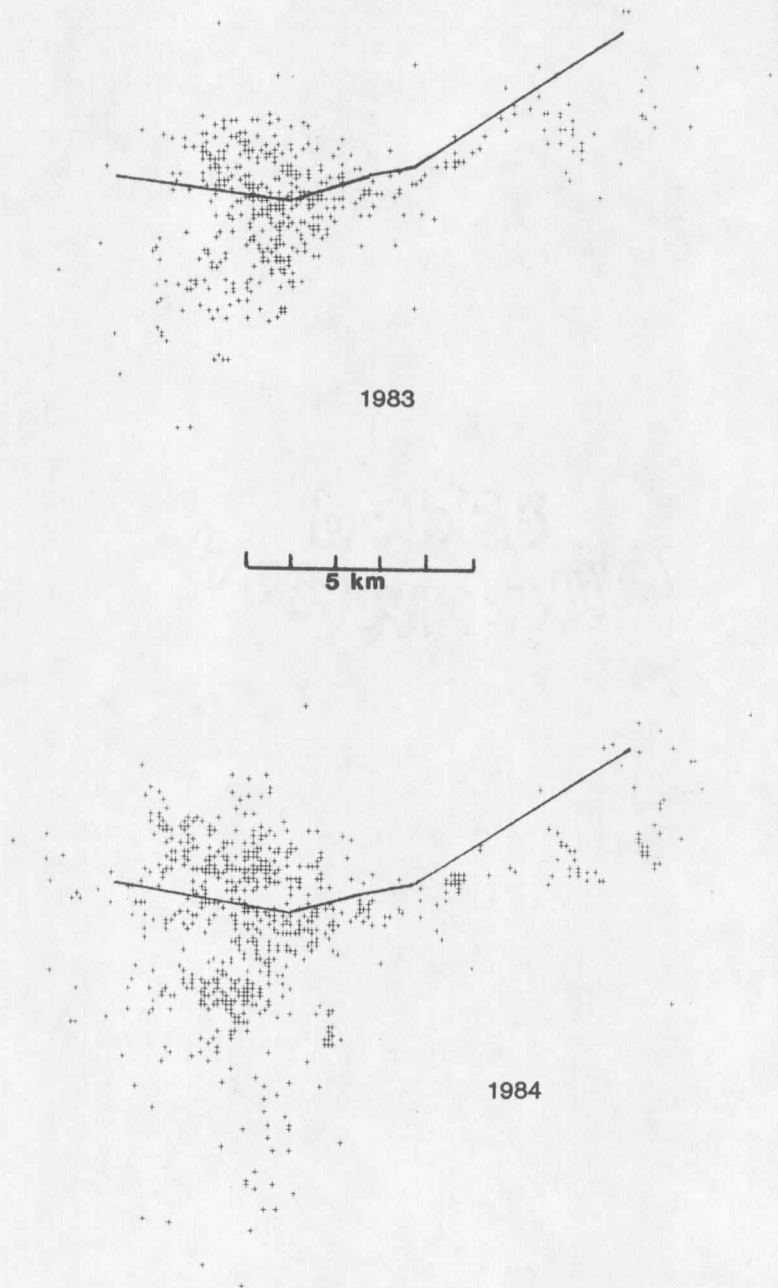


Figure 7. Distribution of elk on the N. Boulder winter range between January and March of 1983 and 1984 based on total visual observations and radiolocations.

both years combined) in a given pasture was high ($r=.91$ and $r=.78$ respectively) (Table 5).

Table 5. Elk distribution in relation to forage distribution within each pasture, 1983 and 1984, N. Boulder winter range, Montana.

Pasture	% Available forage N=7.89 sq.km	% Unmarked elk ¹		% Marked elk ²	
		1983 N=303	1984 N=410	1983 N=775	1984 N=526
Pole Mn.	3	1	4	2	2
Carlson	NA	9	16	3	3
Red Rock	8	13	7	3	1
Torpy	4	8	11	4	3
North	NA	0	0	1	8
Terry	7	0	2	1	7
Lowland	NA	5	2	25	18
Elk	28	21	27	17	15
Boyle	16	11	13	15	17
Berkin	28	21	9	28	26

¹ The percentage of all unmarked elk observed in a given pasture

² The percentage of 24 hour relocations for radioed elk within a given pasture

NA: Information not available

Food Habits

The importance of bunchgrass parks to wintering elk was emphasized by winter food habit analysis. The average elk diet (as determined from 15 fecal samples taken from captured animals in January 1983) consisted of 67 % graminoids, of which bluebunch wheatgrass, rough fescue, and Idaho fescue predominated. Forbs and browse made up 15% and 18% of the average diet. These included a wide variety of species.

Winter Movements

General field and aerial observations indicated that climatic factors influenced elk movements on the study area. Snowfall that accumulated resulted in elk using lower elevations, whereas unseasonable warm periods resulted in elk use of higher elevations. Changes in mean elevation at elk locations was therefore used as an indicator of elk response to climatic conditions. The field seasons were broken into similar periods of weather based on field records and Butte temperatures and precipitation data in order to separate "normal" winter conditions from severe or mild conditions. During each period, mean elevations at elk locations were regressed against mean daily temperatures and mean weekly snow depths (averaging snowstakes from all aspects at 1920 m).

In 1983, mean elevation at elk locations was significantly correlated with mean temperature ($r=.84$) but not significantly correlated with mean snow depth ($r=-.54$). The opposite relation occurred with the 1984 correlations. That is, elevation was significantly correlated with snow depths ($r=-.85$) but not with temperature ($r=.39$). Elk in the winter of 1984 used higher elevations (Figure 8) and more area relative to the winter of 1983. The maximum areas used by radioed elk in

1983 and 1984 were 99 km² and 147 km² respectively. Although snow depths were greater in general in 1983 (Table 19, Appendix A), the predominant winds were from the southwest and kept southerly aspects snowfree. In contrast, in 1984, winds from the northwest predominated and were not as efficient at keeping southerly slopes snowfree. Temperatures in both winters were similar and mild (Table 20, Appendix A).

Figures 29 to 34 (Appendix C) show distribution of radioed elk in relation to mean temperature and snow depth throughout both winters as determined from 24 hour monitoring sessions.

Seasonal Movements

Spring

Elk remained on winter range through April, utilizing new green growth at lower elevations on the winter range. The usual crepuscular activity periods were abandoned at this time and elk were seen feeding at all times of the day. Migration began in early May and was completed by mid-July. A spring storm occurred May 9-12, and elk responded by moving down in elevation from transition range back on to winter range (Table 6).

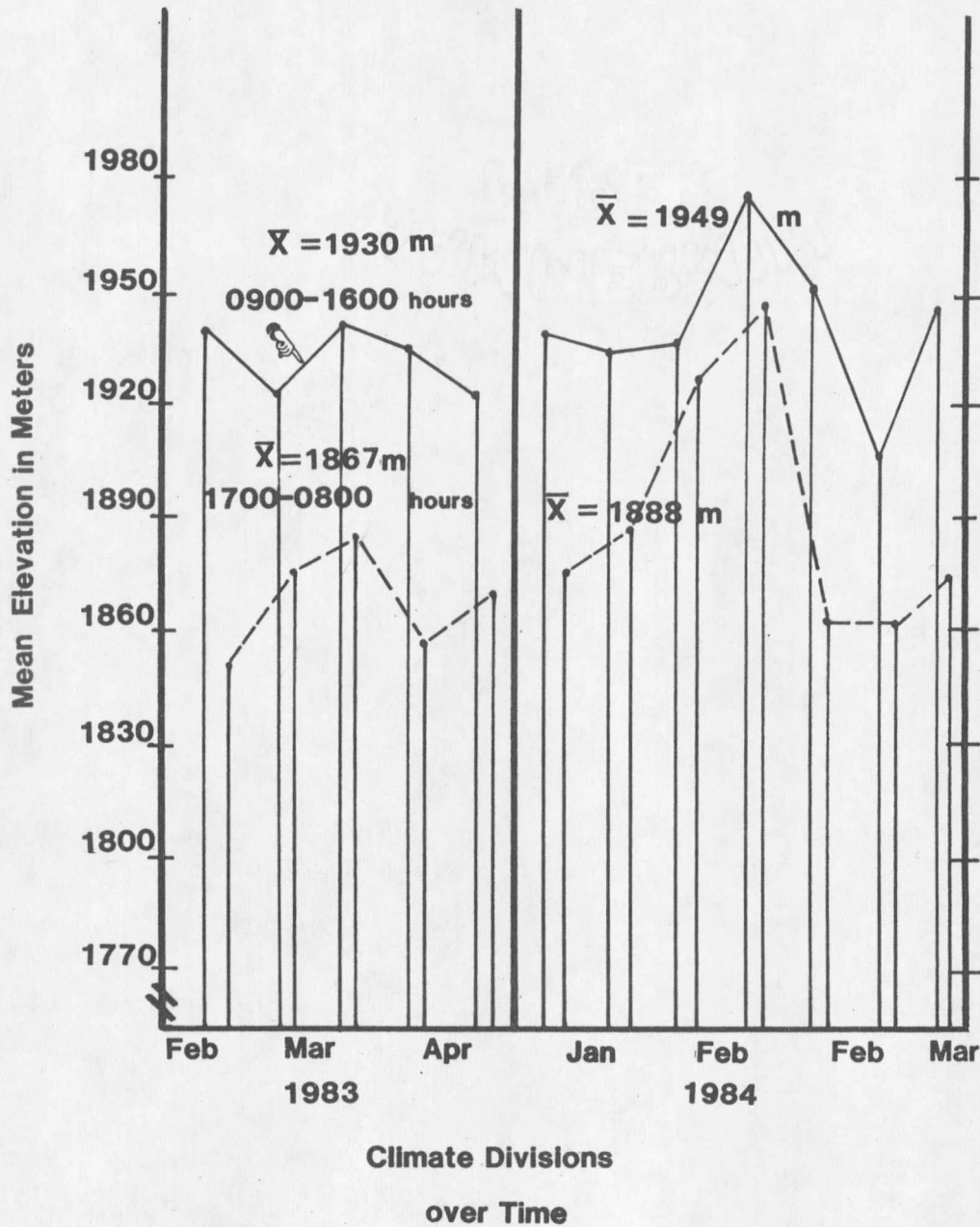


Figure 8. Mean elevation of marked and unmarked elk locations for daytime and evening through early morning periods during each climatic division or period of similar weather based on Butte temperature and precipitation data.

Table 6. Number of radioed elk on winter, transitional, and summer range at various dates in May 1983, North Boulder River, Montana.

No. of radioed elk on:	4/26	5/3	5/5	5/13	5/15	5/19	6/14
Summer range	0	2	2	1	1	1	12
Transition	0	4	4	1	0	3	0
Winter range	13	8	4	9	6	6	0
Unknown location	0	0	3	2	4	2	1

Calving apparently occurred on the upper fringes of winter range and in the Lowland Creek drainage south of the N. Boulder River. Aerial relocations on July 19 (Figure 35, Appendix C) showed that radioed elk migrated to two distinct summer ranges--one a few kilometers north and up in elevation from the winter range, and the other in the Bison Creek drainage ("Elk Park") approximately 9 km south of the N. Boulder River.

Fall

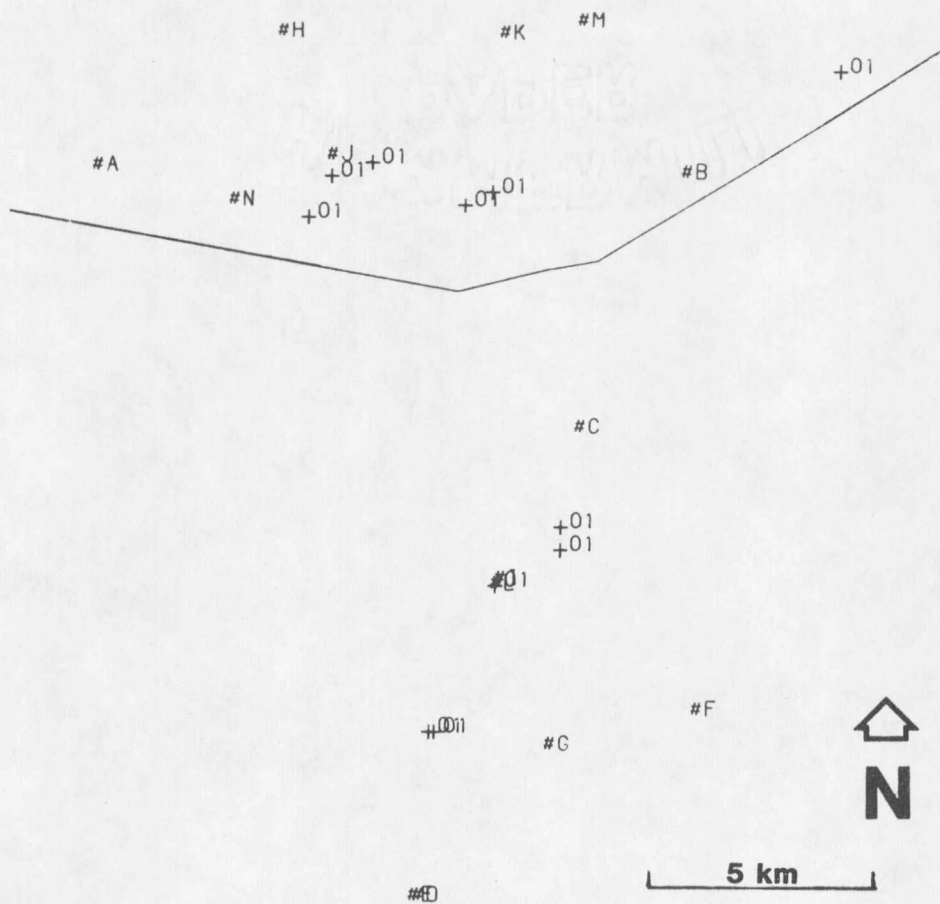
Radioed elk remained on summer range between June and October. The mean elevation of elk locations increased from April through July, then declined in August and September (Figure 35, Appendix C). Few elk were observed during summer and fall aerial flights due to their use of dense timbered cover. During the hunting season, October

25 to November 27, elk moved up in elevation, and three days after the big game season ended, elk were seen from the air to be migrating toward or on the winter range (Figure 9). All radioed elk were on winter range by mid-December, 1983.

Habitat Selection in Relation to Availability

Habitat parameters measured at radioed elk winter locations did not differ significantly from random point descriptions (discriminate analysis $r=.59$) (Figure 10). Each canonical coefficient represents the relative importance of its associated variable in distinguishing between the two groups. The sign of a coefficient denotes whether the variable is making a negative or positive contribution to the discriminant function.

Elk locations demonstrated a small degree of selection for open cover types close to timber, lower topographic points, steeper slopes, and southeast aspects. The analysis also showed elk to prefer areas of lower elevation (and consequently nearer the powerline and the main road) than the 2100 m (7000 ft) contour line which was defined as the upper limit of winter range. Although elk were occasionally seen at this upper limit, the majority of the range used by elk between November and



letters= before big game season

01= after season

Figure 9. Radioed elk distribution relative to the powerline on October 24, 1983 (one day before hunting season began) and November 30, 1983 (3 days after season ended), N. Boulder winter range, Mt.

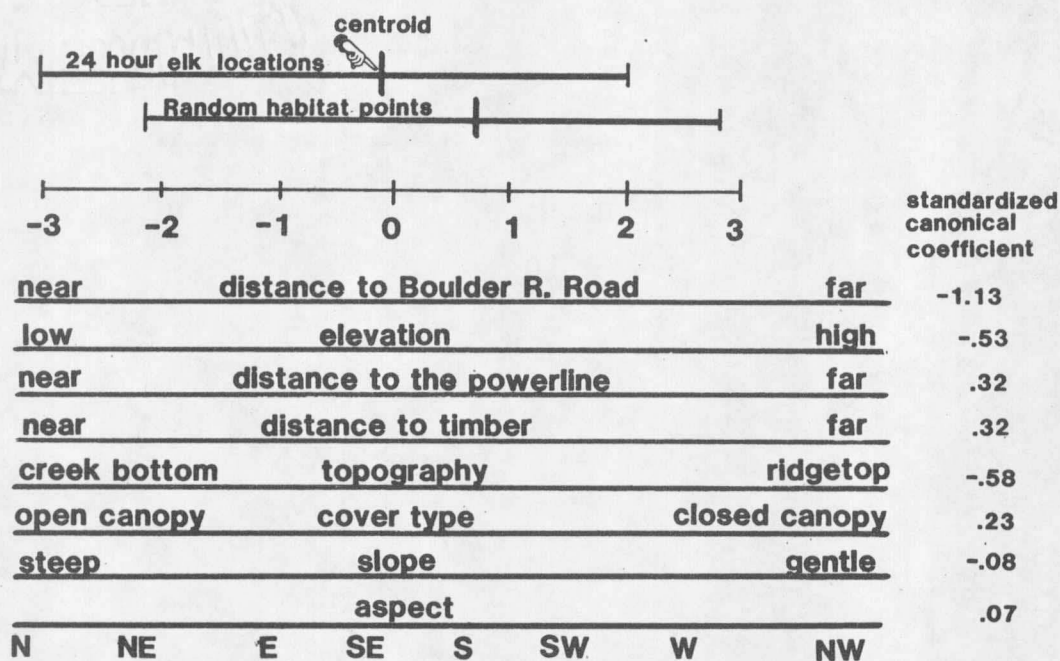


Figure 10. Centroids and ranges of discriminant scores of elk radiolocations (for 1983 and 1984 combined) and random habitat points on the N. Boulder winter range, determined by discriminant analysis. The canonical coefficients describe the relative importance of each measured parameter in distinguishing between the two groups. Habitat parameters and associated relative values explained 59% of the variation between locations and random habitat points.

March in both years was below 2040 m (6800 ft). That is, the 2100 m contour line is an artificial boundary and not a good indicator of available elevations.

Habitat Selection in Relation to Activity

Habitat parameters at all locations of radioed elk during 24 hour sessions were averaged for the February through April and January through March sessions in 1983 and 1984, respectively (total N=1301 relocations).

Slope

Use of slopes during all time periods and in both years was in proportion to the average slope available. That is, elk used shallow slopes as well as steep slopes (Figure 11).

Topography

In both 1983 and 1984, daytime beds on ridgetops, upper slopes, mid-slopes, and creek beds occurred in proportion to the availability of these features. Elk selected the broad flat ridges found between small drainages on the study area, and selected against lower slopes. Use of topography at dusk occurred in proportion to availability with the exception of a selection against ridgetops in 1984. Night locations in 1983 revealed selection against upper and mid-slopes. In both 1983 and

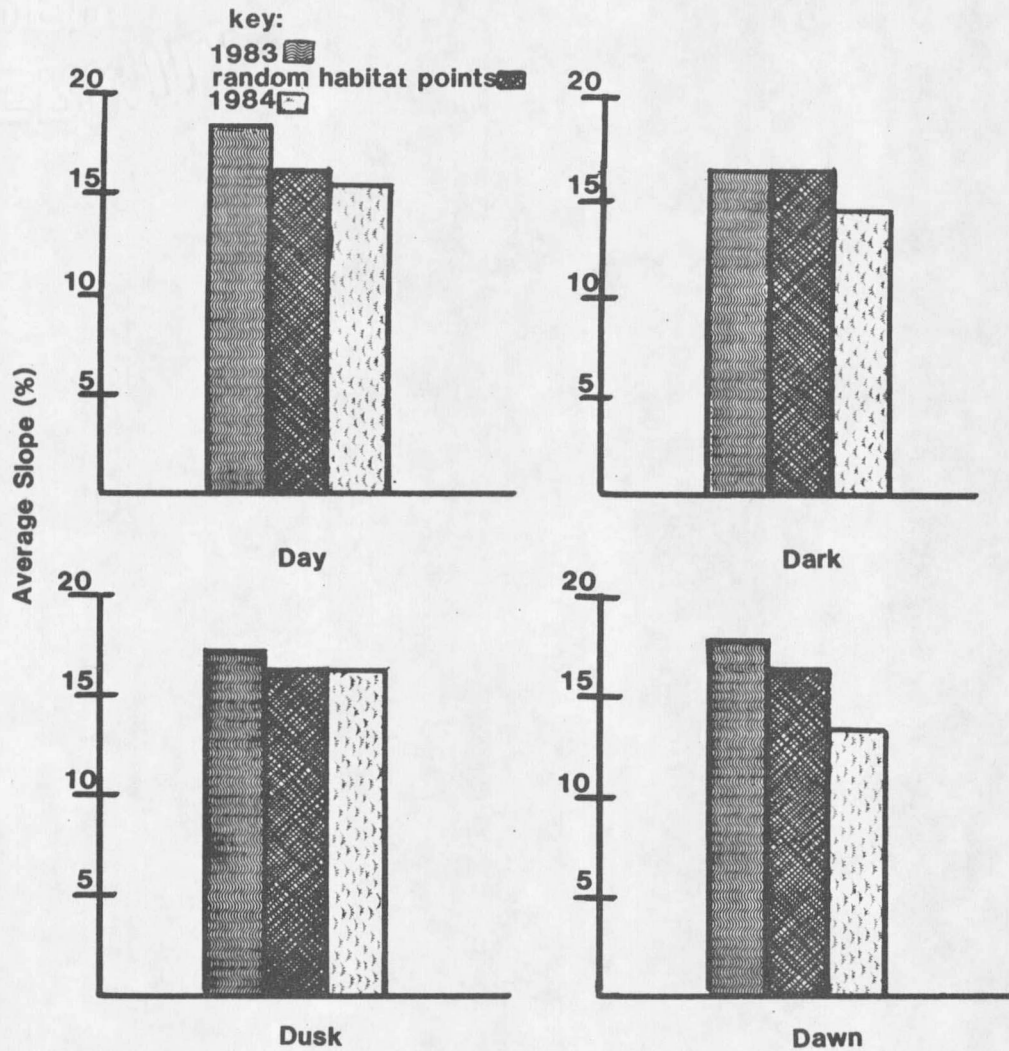


Figure 11. Average slope (%) at elk locations in each of four time divisions in 1983 and 1984 compared to the average available slope on the N. Boulder winter range, MT.

1984, elk selected for drainage bottoms during the night. At dawn, elk in 1983 selected against ridgetops and for broad flat ridges and drainage bottoms, but in 1984, used topography in proportion to its availability (Figure 12).

Aspect

Southerly aspects predominate on the study area, and showed a predominance of all elk locations in all time divisions. Figure 13 indicates at which aspects and times the frequency at elk locations differed from available aspects.

Vegetation Type

Daytime beds were generally in timber. By dusk, elk showed selection for edge, sagebrush, and riparian types in 1984 and bunchgrass parks in 1983. By dark, elk selected for bunchgrass parks. Dawn locations again showed selection for bunchgrass parks in both years and for riparian areas in 1984. Elk use of clearcuts, which were above 2040 m, was very rare (Figure 14). Of the six vegetation types defined, four of the types were typically used by an individual elk per day in both 1983 and 1984.

Elk locations demonstrated an affinity for timber edge and nearness to security cover. The habitat, as determined from random point description, provides a high degree of security in the form of timbered cover and edge (Figure 15).

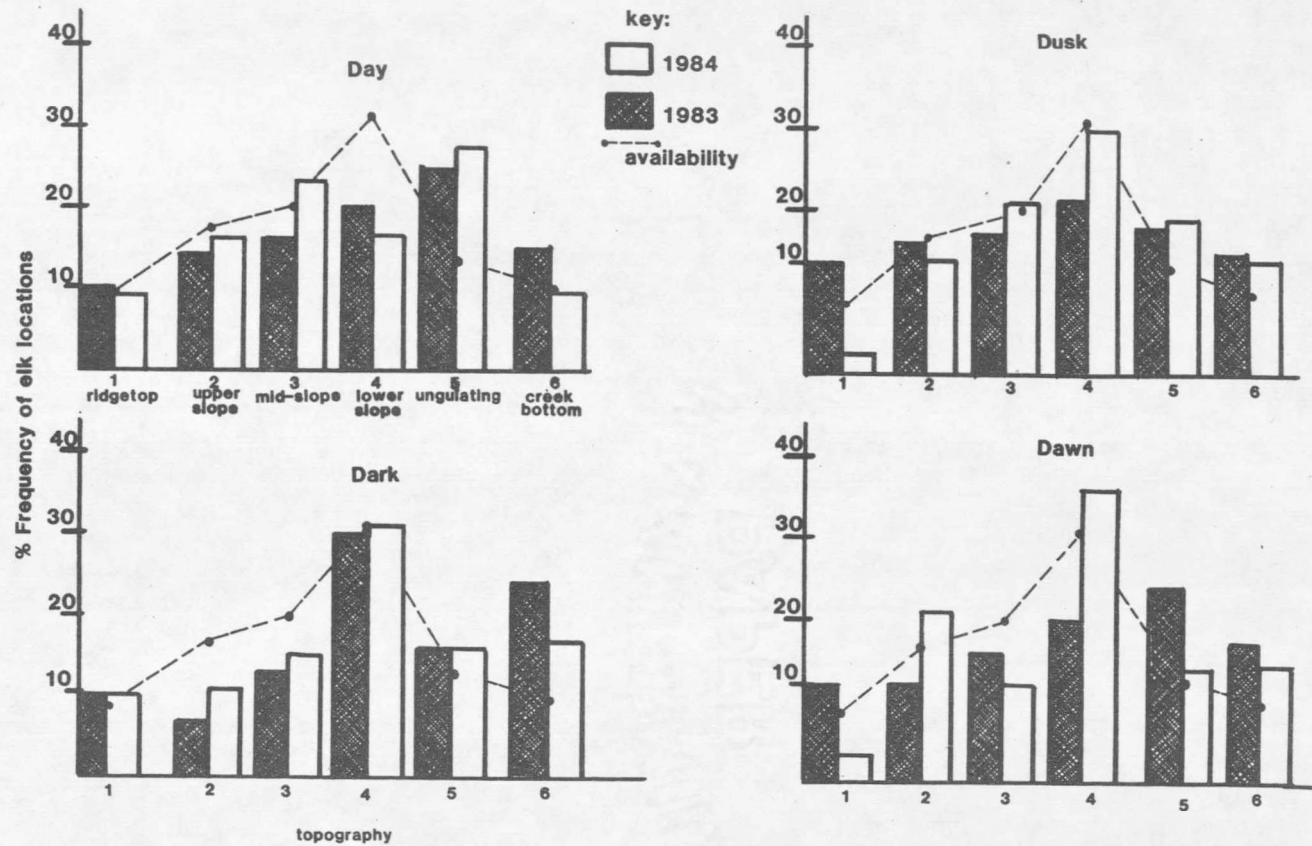


Figure 12. Frequency distribution of winter elk use of topographic features in each of four time divisions in 1983 and 1984 compared to availability of topographic classes on the N. Boulder winter range, MT.

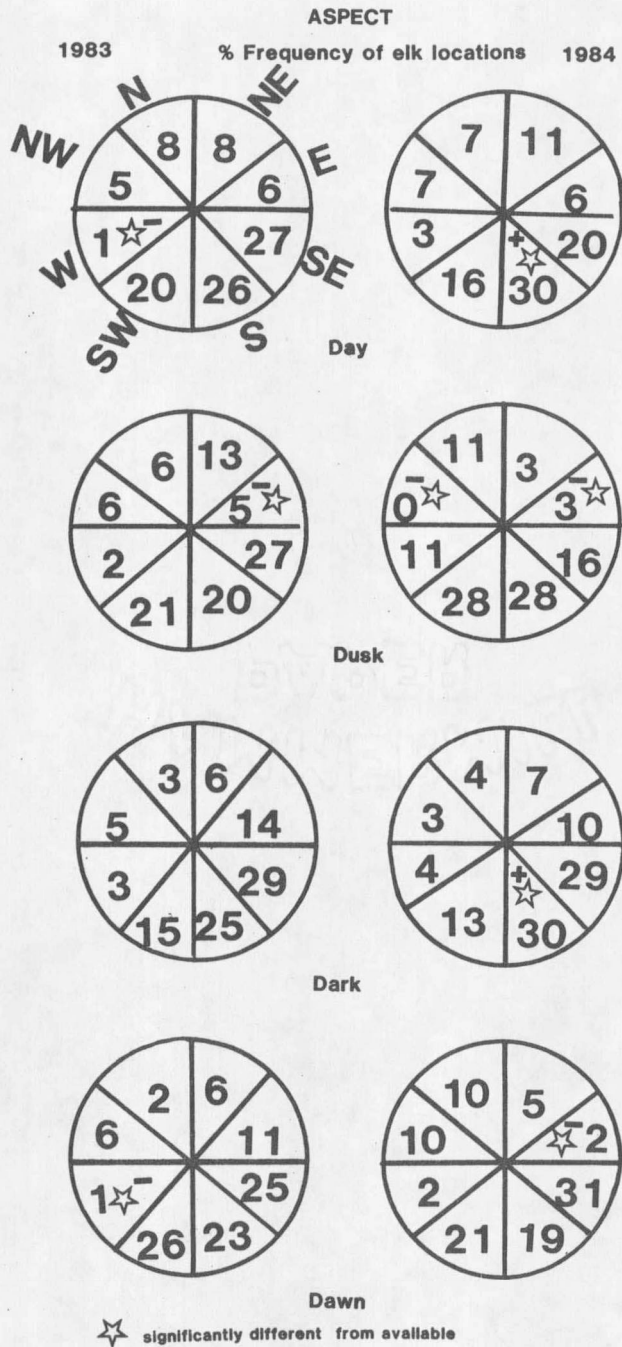


Figure 13. Frequency distribution of winter elk use of aspect for each of four time divisions in 1983 and 1984. Stars indicate frequencies that differ significantly (using chi-square) from available aspects on the N. Boulder winter range, MT.

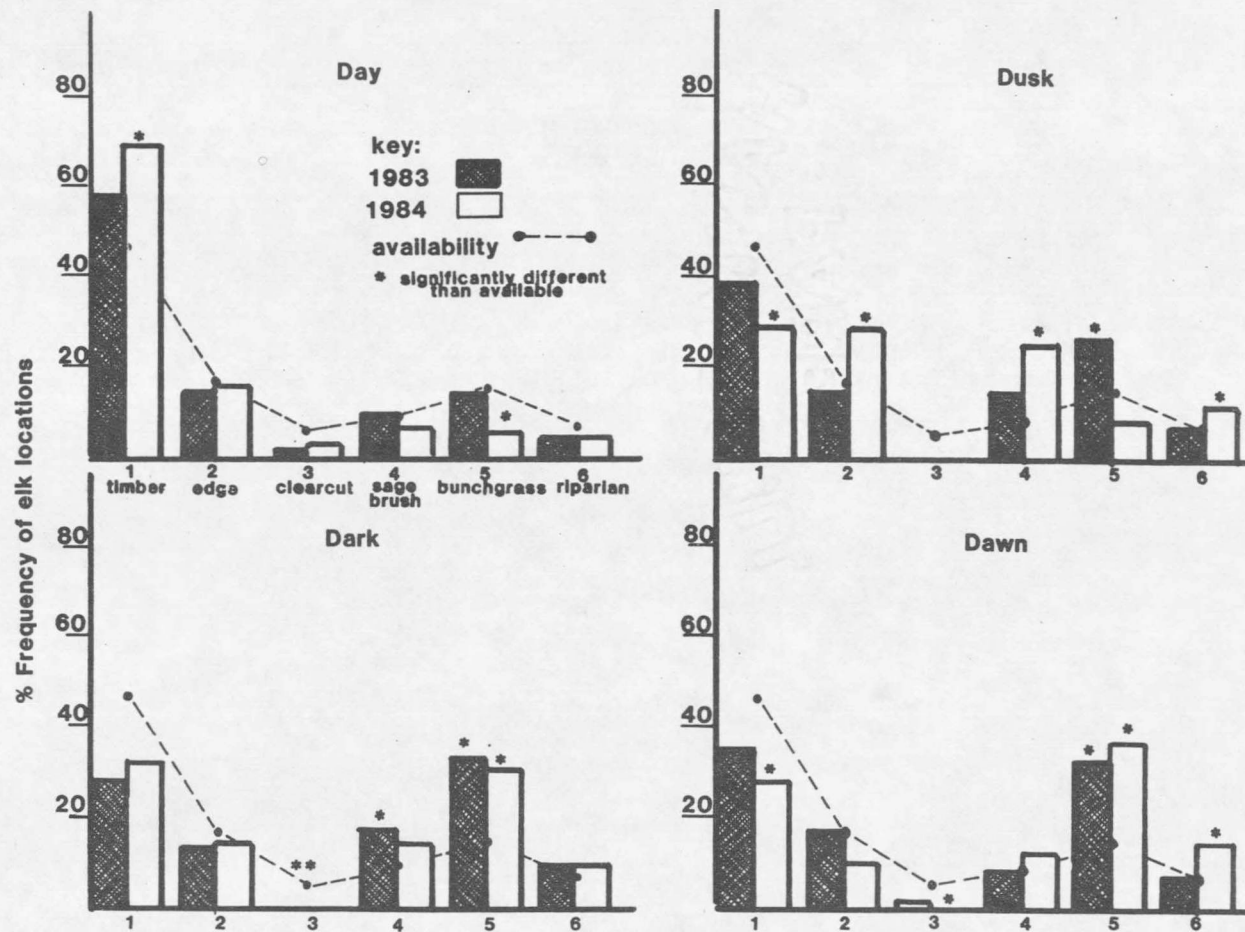


Figure 14. Frequency distribution of winter elk use of major vegetation types in each of four time divisions in 1983 and 1984 relative to their availability on the N. Boulder range.

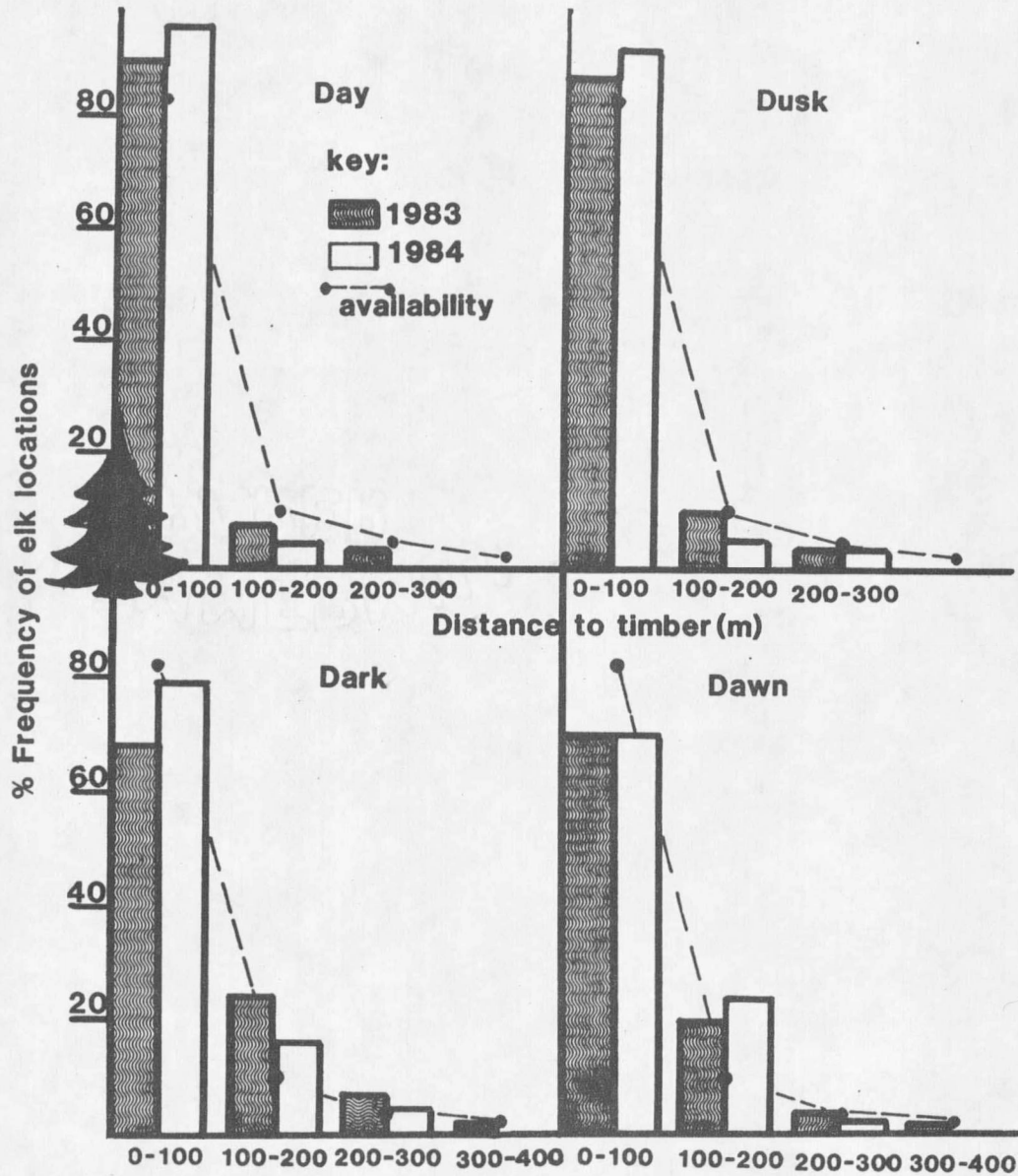


Figure 15. Frequency distribution of distance to timber at elk locations in each of four time divisions in 1983 and 1984, N. Boulder winter range. The 0-100 m class includes elk located within timber.

Snow depth

The average snow depth at elk locations (estimated from weekly snow stake measurements) was 17 cm in both years at daytime locations, 11 cm in both years at dawn and dark locations, and 16 cm and 13 cm at dusk in 1983 and 1984, respectively.

Distance to the Powerline

Elk use of elevation, relative to the average elevation of the powerline, at dawn, daylight, dusk, and dark time divisions, shows the general daily pattern of habitat use on the N. Boulder winter range (Figure 16). Daytime beds throughout the winter occurred, on the average, north of the powerline. Elk began moving south across the powerline and towards feeding areas at dusk, and fed downhill once they reached south facing bunchgrass slopes. Figure 16 indicates that elk were more nocturnal in 1984 and often crossed the powerline to feed after sunset. Information from 24 hour monitoring indicated that elk may be actively moving for a good portion of the night. Typically, at midnight or 2 a.m., elk began moving back up slope, having often spent time in the N. Boulder River bottom and adjacent sagebrush flats. By dawn, elk were feeding uphill and had moved back into timber soon after dawn. A typical home range of an individual elk illustrates this pattern of movement (Figure 17).

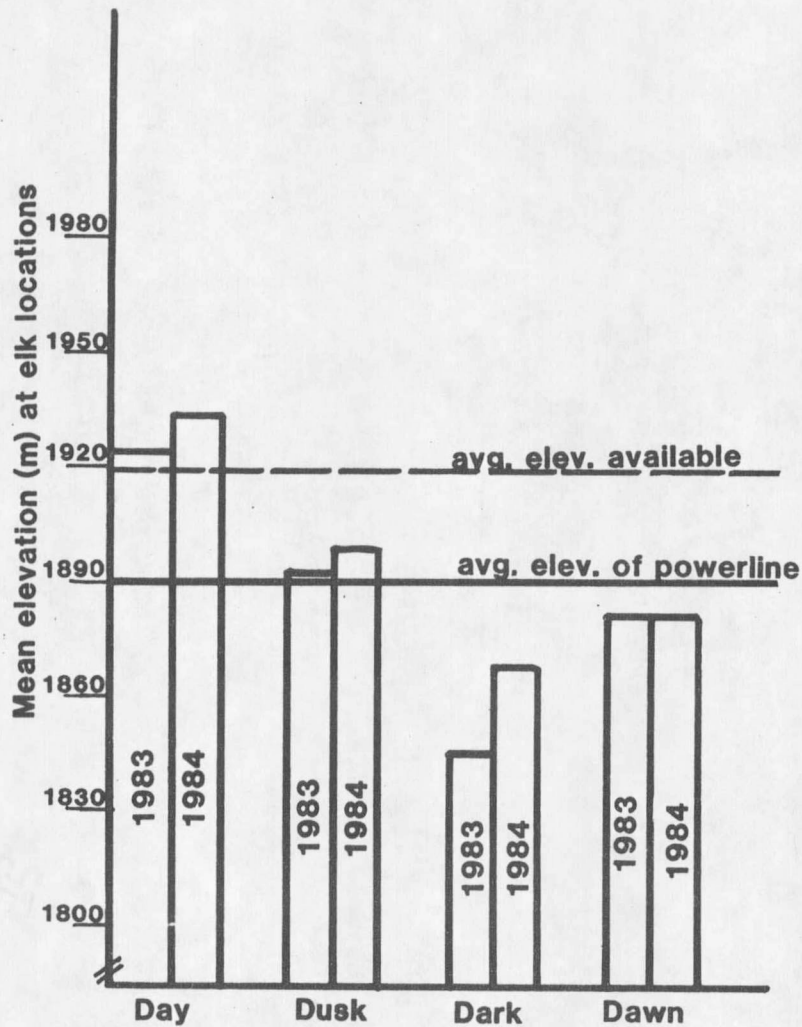


Figure 16. Average elevation (m) at elk locations in each of four time divisions in 1983 and 1984 relative to the average elevation of the powerline and the average elevation available on the N. Boulder winter range, MT.

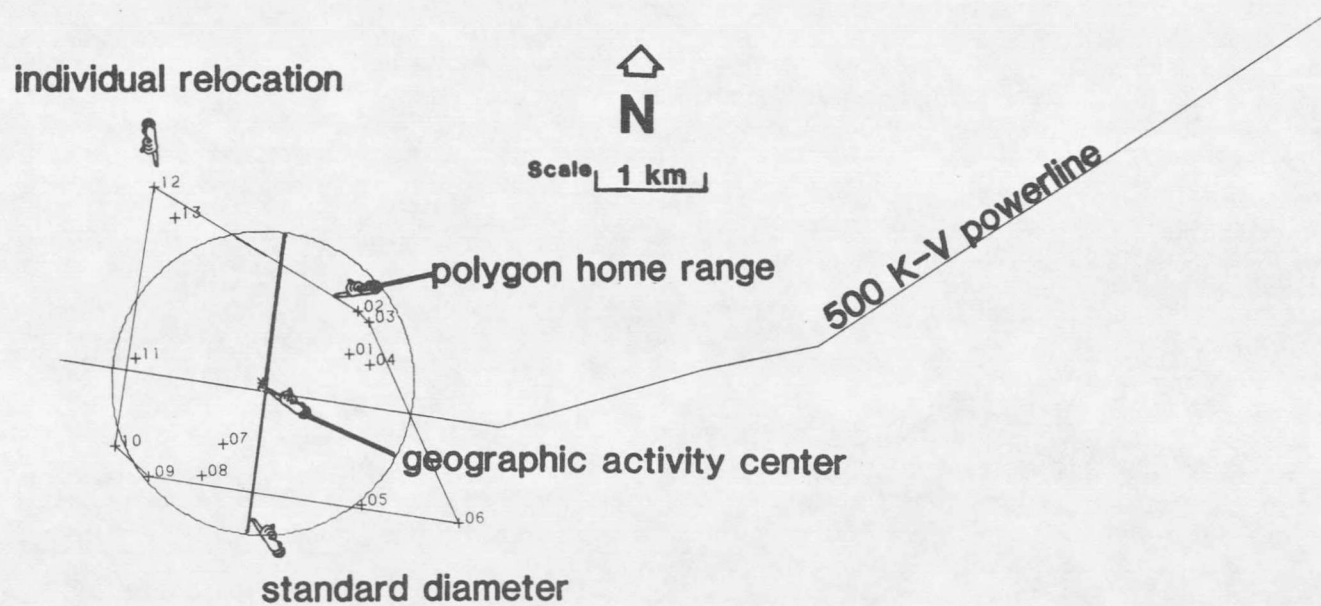


Figure 17. Typical 24 hour home range and habitat use pattern of a radioed elk relative to the powerline on the N. Boulder range. Relocations are numbered sequentially from 1-13 beginning at 1300 hours, every two hours, for a 24 hour period.

Individual Elk Home Ranges and Movements

Daily Home Range

Plots of each 24 hour home range for the 11 elk with functional radios during both field seasons are found in Appendix D (Figures 36-46).

Polygon home range sizes for individual 24 hour sessions (maximum km^2) varied widely among elk and sessions ($0.16 - 16.33 \text{ km}^2$). This is partly a function of the number and timing of relocations within a 24 hour period (Heezen and Tester 1967). The average 24 hour polygon use area for an individual elk was 2.3 km^2 . Standard diameters are thought to be a less variable comparison of home range size (Lonner and Hammond 1980) because the standard diameter is the diameter of a circle with the geographic activity center at its center and at least 68 % of an animals relocations within that circle (Harrison 1958, and Hayne 1949). When averaged for each 24 hour session, daily home range size, as expressed by standard diameters, was quite similar throughout the season (Table 7).

Table 7. Average standard diameter for 14 elk during each 24 hour session, 1983-1984, N. Boulder winter range, Mt.

Date	Average standard diameter (km)	Standard deviation
1983		
2/12-13	1.6	.98
2/18-19	2.3	.67
3/18-19	2.3	.82
3/26-27	1.9	.68
4/16-17	2.3	.73
4/23-24	2.8	1.9
1983 Mean	2.2	
1984		
1/14-15	2.1	1.3
1/21-22	1.6	1.0
2/11-12	2.3	.83
2/18-19	2.3	.69
3/10-11	1.9	.64
3/18-19	2.4	1.8
1984 Mean	2.1	

Cumulative Seasonal Home Ranges

Cumulative winter polygon home range sizes for individual elk varied from 12.5 km² to 35 km² and 14 km² to 44.3 km² in 1983 and 1984, respectively. Cumulative standard diameters varied from 2.6 to 7.6 km in 1983 and 2.8 to 6.1 km in 1984. When averaged for all elk, between year differences in home range size were insignificant (Table 8).

Table 8. Summary of home range sizes for individual elk accumulated throughout the winter, 1983-1984, N. Boulder River, Mt.

Elk ID	SD ¹ 83 km	SD 84 km	Max. area ² 1983 km ²	Max. area 1984 km ²	Mean # of fixes	
					83	84
1	2.6	dead	15.4	dead	85	dead
3	4.2	2.9	26.1	14.0	52	64
4	4.5	dead	26.2	dead	47	dead
5	3.2	2.8	17.4	14.0	52	62
6	2.8	3.8	13.0	33.0	63	47
7	3.6	3.7	34.0	23.2	74	64
8	4.0	3.2	35.5	17.8	64	81
9	3.2	3.7	18.7	29.9	64	50
10	4.5	dead	23.0	dead	55	dead
11	4.8	3.9	20.7	14.8	54	42
12	4.1	4.9	22.6	44.3	74	52
13	7.6	6.1	30.5	16.5	30	21
14	3.7	3.6	17.6	17.5	67	61
15	3.6	3.6	12.5	33.4	62	75
X	4.0	3.8	22.4	23.5	56	56

¹ Standard diameter averaged over 6 sessions.

² Maximum Area of polygon averaged over 6 sessions.

Home ranges were not calculated from flight locations since only 5 winter flights were accomplished in 1983 and 3 in 1984. Youmans (1979) found that even weekly sampling of deer populations from the air underestimated home range size and extent of movements.

Movements

Monitoring during 24 hour sessions indicated that radioed elk moved between each successive relocation. The rate of movement between sessions and years was similar,

rate of movement between sessions and years was similar, averaging .44 km/hour and 10 km/day in 1983, and .37 km/hour and 8 km/day in 1984. Elk using Lowland Creek moved an average distance of 10.4 km/day, compared to an average movement of 9.2 km/day for elk on the N. Boulder range.

The minimum (straight line) distance that an elk would have to travel to maintain the typical pattern of using four vegetation types was calculated to be 2.2 km for an elk bedding below the powerline, 4.7 km for an elk bedding above the powerline, and 2.3 km for an elk utilizing the Lowland Creek area.

Maximum elk movements calculated with TELDAY indicated that it was not unusual for elk to move as far as 65 km per day, especially during mild periods of weather.

Fidelity to Home Range

Geographic activity centers (GAC) were used to compare fidelity to winter home range between years. A two-sample t-test was used to test for differences in GAC's between years for significant shifts in either an east/west direction or a north/south direction. Of 11 radioed elk, 1 demonstrated a significant shift in the east/west direction, 4 demonstrated a north/south shift, 2 shifted in both directions ($P < .001$), and 4 did not

significantly shift activity centers between 1983 and 1984. Of the 6 elk shifting in latitude, 5 moved in a direction away from the powerline an average distance of 1.12 km, and 1 moved in a direction toward the powerline 1.2 km (Figures 18-23).

It was previously mentioned that more range was utilized in 1984 than in 1983. This additional range use occurred on the west end of the study area, and south of the N. Boulder River in the Lowland Creek drainage. In 1983, soon after elk were collared, elk #6 moved south to the Lowland Creek drainage and remained there throughout the winter. As spring migration began, 5 additional elk moved south. That is, the Lowland Creek area appeared to support a small number of wintering elk in 1983, but was used primarily as transitional range. In 1984, however, the Lowland drainage had less snow cover and supported more elk, including 4 radioed animals (ID's 6,7,9,12). All of the radioed animals that wintered in Lowland Creek in 1984 also used this drainage while migrating to summer range in "Elk Park" in the spring of 1983. Elk #9 and #12 crossed the river onto the study area several times in 1984, but spent most of the winter in Lowland Creek. Geographic activity centers of unmarked elk did not differ significantly between years (Figure 24).

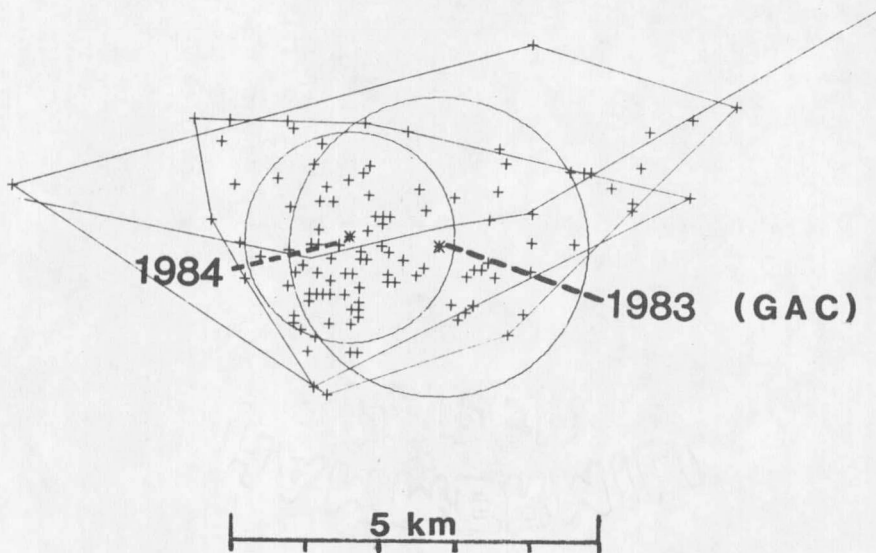
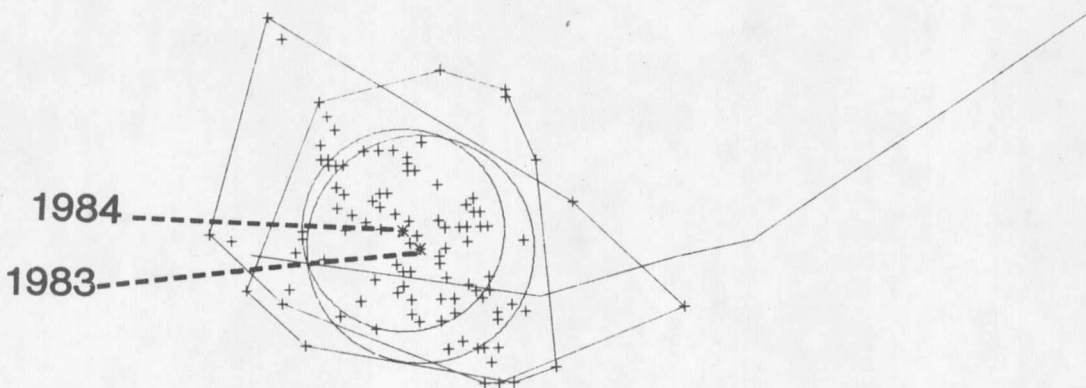
ELK#3**ELK#5**

Figure 18. Seasonal polygons and standard diameters for elk #3 and #5 in 1983 and 1984 relative to the powerline, N. Boulder winter range, MT.

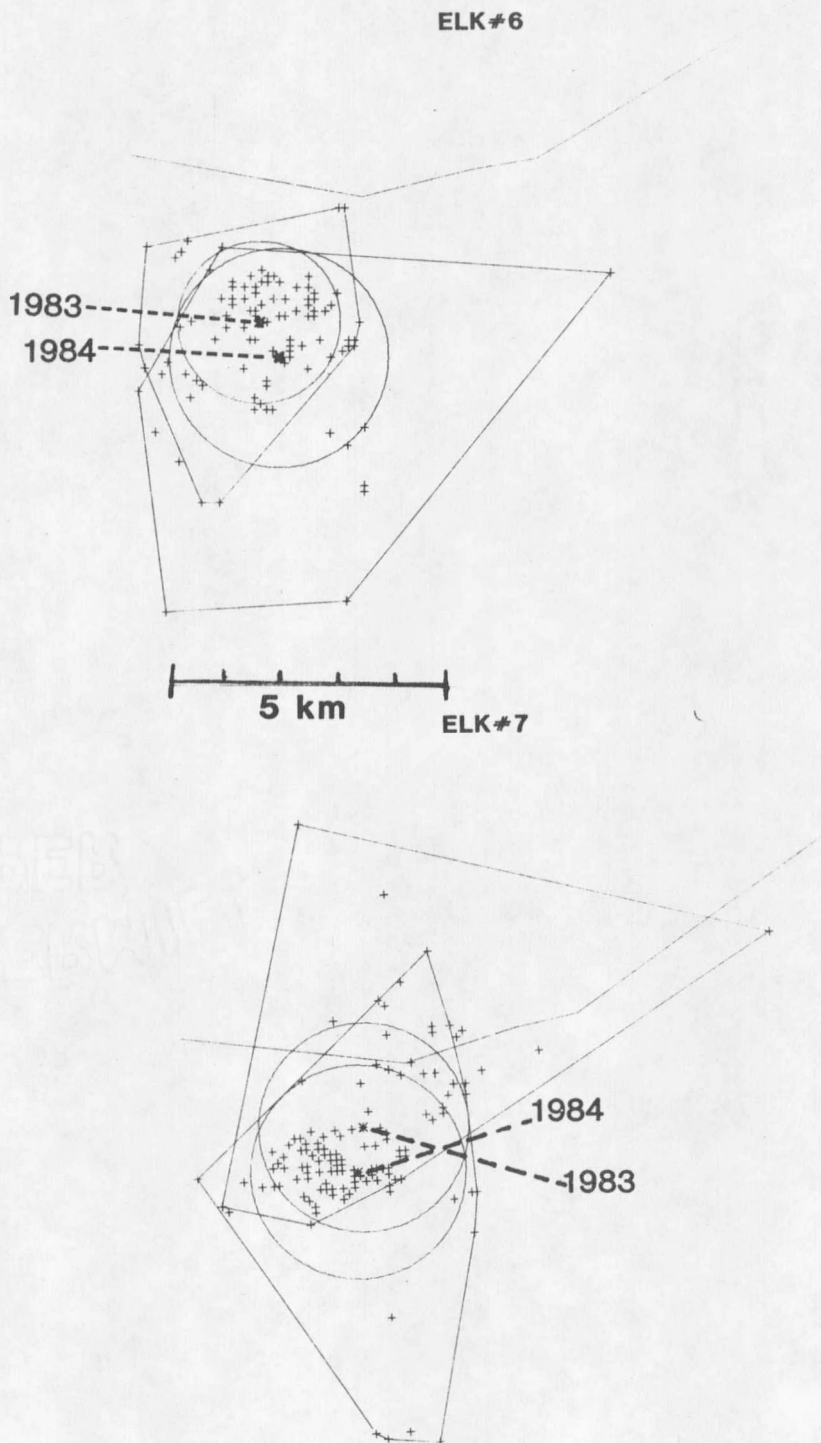
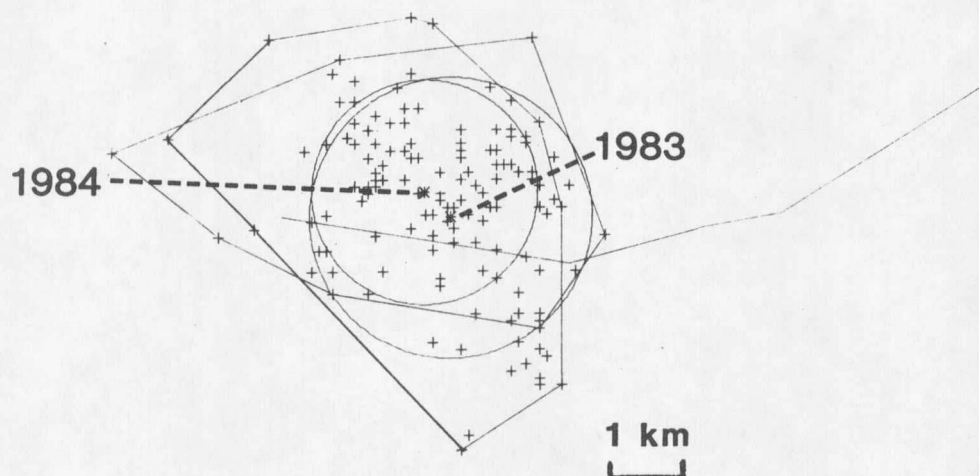


Figure 19. Seasonal polygons and standard diameters for elk #6 and #7 in 1983 and 1984 relative to the powerline, N. Boulder winter range, MT.

ELK #8



ELK #9

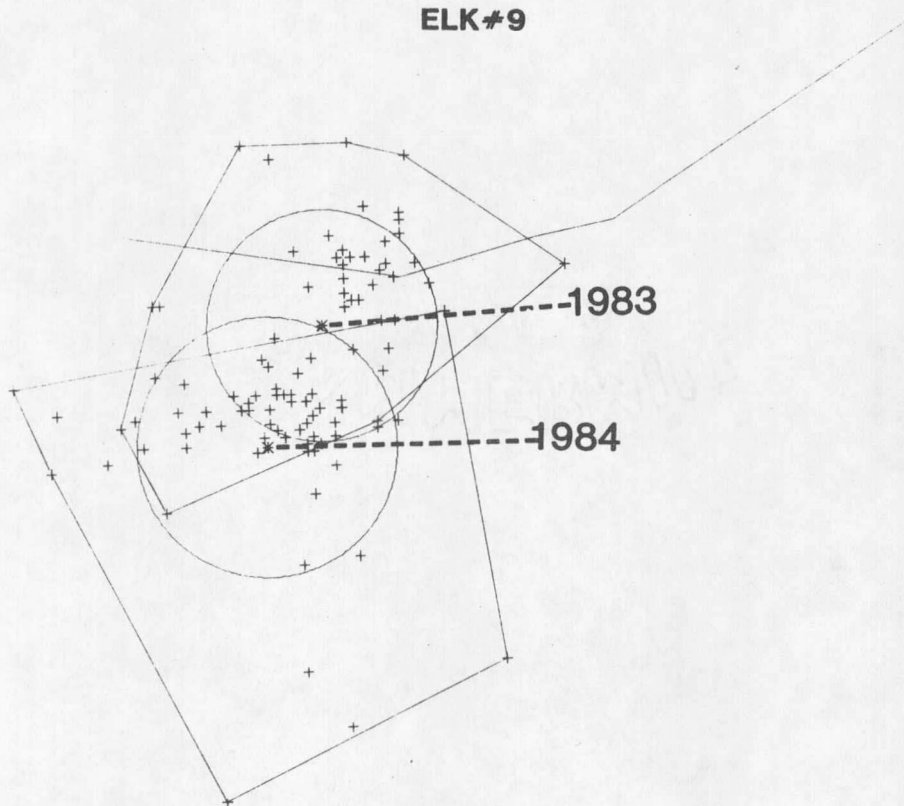
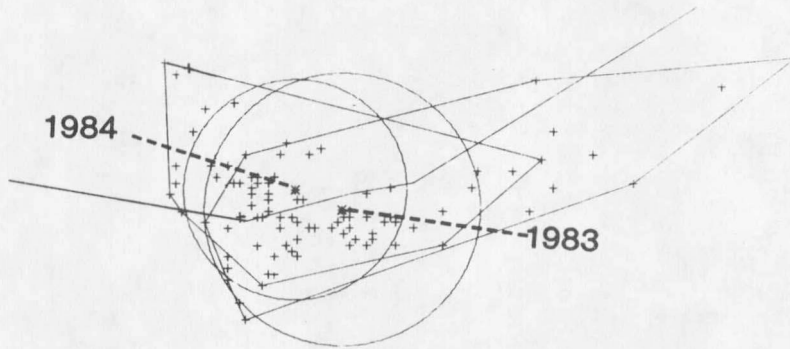


Figure 20. Seasonal polygons and standard diameters for elk #8 and #9 in 1983 and 1984 relative to the powerline, N. Boulder winter range, MT.

ELK #11



ELK #12

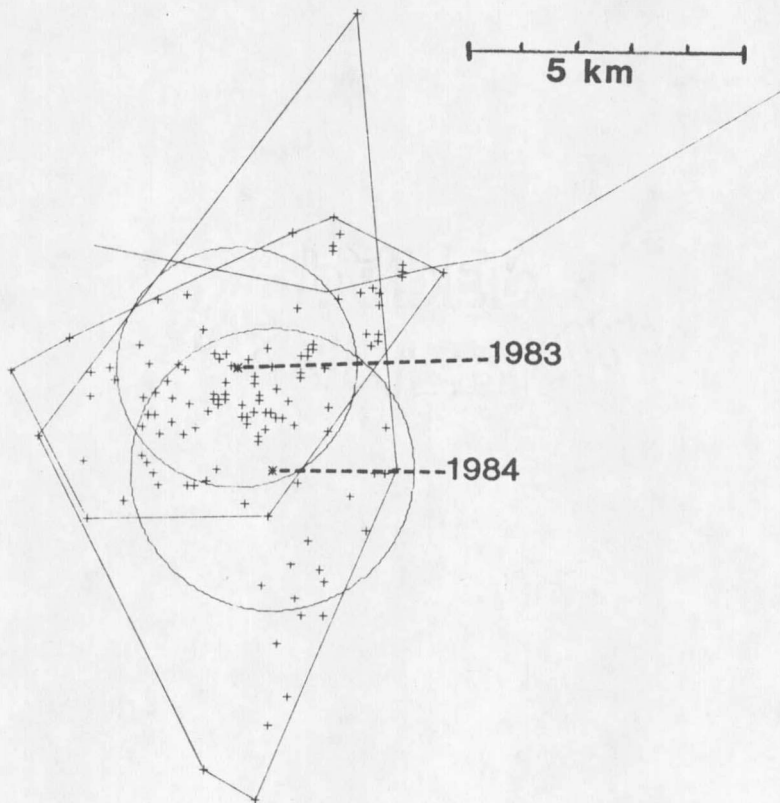


Figure 21. Seasonal polygons and standard diameters for elk #11 and #12 in 1983 and 1984 relative to the powerline, N. Boulder winter range, MT.

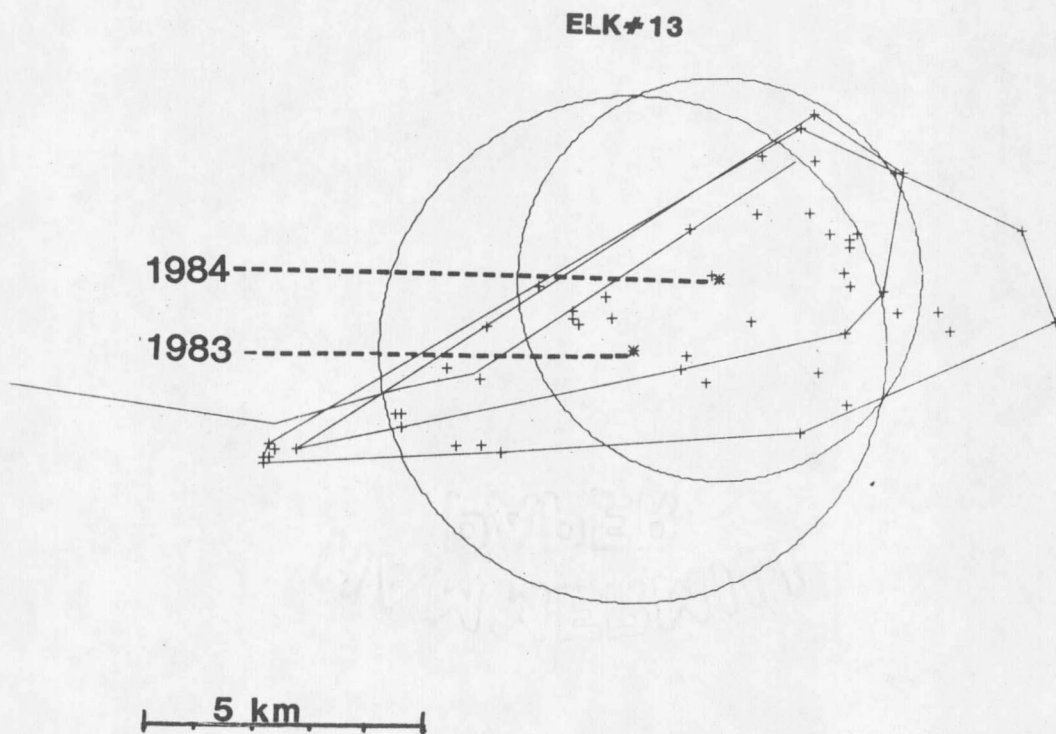


Figure 22. Seasonal polygons and standard diameters for elk #13 in 1983 and 1984 relative to the powerline, N. Boulder winter range, MT.

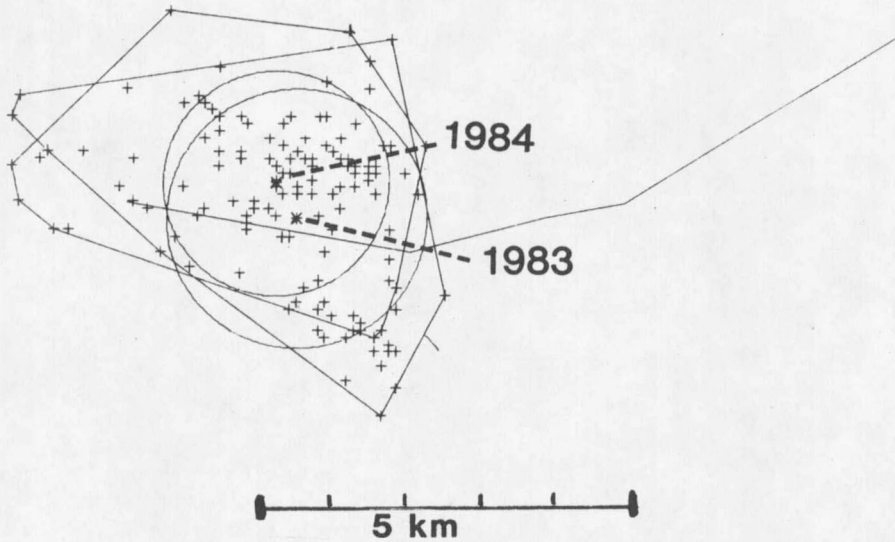
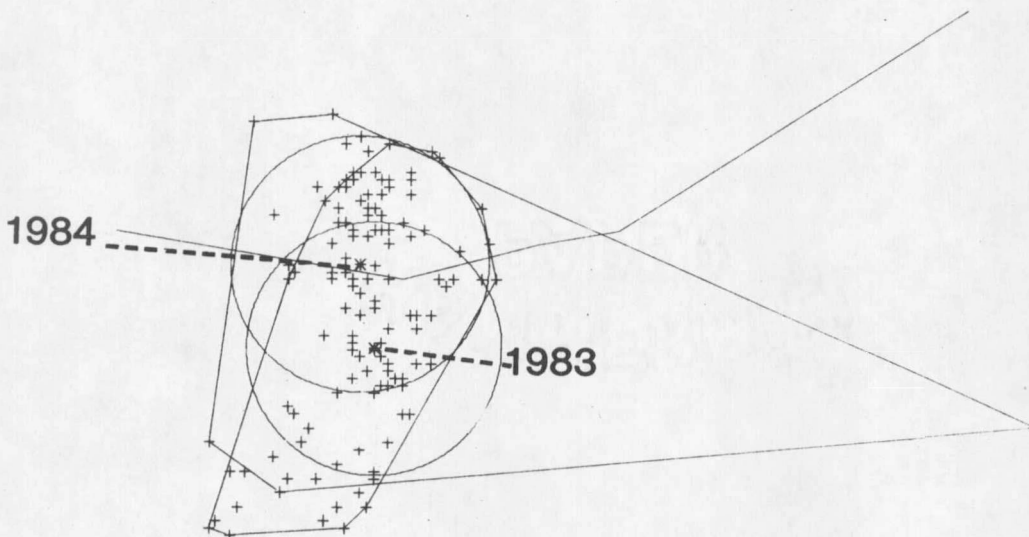
ELK #14**ELK #15**

Figure 23. Seasonal polygons and standard diameters for elk #14 and #15 in 1983 and 1984 relative to the powerline, N. Boulder winter range, MT.

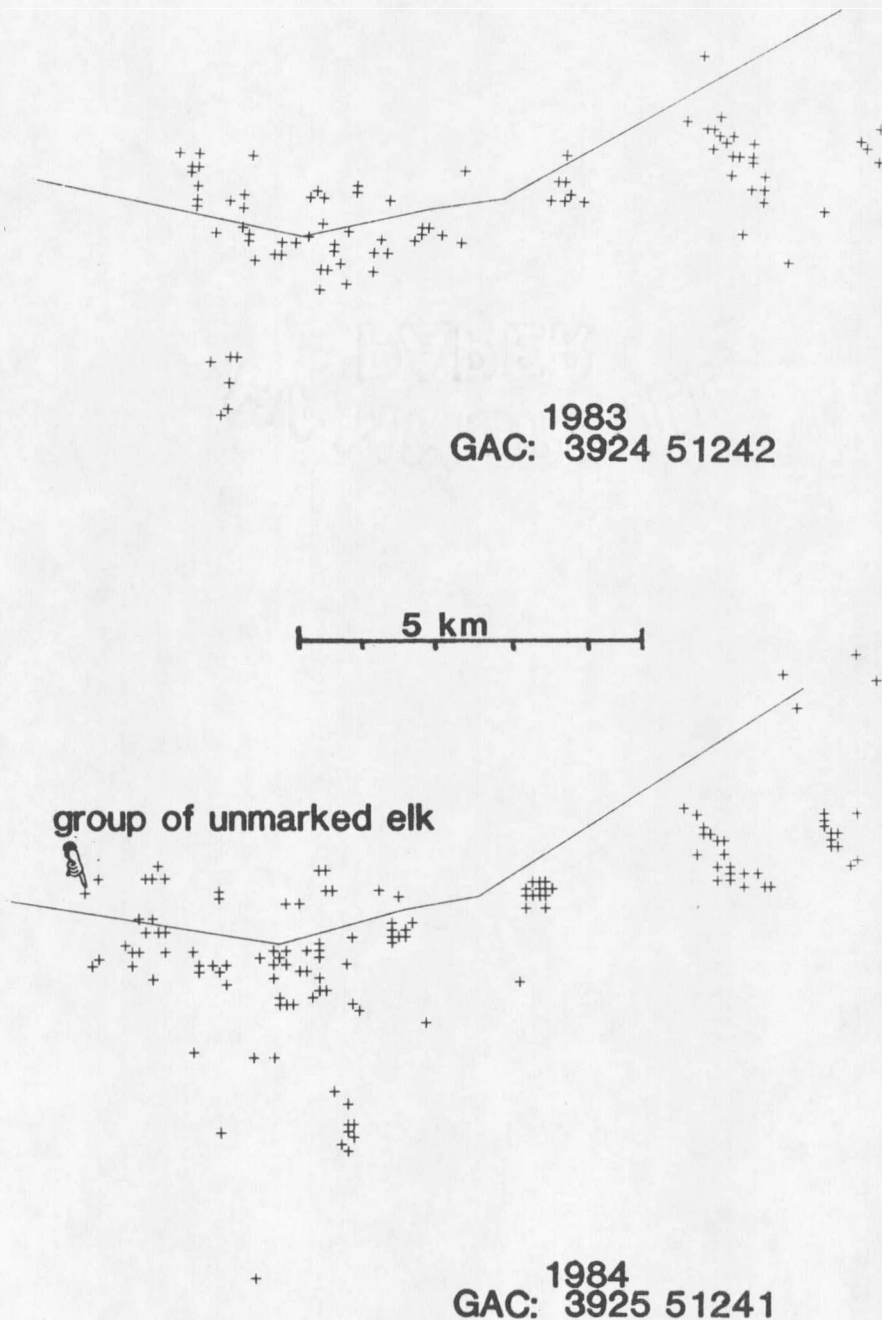


Figure 24. Distribution of groups of unmarked elk on the N. Boulder range based on direct observations in 1983 and 1984 between January and March. The center of distribution is the geographic activity center(GAC) stated as UTM coordinates.

Powerline Effects

Clearing and Line Construction

In late April 1983, BPA contractors were allowed entry onto the eastern most portion of the study area (Pole Mountain) to begin stringing conductors on towers. Four radioed elk previously utilizing this area moved out of the area soon after construction began (Figure 25). A t-test showed the shift south to be significant ($P < .001$). It is not known if they eventually came back before migrating north, but it is doubtful since construction expanded after May 15 when road closures were no longer in effect. Timber clearing for the corridor disrupted one known bedding area. However, timber adjacent to the clearing was still available and utilized by elk for bedding in 1984.

Elk Distribution Near the Line

Results of the multiple regression analysis of pellet group and plant utilization transects under and parallel to the powerline corridor (total $N=90$) are presented in Tables 9 and 10.

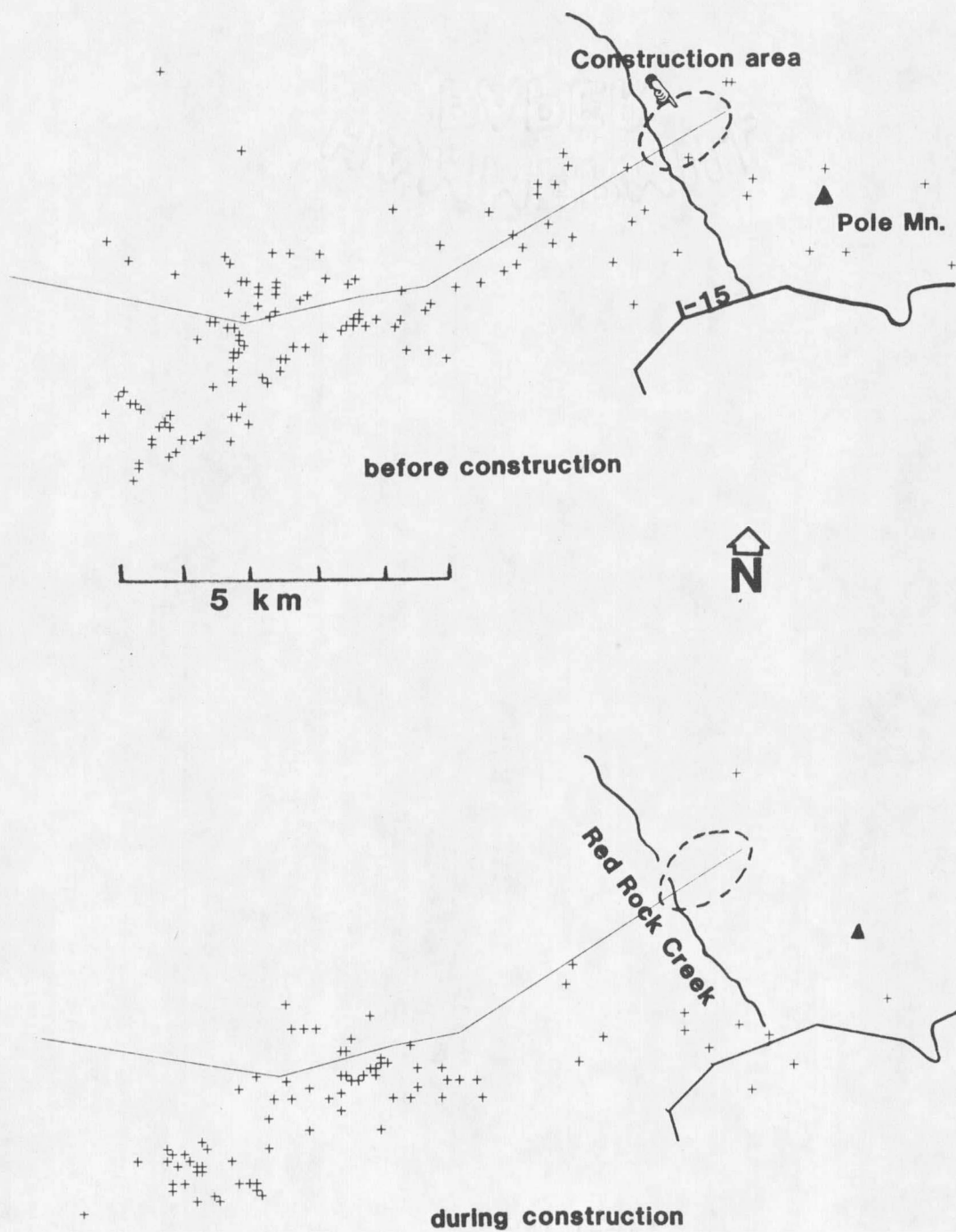


Figure 25. Relocations of four radioed elk before and during powerline construction on the eastern edge of the N. Boulder winter range, MT.

Table 9. Contribution of significant factors ($P < .05$) to the pellet group regression, 1983 & 1984 pellet group transects.

Variable	Contribution to R^2 :	
	1983	1984
Cattle use	XXX	-.18
Total percent plants grazed	+.21	+.16
Cover Type	-.21	-.04
Aspect	-.19	-.01
Slope	+.05	+.01
Distance from powerline	+.02	+.0001
Direction from powerline	-.02	+.004
Total R^2 70($r = .84$) 1983		
Total R^2 41($r = .64$) 1984		

Table 10. Contribution of significant factors ($P < .05$) to the total R^2 in the total plant utilization regression, 1983 and 1984.

Variable	Contribution to R^2 :	
	1983	1984
Cattle use	XXX	+.18
No. of pellet groups	+.21	+.16
Aspect	+.29	-.05
Slope	+.16	-.001
Cover	+.10	+.02
Distance to powerline	-.03	-.001
Direction from powerline	+.04	not signif.
Total R^2 77($r = .88$) 1983		
Total R^2 35($r = .60$) 1984		

In 1983, the factors that best explained variation in the number of pellet groups on a transect included the percent of plants grazed, cover type, and aspect. The number of pellet groups counted increased as the number of plants grazed increased, in timbered cover types and on northerly and easterly aspects. The number of pellet groups also increased with distance from the powerline and north of the powerline (relative to south).

Total utilization of bunchgrass in 1983 (cattle plus elk use) was best explained by the number of pellet groups, aspect, slope, and cover type. Feeding occurred on steeper, south slopes with sagebrush and grass cover. Although distance or direction from the powerline did not contribute a great deal to the regression in 1983 (before energization), more plants were grazed on transects south of the powerline and relatively closer to the line.

The same relations that explained variation in number of pellet groups in 1983 held in 1984 (but explained less), with the exception of direction from the powerline; the number of pellet groups increased south of the line in 1984.

Total bunchgrass utilization in 1984 was best explained by cattle utilization. That is, most of the vegetation under and adjacent to the powerline was removed by cattle. The number of animal unit months (AUMs) of cattle grazed on the winter range increased from 625 in

1983 to 1990 in 1984. Factors explaining total utilization related more to cattle grazing than to elk grazing. Total utilization showed a relative increase on northerly and easterly aspects, closer to the powerline, on open cover types, and shallower slopes.

Pellet group counts were lower on transects heavily grazed by cattle. That is, the percent of plants grazed by cattle negatively influenced the occurrence of elk within 200 m on either side of the powerline. This included mostly gentle slopes. Cattle utilization (percent of plants grazed) on the Boyle and Berkin pastures, both having steep south slopes and both heavily used by wintering elk, averaged 41% and 53%, respectively. Average plant biomass removed by cattle was 21% in Boyle Pasture and 32% in Berkin Pasture. The "Elk Pasture" was taken out of the pasture rotation system and reserved for winter elk use in 1975. Elk have traditionally shown heavy use of this pasture for feeding.

Analysis of variance showed the number of pellet groups to be significantly different ($P < .001$) between transects at intervals of 15, 50, 100, and 200 m north and south of the powerline in 1983, but not in 1984. The data were biased due to heavy elk use around a salt block (present for many years) on a transect 50 m north of the powerline (Figure 26).

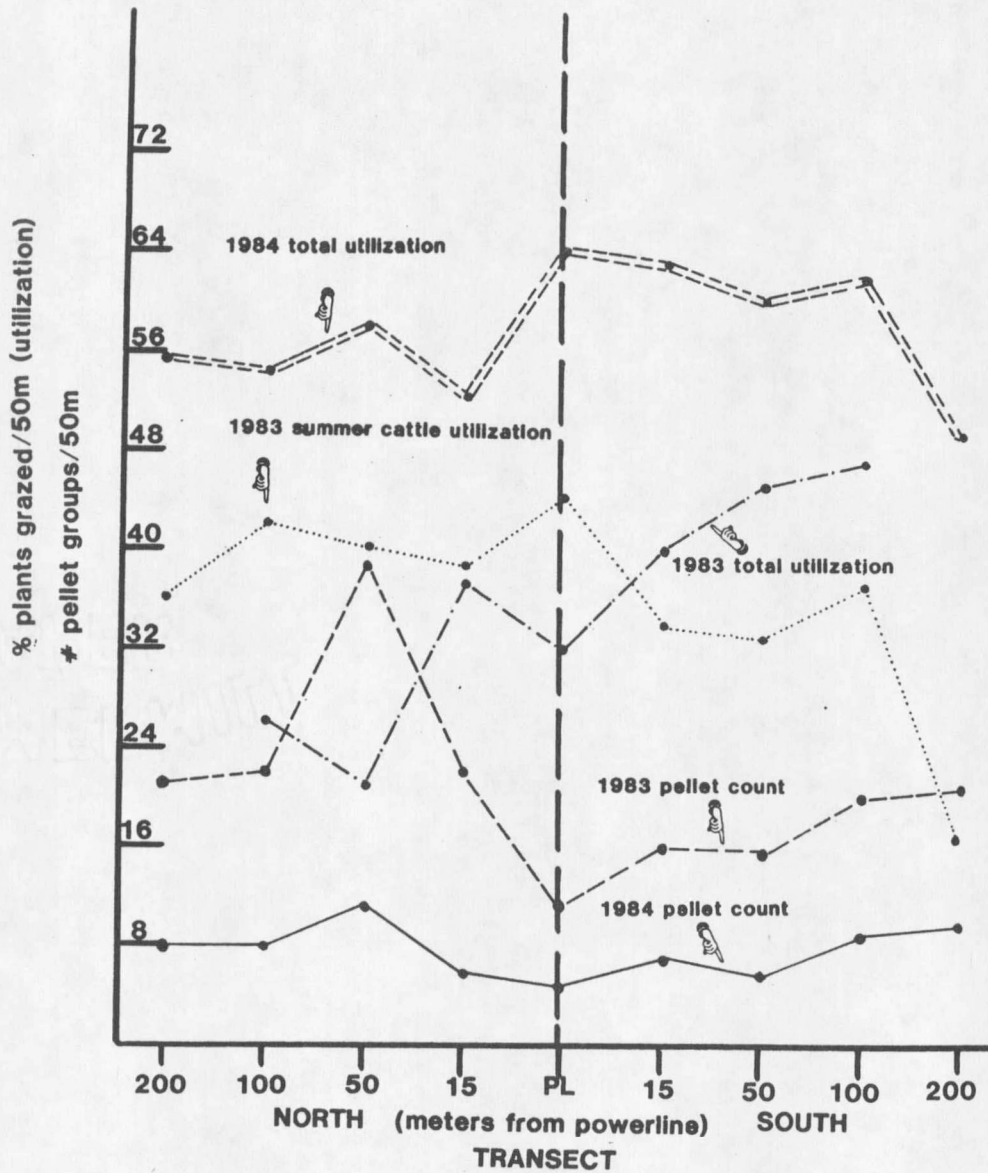


Figure 26. Average number of pellet groups counted and total percent of grazed bunchgrass plants in 1983 and 1984 and the percent of plants grazed by cattle in 1983 on 50 m transects under and adjacent to the powerline (total N=90).

Powerline Crossings

Track transects, twelve 100 m lines, were read 5 times between January and April 1983. Lack of sufficient amounts of new snow prevented more frequent readings. In 1984, transects were read 13 times between late December 1983 and March 1984.

There were several major trails on the west half of the winter range which elk used in travelling from bedding areas north of the powerline to feeding areas south of the corridor. Because 2 sets of transects intersected these trails (2 and 4), and the other 2 sets did not, there was much variability in the data. Transect "1" occurred in an open meadow that elk used consistently in 1983, but not in 1984. While measuring cattle utilization in the fall of 1983, it was noticed that cattle had grazed that area very heavily. Because of these sources of variability and small sample sizes, it was felt that statistical comparisons between years and among transects were not meaningful. The data are presented in Table 11.

The comparison of track counts immediately after a storm relative to 1 or 2 days following, in 1984, may have significant biological implications. Data from the 2 transect sets where elk frequently crossed are presented.

Table 11. The average number of track crossings on 100 m line transects (n=12) under, and parallel north and south of the powerline, N. Boulder winter range, 1983-1984.

Year/transect		Average no. tracks crossing transect:		
		100 m south	Center	100 m north
1983	1	8.4	10.6	8.8
1984	1	.8	0	.5
1983	2	3.5	0	.5
1984	2	5.2	3.3	5.3
1983	3	2.0	0	0
1984	3	1.4	.6	.15
1983	4	4.0	3.2	3.0
1984	4	11.5	7.7	9.0
1983 Mean		4.5	3.8	3.5
1984 Mean		4.7	3.4	3.2

On 4 different occasions, transects were run immediately after a storm and again the following day or 2 days later (if no new snow fell during that time). No track crossings were counted on the day immediately following a storm. One to 2 days after a storm, elk crossings were usually numerous, especially if crossings just missing the transects are taken into account (Table 12).

Table 12. Comparison of track crossings under and near the powerline the day following a storm vs. one or two days later, N. Boulder winter range, 1984.

Transect number	Date of run	Date of storm	Number of tracks crossing		
			100 m north	Center	100 m south
4	2/18	2/17	0	0	0
4	2/20	2/17	40	32	41
2	2/22	2/21	0	0	0
2	2/24	2/21	30	43	36
4	2/22	2/21	0	0	0
4	2/23	2/21	48	64	87
4	3/5	3/4	0	0	0
4	3/6	3/4	0	0	0
			(tracks cross just west of transect)		
2	3/5	3/4	0	0	0
2	3/6	3/4	0	0	4
			(tracks cross east of transect)		
4	3/11	3/10	0	0	0
4	3/12	3/10	10	14	2

Elk Observations Near the Line

I had the opportunity on several occasions to observe elk cross under the line in 1984. In fair weather, elk walked slowly and calmly across the corridor in small "sub-groups" of 2 and 3 animals. On March 2nd in fair weather elk were seen crossing the powerline at dusk and moving downhill into the "Elk Pasture". The following morning, it was snowing hard shortly before dawn. Because

of poor visibility, I climbed the ridge on foot and observed approximately 140 elk spread out and feeding about 250 m south of the powerline. One half hour after dawn, the lead cows began walking uphill, and the rest of the group followed single file. Noise from the powerline, a crackling and hissing sound, was quite loud from my post 300 m away. About 20 m from the outer conductor, the lead elk stopped and hesitated and the rest of the elk closed in on them in a large tight circle. They stood in place for about 5 minutes, then some exhibited a westward pacing movement parallel to the line. Snowfall let up slightly at this time, and the lead elk began crossing the corridor and moving quickly into a timber patch north of the line. The rest of the group followed single file.

Acoustical Effects

Ambient noise levels on the study area range between 25 and 45 dB(A). Statistical plots produced from the BPA weather and noise station data on the study area indicate that during foul weather (precipitation), audible noise exceeds 55 dB(A) at the edge of the corridor (Table 13). At the centerline during precipitation, the noise level at an average powerline elevation of 1890 m is 60 dB(A), decreasing to 49 dB(A) at 120 m and to 40 dB(A) at 500 m (BBST 1982).

Table 13. Percent of the time noise levels exceeded 55 dB(A) at the edge of the corridor in 1984, based on BPA noise statistical plots, averaged for all frequencies.

Month	% of time noise exceeded 55 dB(A) and % standard deviation (in parentheses)
Nov. 83	8.5 (4.1)
Dec. 83	10.0 (7.8)
Jan. 84	7.2 (5.2)
Feb. 84	7.6 (5.6)
Mar. 84	17.2 (13.9)

Elk Distribution and Audible Noise

Elk 24 hour relocations were analyzed for differences in distribution relative to the powerline, between years, and considering locations during and not during precipitation, using analysis of variance. Results of this analysis revealed that elk were distributed significantly closer to the powerline in 1983 than in 1984 ($P < .001$). Relocations during precipitation were also significantly closer to the powerline in 1983 relative to relocations during precipitation in 1984 ($P < .001$). However, no significant differences occurred between 1984 precipitation and non-precipitation relocations.

A closer look at elk distribution around the powerline revealed that during precipitation in 1984, the highest percentage of elk were found within 100 m of the powerline and the lowest percentage 101-200 m away (Figure 27). TELDAY plots of relocations during precipitation showed indication of this "clumping" effect south of the

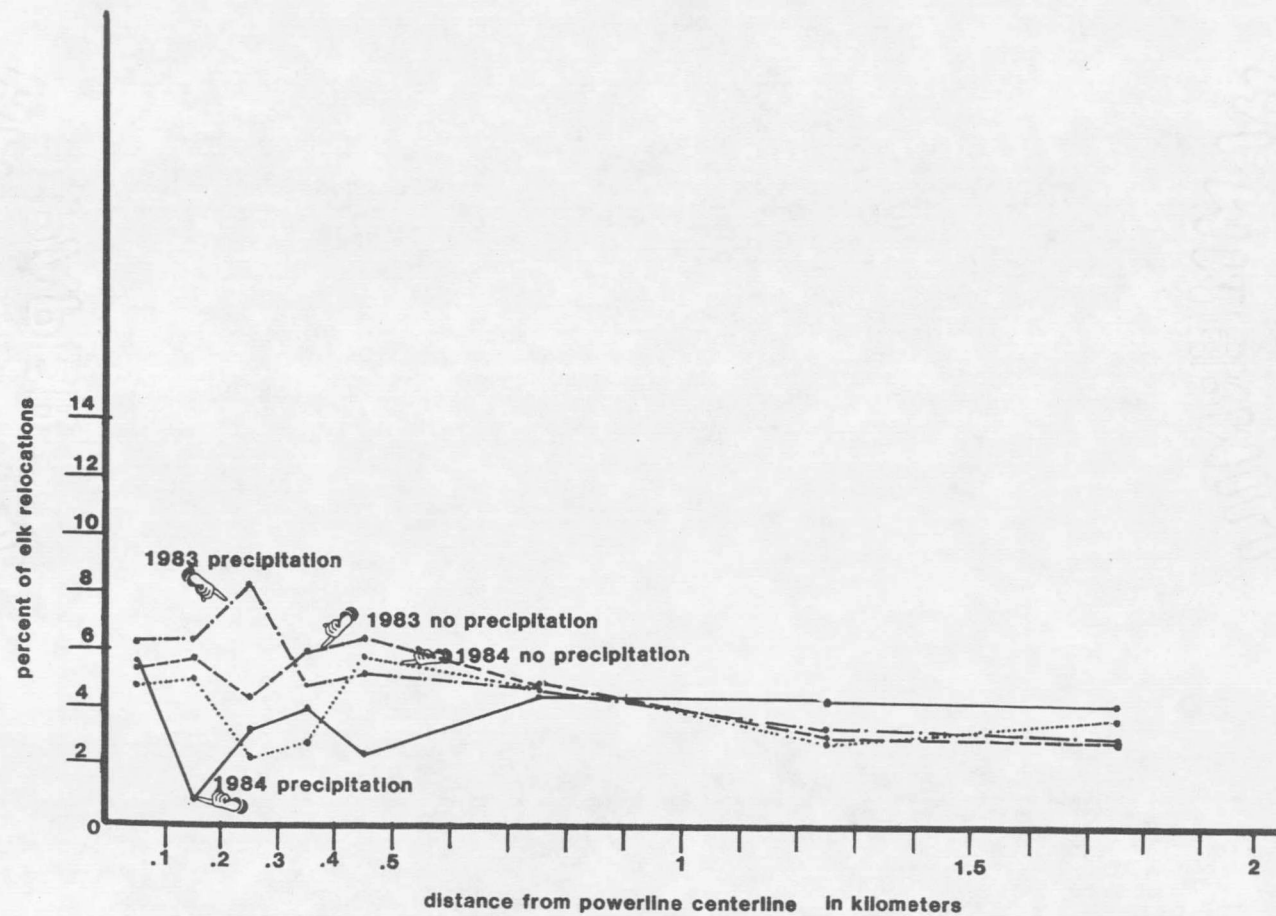


Figure 27. Radioed elk distribution over the entire winter period in relation to distance from the powerline (km) in 1983 and 1984 during precipitation and during fair weather, N. Boulder winter range, Mt.

powerline during morning hours. Dusk plots showed 2 cases of potential "turnaround" effects, and 4 cases of elk crossing the powerline at dusk during light snowfall. Daytime beds were generally greater than 300 m from the powerline regardless of weather conditions.

Throwing out daytime locations and locations of elk using Lowland Creek (>2 km from the study area), it was found that elk were distributed significantly nearer the powerline at dawn and dark during fair weather relative to foul weather in 1984 ($P < .05$). This relationship did not hold at dusk (Table 14).

Table 14. Percent of elk relocations in 1984 during precipitation (P) and non-precipitation (NP), within various distances from the powerline at dawn, dusk, and dark, N. Boulder winter range.

X m	% Relocations within X m of powerline					
	Dawn		Dusk		Dark	
	P n=37	NP n=105	P n=15	NP n=61	P n=28	NP n=54
100 m	3	13	7	2	8	11
200 m	5	23	7	4	8	16
300 m	22	36	7	13	8	16
>300	78	64	93	87	92	84

Powerline Access Roads and Hunting

Powerline access spurs from the N. Boulder River Road were constructed in 1982. Jeep trails and unimproved dirt roads already existed, and these were widened, improved, and gravelled from the N. Boulder River Road to the

powerline. New roads, 15 km in total length, were built under the line to access every tower.

Data collected during hunter check stations revealed that in 1982, 84 % of the hunters interviewed resided in Butte, Montana, 30 % reported seeing elk, but only 3 % killed an animal. In 1983, 74 % of those interviewed were from Butte, 29 % saw elk, and 2 % killed an animal. In both years, 88 % of those interviewed indicated that they hunted from roads at least part of the time. In 1982, 18 % of the interviewed hunters specified they did not hunt on BPA roads and had various negative comments about the powerline and the new roads. In 1983, 7 % made this specification or offered negative comments (Table 15).

Table 15. Examples of comments offered by hunters about BPA roads and the powerline in 1982 and 1983, N. Boulder River, Montana.

1982

- (1) "BPA roads concentrate people and push the elk up in elevation. Would be mass slaughter if it snowed hard during the season."
- (2) "BPA left a big mess behind."
- (3) "The construction of this powerline lowered the quality of hunting in this area."

1983

- (1) "The density of road hunters has increased because of BPA access roads. People are driving off the roads as well, even if there are road closures."
 - (2) "The noise from the powerline is bad for elk."
-

The overall distribution of hunting pressure changed between 1982 and 1983 (Table 16) probably in response to greater use of the new BPA access roads or improved old roads. It decreased in the Thunderbolt Creek area and along the Continental Divide, and increased in Alta Gulch west to Boyle Gulch, in the Little Cottonwood Creek area, and in the Red Rock Creek area (see Figure 1 for a map).

Table 16. Percent of hunters interviewed hunting a given area in 1982 and 1983, N. Boulder River, MT.

Area used	% Hunting in 1982 (N=109)	% Hunting in 1983 (N=140)
Thunderbolt Cr.		
Saratoga Mine	63	27
Little Cotton- wood Cr, Rock Cr.	10	28
Berkin Flat	8	11
Alta Gulch to Boyle Gulch	14	51
Red Rock Cr. Pole Mn.	5	17
Lockhart Meadow Cont. Divide	18	10

According to MDFWP hunter survey data, the average number of hunters hunting district 318 between 1957 and 1973 was 702 (s=140), and between 1974 and 1983, 1244 (s=170). Because the accuracy of the surveys has increased in recent years, these numbers may not be

entirely comparable (Frisina pers. comm.). The historic hunter success rates on district 318 were, on the average, 25 % lower than regional success rates between 1957 and 1973, and 50 % lower between 1974 and 1983. The number of hunters in 1982 and 1983 were 13.5% and 23% lower, respectively, than the 1974-1983 average. District 318 had a bull only season until 1979 (Table 17). From 1979 to the present, either sex permits have been issued (Table 18). The composition of the bull harvest has averaged 40% mature bulls (2+) and 60 % yearlings. Despite the drop in hunters in 1983 and 1984, the number of elk harvested remained quite steady.

Table 17. Bull harvest statistics from district 318, Montana.

Year	No. hunters	Total harvest	%Success-318	Regional
1980	1119	104	9	16
1981	1184	107	9	16
1982	1076	104	10	16
1983	958	112	12	16

Table 18. Harvest data from either sex permits, district 318, Montana.

Year	No. permits issued	No. animals killed
1979	25	10
1980	25	9
1981	75	36
1982	25	6
1983	75	25
1984	200 (Frisina pers. comm.)	

DISCUSSION

The extent and condition of winter range is believed to be important in regulating the size and productivity of elk populations (Boyd 1970, Knight 1970). Climate and land use in turn influence how much range is available and the condition of available elk winter range.

The elk population on the N. Boulder winter range has increased for the past 20 years, with a concurrent downward trend in calf recruitment (Figure 3), indicating that the winter population may be at or above the carrying capacity of the range. Changes in calf survival with both climate and cow population density is expected for a population at carrying capacity (Sauer and Boyce 1983, Picton 1984c). Fluctuations in calf/cow ratios over time may also be related to the method of classification. A large calf cohort results in a high proportion of yearling elk the following year. A classification count in that year would underestimate production since non-breeding yearling cows cannot be distinguished from adult cows in the field (Frisina pers. comm.). Because of the segregation of mature bulls from cow/calf groups during the winter and a permit system of harvesting antlerless elk

in this district, it is doubtful at this time that harvest plays a big role in the regulation of the winter population.

Cattle grazing is an important land use on the study area. Although cattle use and elk use are segregated temporally, they share a common forage base; therefore, the potential for indirect competition exists (Stevens 1966). Track transects (Table 11, transect 1, 1984), pellet group counts (Tables 9 and 10, 1984), and field observations, verified that elk avoided areas that cattle grazed heavily the previous summer. Equal elk/cattle forage allocation within the N. Boulder winter range zone in an average production year with average snow accumulations was calculated to be 860 AUMs cattle and 415 head of elk (Frisina et al. 1976). Over the past nine years, an average of 880 AUMs of cattle were grazed each year on the winter range, which roughly corresponds to the above calculation. Elk have increased beyond their theoretical carrying capacity under current cattle stocking rates. This may be related to recent mild winters in which the forage supply was greater than normal, or because elk populations at carrying capacity may also increase at the expense of the soil/plant range capital before negative feedback mechanisms operate to bring the herd and the range to a steady state.

It is expected that the winter elk population in 1985 will exceed 600 animals. A severely snow-restricted winter range may not support this many elk under current cattle stocking rates.

Comparisons show that the general distribution of elk on winter range has not changed over time (Figures 4, 5, 6, and 7). Although cover on winter range is important to elk for security and shelter during severe weather (Peek et al. 1982), it appears that cover on the study area is adequate (Figure 13), and that overall winter distribution is keyed to available forage (Table 5). High correlations of elk use with the distribution of available forage were also documented by Franklin et al. (1975) and Clary and Larson (1971). Irwin and Peek (1983) found that forage conditions were the primary factor influencing the size of elk home ranges in Idaho. The importance of snow depth and type (which influences forage distribution and availability) on elk distribution has been documented by Beall (1974), Knight (1970), and Desimone and Thompson (1983).

Although elk distribution determined from pellet group counts and radiotelemetry was similar, telemetry underestimated elk use on the eastern half of the study area (also discussed by Leopold et al. 1984, Collins 1984, and Collins and Urness 1979), because only 1 of 15 radioed elk consistently used the east end (Pole

Mountain). Seven additional elk were collared in 1984 including five elk that use the Pole Mountain area. Information will be gathered on this segment of the herd during the remainder of the study. Aerial and visual observations were also used to document elk distribution, but these are limited to early morning and late evening when elk feed in open habitats. Therefore, these methods underestimated elk use of bedding sites.

Changes in elk distribution over time, although subtle, are apparent from pellet group counts (Figures 5 and 6). Decreases in elk use between 1983 and 1984 occurred in the vicinity of a timber sale in which harvest began in the summer of 1983, and near Red Rock Creek Road, where winter vehicular traffic has probably increased because the road was improved as a powerline access route. Increases in the use of higher elevation areas between 1975 and 1984 are likely attributable to elk population growth and mild winter conditions. Beall (1974) found that elk did not use logged sites the winter following timber removal, and that elk used higher elevations in mild winters. Coop (1973) commented that elk avoid roads with vehicular activity.

Geist (1982) suggested that elk are sensitive to disturbance by humans. Winter range on the N. Boulder puts elk in close proximity to human activities, and elk seemed to prefer to remain as high in elevation (toward

remote summer range) as possible in relation to forage conditions and day to day weather. There is also evidence that elk have a relatively low upper critical temperature and that use of high elevations is related to intolerance of heat during mild winter periods (Beall 1974, Murie 1951). In 1983, elevations at elk locations were highly correlated with variations in temperature, whereas in 1984, elk movements up and down in elevation were highly correlated with changes in snow depths. Normal snow patterns in the N. Boulder drainage are influenced by southwest winds that usually occur all winter. This was the case in 1983 according to local residents. Although there was less overall snow in 1984 compared to 1983, winds from the northwest predominated and snow patterns were quite variable. It is possible that elk are especially responsive to snow conditions which deviate from the average conditions. Mclean (1972) found that elk in the Lochsa drainage of Idaho moved up in elevation in response to snow depth, temperature, and available food, and speculated that within seasonal areas, movements are influenced by a combination of these factors or extremes of any one factor. In one winter during his study, he found that elk moved up in elevation with increasing temperatures despite a concurrent increase in snow depths.

Spring migration seemed to be delayed by elk use of the first available succulent forage at lower elevations in April. This was also observed by Mclean (1972), Dalke et al. (1965), and Beall (1974). Subsequent altitudinal movements seemed to be correlated with rising temperatures and vegetation development, although elk did respond to late spring snow storms by moving back onto winter range. Brazda (1953) reported that snow cover did not influence elk migration to summer range in the Gallatin drainage of Montana, but that migration was highly influenced by calving activities. Dalke et al. (1965) found that elk followed developing vegetation to summer range. Mclean (1972) stated that spring migration was closely tied to temperature indicating that when elk reach the upper critical temperature of the thermoneutral zone, it is energetically beneficial for them to seek cooler areas at higher elevations. In the fall, movements back to winter range commenced as soon as the big game season ended, as Coop (1973) also observed.

Elk did not show strong selection for any of the habitat parameters measured compared to measurements at random points throughout the winter range in 1983 and 1984 (Figure 10). Both winters being mild, elk were not restricted from using portions of the winter range because of deep snow. Conversations with local ranchers and resource managers revealed that in heavy snow years, elk

congregate in the N. Boulder River willow and hay bottoms and at lower elevations within the canyon.

The general southerly exposure and regular drainage pattern that creates a complex of bunchgrass parks and timbered cover patches on this winter range provides an energetically favorable situation for elk in the winter. It therefore seems logical to conclude that elk select winter range with inherently beneficial characteristics, and utilize the entire range when conditions permit. Similar to my results, Jeffrey (1963) measured 26 variables on winter range in Utah and could account for only 30 % of the variation in elk use, and Irwin and Peek (1983) concluded that elk in Idaho selected southwest facing winter home ranges with adequate supplies of food and cover rather than selecting for components within the winter range.

Use of habitat features during different time divisions corresponded to elk activities. During the day, security cover was likely important since elk chose higher elevation timbered areas for bedding and rumination. At dusk, feeding activities predominated, and elk chose areas with available forage but still close to timbered cover. Although no visual observations were possible to confirm telemetry findings, night monitoring indicated that elk did not stay bedded down, but rather crossed the N. Boulder River road, and actively sought out feeding areas

in the valley bottom which lack security cover. Rost and Bailey (1979) suggested that animals avoid roads if they use areas near roads at night but not in daylight, and Vogel (1983) found that deer were more nocturnally active in the presence of disturbance. In the N. Boulder, elk apparently used darkness as a means of securing use of areas having rich food resources, but which have a high potential for disturbance and a lack of security cover in daylight.

Elk and mule deer utilized common feeding areas on the study area, although mule deer feeding periods occurred later in the morning and earlier in the evening than elk feeding activity peaks. When feeding periods overlapped, elk appeared to be dominant over mule deer and often behaved aggressively toward mule deer. Temporal partitioning may be important to elk and deer in areas where they compete for the same forage base.

Home range standard diameters were fairly consistent among radioed elk throughout the winter. As expected, the home range size for an individual determined over a 24 hour period is much smaller than the home range size for an individual from locations accumulated throughout the winter season. An elk's temporal response to varying weather conditions represents the fourth dimension or time dimension of home range (Baker 1978). The intensity of

relocations should therefore be keyed to the specific time frame that the researcher is interested in.

Continuous telemetric monitoring showed that elk (for both winters) on the study area travelled an average of 9 km/day. There were only small differences in average daily movements between elk that used Lowland Creek and elk that used the N. Boulder range. On the N. Boulder range, elk usually travelled between bedding sites north of the powerline to feeding sites south of the powerline, even though it would be more efficient for an individual elk to bed and feed south of the powerline, or to use the Lowland Creek range. In more severe winters, elk probably do not use higher elevation areas north of the powerline as extensively as my data indicate, because movements would be restricted by deep snow.

Continuous monitoring on this study area and on the Long Tom Creek area nearby (Lonner and Hammond 1980) showed that elk were active at an average rate of .44 km/hour and .46 km/hour, respectively. Because Craighead et al. (1973) verified daytime telemetry locations with visual observations and found that 40 % of an elk's daily time budget was spent bedded down, it may be that these movements are an artifact of triangulation error. Small errors from a variety of sources (Denton 1973, Pac 1978) during successive locations of a bedded animal could be

interpreted as small movements. On the other hand, movements may be real.

It is not known whether between year shifts in individual elk geographic activity centers was related to energization of the powerline, or population pressures and mild weather. It is possible that elk in late fall migrated back to the N. Boulder range through Lowland Creek, were inhibited by an energized powerline, and then returned to Lowland Creek to winter. Youmans (1979) documented that some mule deer on winter range exhibited exploratory movements before settling on a core home range where they spent the rest of the winter. It is also possible that elk shifted to Lowland Creek because those individuals were familiar with that drainage (which they used as a migration corridor) and that range was able to support more wintering animals in 1984 compared to 1983. The three statistically significant between year shifts in GAC away from the powerline on the "study area proper" were also shifts up in elevation. These shifts could be interpreted as a response to mild winter conditions. Elk literature considers that an individual returning to the same winter range, regardless of the specific area within the range that the animal uses, shows fidelity to winter range. Elk shifts within seasonal home ranges between years on the N. Boulder range are not in conflict with the existing literature.

It is not surprising that elk were displaced from the Pole Mountain powerline construction area in the spring of 1983. Stahlecker (1975) reported that animal activity ceased in the vicinity of a 230-kV construction site in Colorado. Ward (1973) and Beall (1974) found that during the initial stages of active logging, elk moved out of the area, but eventually resumed normal activities. Because spring is an energetically critical time for cow elk and the effects of even short term displacement at this time could be significant, I support Thompson's (1977) suggestion that powerline construction activities through heavy seasonal use areas during critical periods should be prohibited.

The physical presence of a 500-kV powerline bisecting major use areas on elk winter range did not noticeably change overall elk distribution or prevent elk from travelling between bedding and feeding areas. Elk were sometimes seen feeding under the conductors during fair weather (no precipitation) where the corridor included undisturbed, available forage. As expected for a species operating under an energy conservation strategy, general elk distribution was best explained by traditional use of slopes, aspects, cover types, and the influence of cattle grazing, all in relation to snow accumulations.

Track counts and behavioral observations indicated that patterns of elk activity are disrupted by an

energized powerline during precipitation or "foul weather". Most noticeably this was a function of audible noise (measured as dB(A)), a random broadband crackling, hissing noise with a 120 Hz hum, which is a result of corona discharge. Corona discharge occurs when the electric field intensity on the surface of a conductor exceeds the breakdown strength of air; thus this phenomena is intensified at higher altitudes. Water beads on the conductors are the most significant cause of corona. In reference to wildlife impact, Lee and Griffith (1978) emphasized that there is the potential for audible noise effects to combine synergistically with the effects of construction, maintenance activities, electric fields, and/or magnetic fields.

Lee and Griffith (1978) defined "noise" as an unwanted sound, an environmental pollutant. The potential hazards of noise in the wildlife environment include masking of communication, reducing the ability of animals to locate potential danger, physiological effects, and resulting behavioral changes (Lee and Griffith 1978, Skovlin 1982). Behavioral effects theoretically would be expected anytime corona noise increases 1-3 dB beyond the acclimation background noise level (Picton pers. comm., Mountcastle 1974). Distribution of elk and behavioral observations relative to an energized powerline might be explained by a model in which elk hesitate before crossing

a "noisy" corridor, giving an apparent concentration of elk next to the powerline as the acoustical corridor interferes with the flow of elk (Picton pers. comm.). This is not to say that elk do not ultimately cross the powerline during foul weather, but that crossing a noisy corridor results in stress. Ames (1978) considered sound to be a potential "stressor" since it increased heart and respiratory rates in domestic sheep. Alarm reactions, excitement, and stress cost vital energy (Geist 1978).

Track transects examined on consecutive days in 1984 indicated that elk did not cross the powerline corridor the evening of a storm, nor did they cross the following morning, regardless of weather conditions. Two interpretations are possible. Either elk do not always feed actively during foul weather (and consequently do not cross the powerline toward feeding areas) because activity during cold weather results in a thermoregulatory penalty (Gates and Hudson 1979), or elk avoid the area around the corridor which is affected by significant precipitation noise levels. Whatever the cause, storms disrupted normal activity patterns over two feeding periods. That is, following a storm, elk did not seem to move south to feed the following morning. This would be a reversal of the basic activity pattern which involves elk moving north across the corridor into timber at dawn. Elk in 1984 may have been more likely to cross the corridor after dark

(Figure 16) also as a response to disturbance from powerline noise.

Driscoll (1975) suggested that audible noise makes powerline rights-of-way less desirable to animals during inclement weather. Klein (1971) mentioned that reindeer (Rangifer tarandus) in Norway are disturbed by newly constructed powerlines because of their unfamiliarity and the "hum" that powerlines produce. Lee and Reiner (1983) reported that cattle decreased use in the vicinity of a 1100-kV powerline in Oregon when it was energized and increased use when the line was de-energized. They speculated this response was the result of transient audible noise and/or electric field effects. Rogers (1982) stated that cattle were typically startled by bursts of corona noise when an EHV powerline was energized. Goodwin (1975), on the other hand, reported that track patterns of elk crossing a 500-kV corridor in Idaho during precipitation did not indicate avoidance or deviation from the norm. He also observed two cow elk crossing the corridor during a precipitation noise level of 63 dB(A) without evidence of inhibition. It is probable that animals acclimate to continuous and intermittent sounds of 100 dB(A) or less (Ames 1978), especially if the benefits to using a noisy corridor (forage) exceed the costs (stress). Acclimation is also a function of background noise levels, and the rate of

animal exposure to precipitation noise levels. The differences between the current study and Goodwin's study should be emphasized. Animals had been accustomed to the energized powerline on the the Idaho study area for a year and one half before the study was initiated. The line was cleared through dense timber and Goodwin found that differences in animal use of the right-of-way and other forest clearings were directly proportional to the amount of understory available as food. The Idaho area receives a great deal of precipitation as snow (38-152 cm/year), so wild animals there would be exposed to precipitation noise levels more continuously than elk on the relatively dry (30 cm/year precipitation) N. Boulder range. Also in contrast to Goodwin's study, the N. Boulder powerline was energized during the study, crosses a bunchgrass range at about the level where timber begins, and therefore involved little timber removal and no concurrent increases in the forage base. The higher altitudes (1644-2220 m) and more open habitat on the N. Boulder mean more corona discharge and less noise attenuation (BBST 1982) compared to the Idaho study area elevations (780-1700 m) and timbered habitat.

Approximately 13 % of the winter range is impacted by an "acoustical corridor" with a length of 14.4 km and a width of 500 m (the point at which the noise attenuates to the upper limit of ambient levels is 250 m on either side

of the corridor). In 1984, precipitation effects occurred on an average of 10.5 % of the 121 days in the winter period (Table 13). A normal winter was calculated to have precipitation effects on 22.5 % of the 121 day period (Picton 1984b). Although it is expected that elk can acclimate to precipitation noise levels, there is little basis for assuming more acclimation by N. Boulder elk than is currently present.

I suggest that future EHV powerline corridors are not placed on winter game ranges in a manner that separates major use areas. Corridors could be placed across areas that large ungulates already avoid, such as large clearcuts (Thompson 1977).

Hunting success rates in hunting district 318 have been consistently lower than the regional averages. This may indicate that this district has high security habitat for elk on fall transition range. Security is influenced by the presence of access roads and the amount of good quality hiding cover (Lonner and Cada 1982). It is also possible that the area, which is hunted almost exclusively by locals, has always had a high percentage of road hunters (the 1982 and 1983 data indicate this trend), and studies in Montana have shown that road hunters add little to the harvest (Basile 1973, Coop 1973). Griffith (1977) and Goodwin (1975) reported heavy use of transmission line access roads, so the predominance of road hunters in 1983

and 1984 may also be the result of new and improved powerline access roads. Comments offered by some hunters interviewed in 1982 and 1983, indicated that the presence of the powerline and improved access decreased the "quality" of hunting for some people who traditionally hunt this area. This may explain the decrease in the number of hunters and negative comments in 1983 compared to 1982 (Table 15).

Improved access and the 15 km of new access probably changed the kinds of vehicles travelling through the area (four wheel drive not required), increased the rate at which vehicles can move through the area and thereby encounter animals, and shifted hunter distribution. Since the improved access roads are clustered on winter range, the greatest impact to elk would be in an autumn with heavy snow when elk are forced to come down in elevation during the hunting season.

Closure of the powerline access roads during the hunting season might lower hunter density and increase the effective length of the season by holding elk in the area longer and spreading out the harvest (Lonner and Cada 1982, and Marcum and Lemkuhl 1980). However, road closures might also exclude some people (family groups and older people) from seeking hunting opportunities in this area.

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APPENDICES

APPENDIX A
WEATHER DATA

Table 19. Mean snow depth in cm between January and March at each snow stake in 1983 and 1984. Elevation at snow stakes ranged from 1905-1965 m.

Aspect and cover type at stake	1983		1984	
	depth and cm	st. dev. cm	depth and cm	st. dev. cm
Flat, open	32	11.6	22	7.2
Flat, timber	16	6.4	7	4.7
West, open	14	5.0	12	8.0
South, open	12	5.4	10	7.9
North, open	35	11.4	25	9.5
North, timber	14	7.9	5	4.7
East, open	28	12.0	24	8.7
East, timber	16	3.4	9	6.7

Table 20. Means, standard deviations, and ranges of temperatures (Centigrade) based on Butte weather data (USDC-NOAA).

Month/year	Mean temp.		Standard dev.		Range	
	Min.	Max.	Min.	Max.	Min.	Max.
Jan. 1983	-9.7	1.06	4.4	6.3	-24-+1	-11-+9
Feb. 1983	-8.6	2.67	6.3	4.2	-23-+2	-7-+11
Mar. 1983	-5.4	5.72	4.3	4.5	-5-+15	-19-+.3
Jan. 1984	-8.9	3.78	10.4	8.5	-16-+11	-32-+3
Feb. 1984	-10.9	3.27	5.0	3.4	-22-+4	-2-+9
Mar. 1984	-4.8	4.72	3.5	2.8	-16-+.5	-2-+11

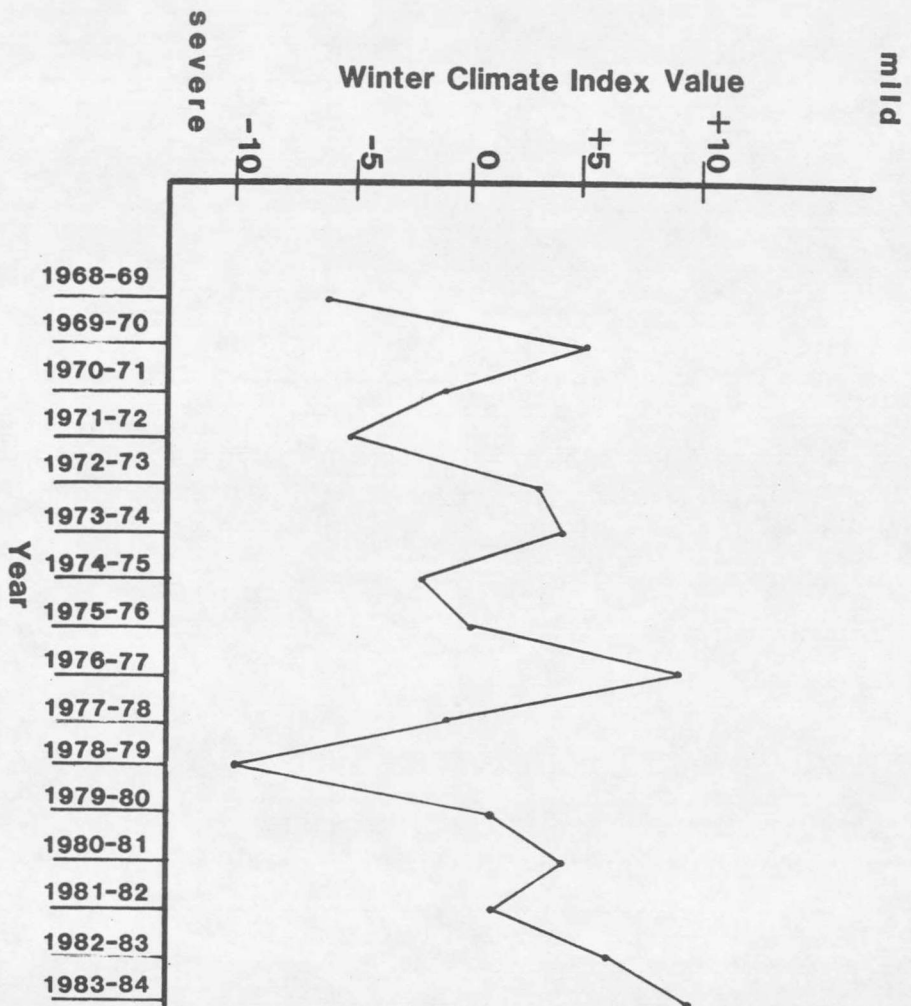


Figure 28. Winter climate index values (Picton 1984c) based on Boulder MT. data, 1968 to 1984.

APPENDIX B

COMPUTER CODING FORMAT FOR ELK OBSERVATIONS
AND RADIO LOCATIONS

Table 21. Coding format for elk observations.

Column(s)	Item	Explanation
1-4	observation #	consecutive integers
5	observer	
6-11	date	e.g. 01/13/83
12-15	time	military
16	day/night	1=dawn, 2=day, 3=dusk, 4=dark
17	observation type	2=air radio fix; no visual 3=visual observations 5=air radio fix; visual 6=aerial survey 8=24 hour monitoring
18-19	animal Id.	00=unmarked elk 1-15=elk Id. based on frequency.
20-22	group size	
23-24	# females	
25-26	# males	
27-28	# calves	
29-30	# unknown	
31	observer loc.	1=on foot, 2=from vehicle, 3=from sta. 1, 4=from sta. 2 5=from sta. 3, 6=from air 7=from 2 of 3 stations 8=3 station triangulation
38-41	UTM x coord.	4 digit latitude
42-46	UTM y coord.	5 digit longitude
47	activity	0=bedded, 1=feeding, 2=running 3=walking, 6=vigilant, watchful 8=unknown (no visual)
48	disturbance?	1=disturbed by observer 2=not disturbed
49	proximity to Boulder R. Rd.	straight line distance: 1=0-.5 km, 2=.5-1, 3=1-1.5, 4=1.5-2, 5=>2
50	human activity in vicinity	1=roads, 2=cattle, 3=buildings, 4=ranching activity, 5=hunting 6=snowmobiling, 7=chainsaw
51	distance from powerline r-o-w	straight line distance: 1=0-100m, 2=100-200, 3=200-300, 4=300-400, 5=400-500, 6=.5-1 km, 7=1-1.5, 8=1.5-2,

Table 22 (continued)

52-54	ambient temp.	col.52:0=below 0 ⁰ F.,1=above 0 col.53-54: degrees F.
55	wind speed	0=no wind, 1=0-5mph, 2=5-10, 3=10-20, 4=>20 mph
56	wind direction	0=no wind,1=north,2=northeast 3=east, 4=southeast, 5=south, 6=sw, 7=w, 8=nw
57	cloud cover	0=<10%, 1=10-50%, 2=50-90% 3=overcast, 4=fog
58	precipitation	0=none,1=mist or light snow, 2=rain, 3=intermittant snow 4=intermit. snow or rain, 5=thunderstorm, 6=hail or sleet
62	type of snow	0=no snow, 1=powder,3=crust 4=wet, 5=ice
63	ground condition	4=trace of snow, 5=all snow 6=green up, 7=patchy snow
64-67	elevation	estimated to the nearest 40 ft contour line on a map
68-69	slope	estimated from maps (%)
70	topography	1=ridgetop, 2=upper slope, 3=mid-slope, 4=lower slope, 5=ungulating flat,6=river or creek bottom, or gulch
71	aspect	same codes as wind direction
72-73	vegetation	10=timber 13=aspen stand 20=open bunchgrass park 21=grass/timber edge 22=clearcut 23=clearcut/forest edge 30=sagebrush stand 40=riparian vegetation
74	distance to hiding cover	1=0-100 m,2=100-200,3=200-300, 4=300-400 m, 5=400-500, 6=>500 m

APPENDIX C

ELK DISTRIBUTION DURING 24 HOUR MONITORING
AND AERIAL FLIGHTS

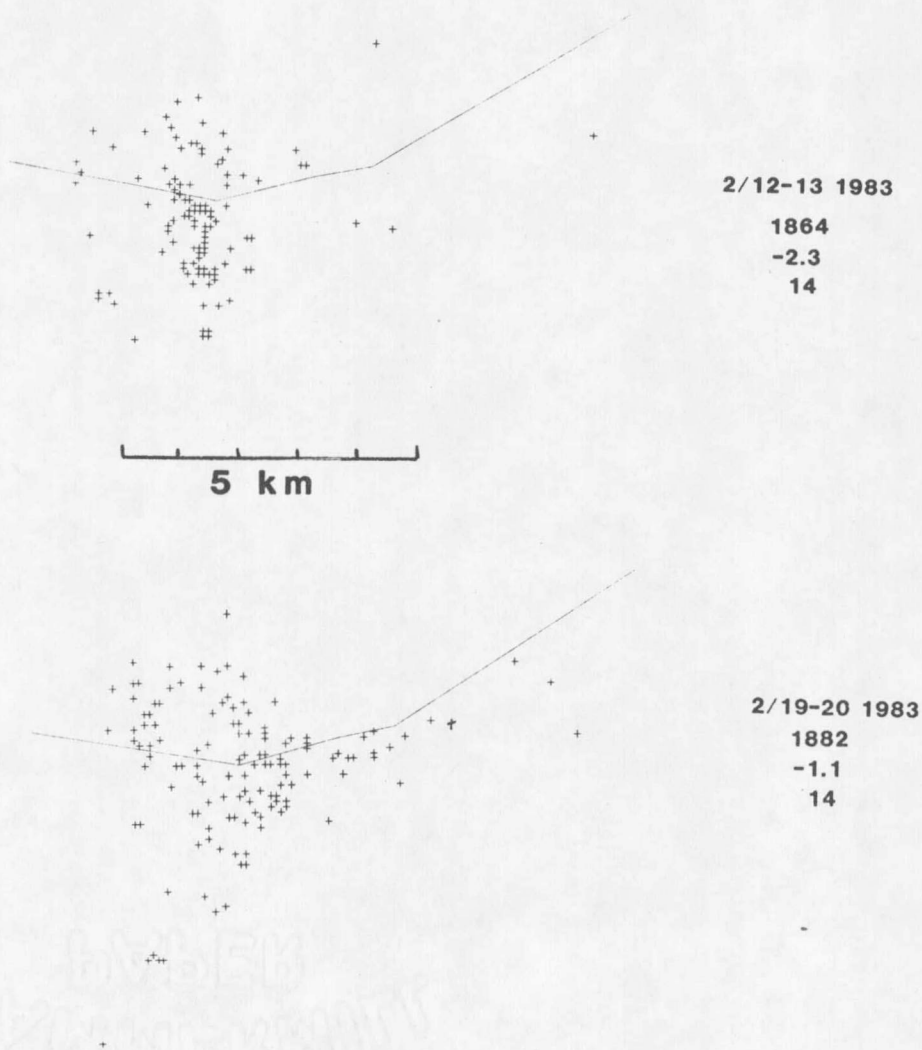


Figure 29. Radioed elk distribution during 24 hour monitoring sessions in February 1983. Under the date is given (top to bottom) mean elevation at elk locations (m), mean temperature over the period (C), and mean weekly snow depth (cm) on the N. Boulder winter range, MT.

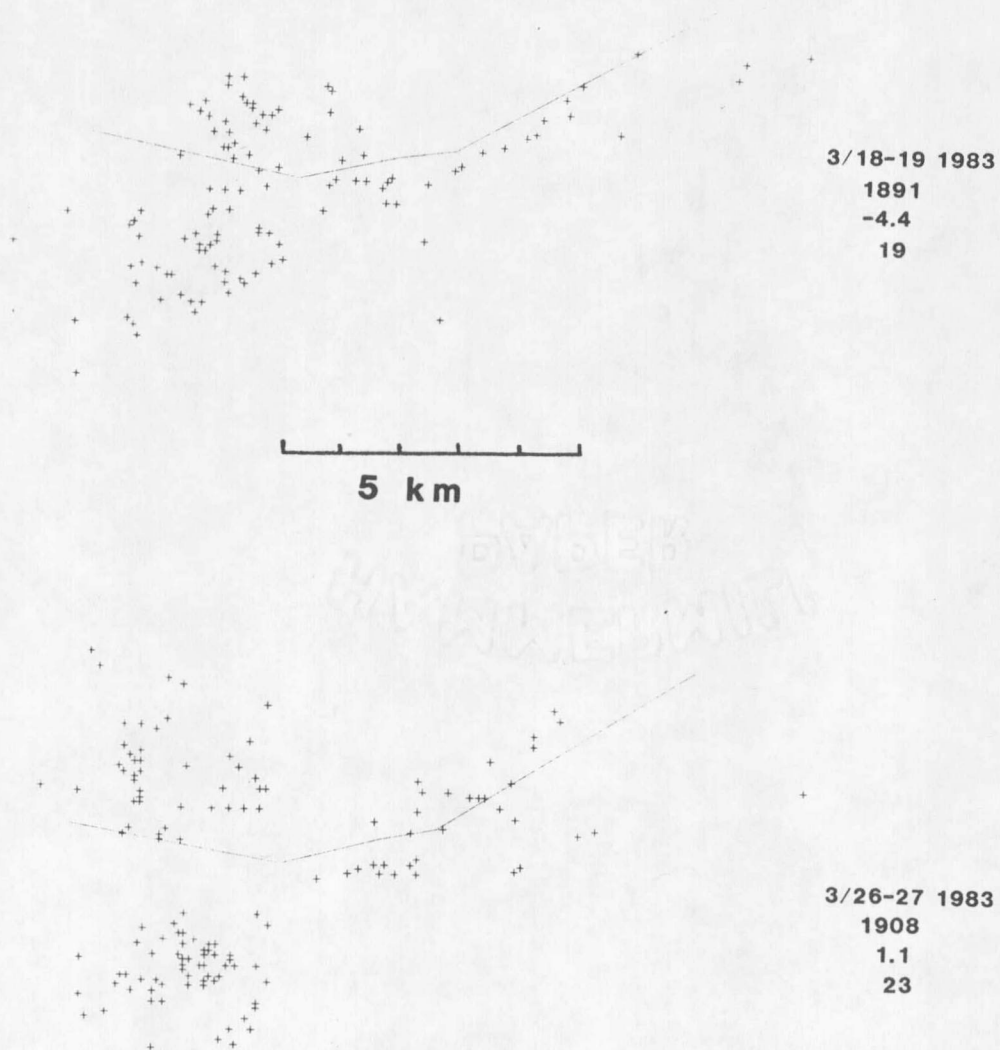


Figure 30. Radioed elk distribution during 24 hour monitoring sessions in March 1983. Under the date is given (top to bottom) mean elevation at elk locations (m), mean temperature over the period (C), and mean weekly snow depth (cm) on the N.Boulder winter range, MT.

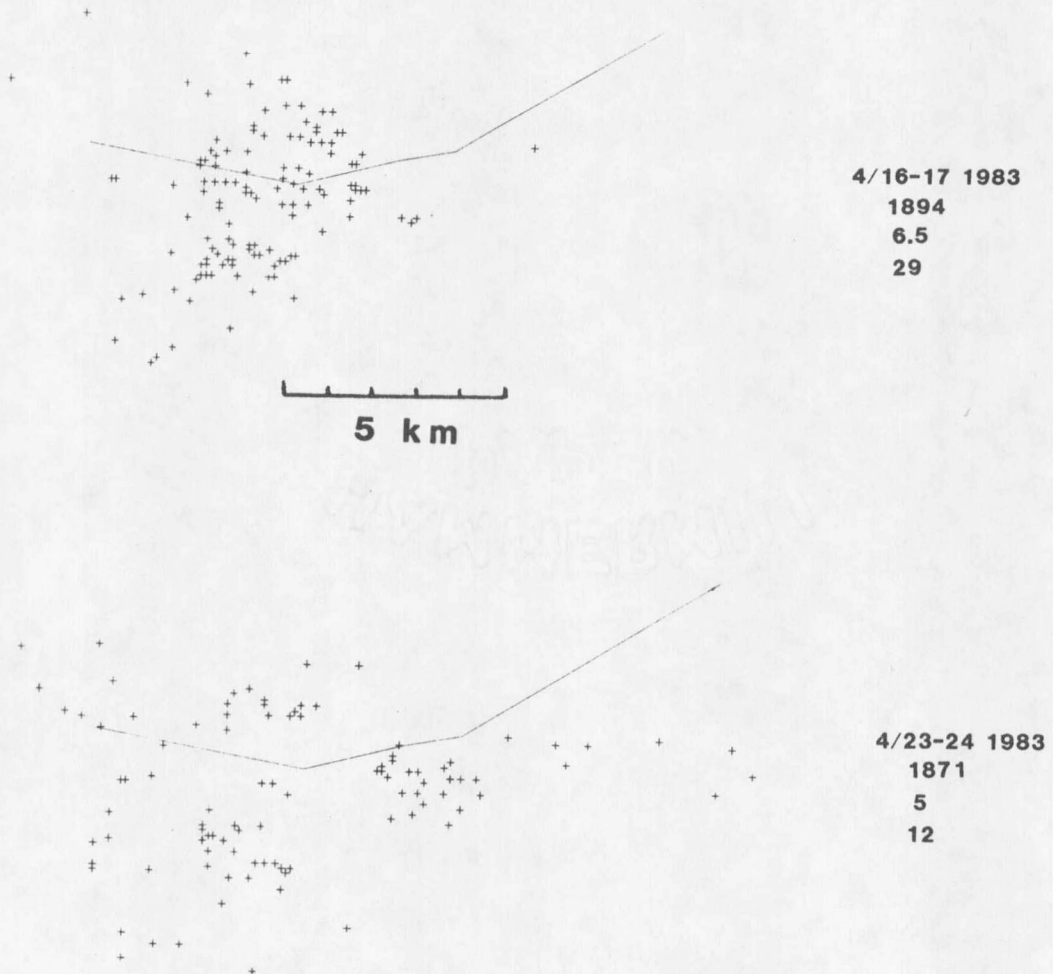


Figure 31. Radioed elk distribution during 24 hour monitoring sessions in April 1983. Under the date is given (top to bottom), mean elevation at elk locations (m), mean temperature over the period (C), and mean weekly snow depth (cm) on the N. Boulder winter range, MT.

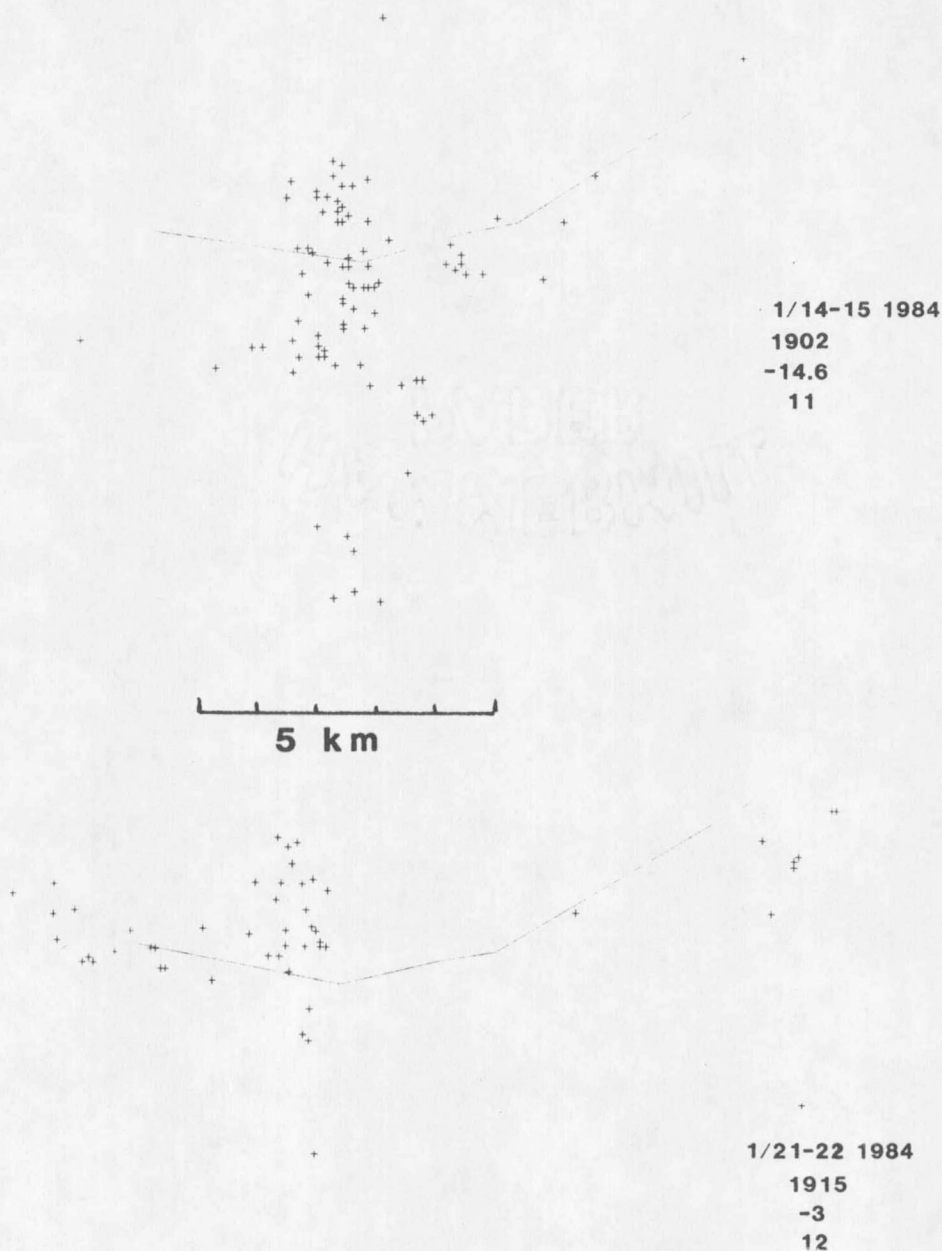


Figure 32. Radioed elk distribution during 24 hour monitoring sessions in January 1984. Under the date is given (top to bottom), mean elevation at elk locations (m), mean temperature over the period (C), and mean weekly snow depth (cm) on the N. Boulder winter range, MT.

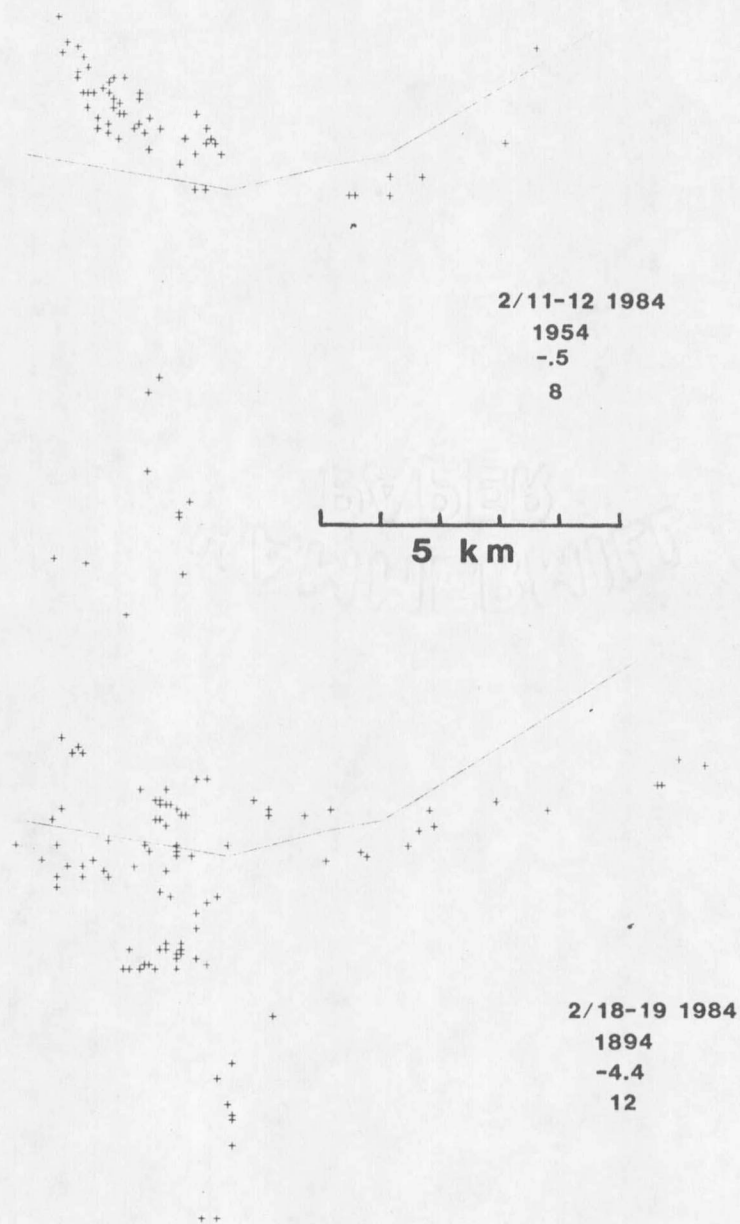


Figure 33. Radioed elk distribution during 24 hour monitoring sessions in February 1984. Under the date is given (top to bottom), mean elevation at elk locations (m), mean temperature over the period (C), and mean weekly snow depth (cm) on the N. Boulder winter range, MT.

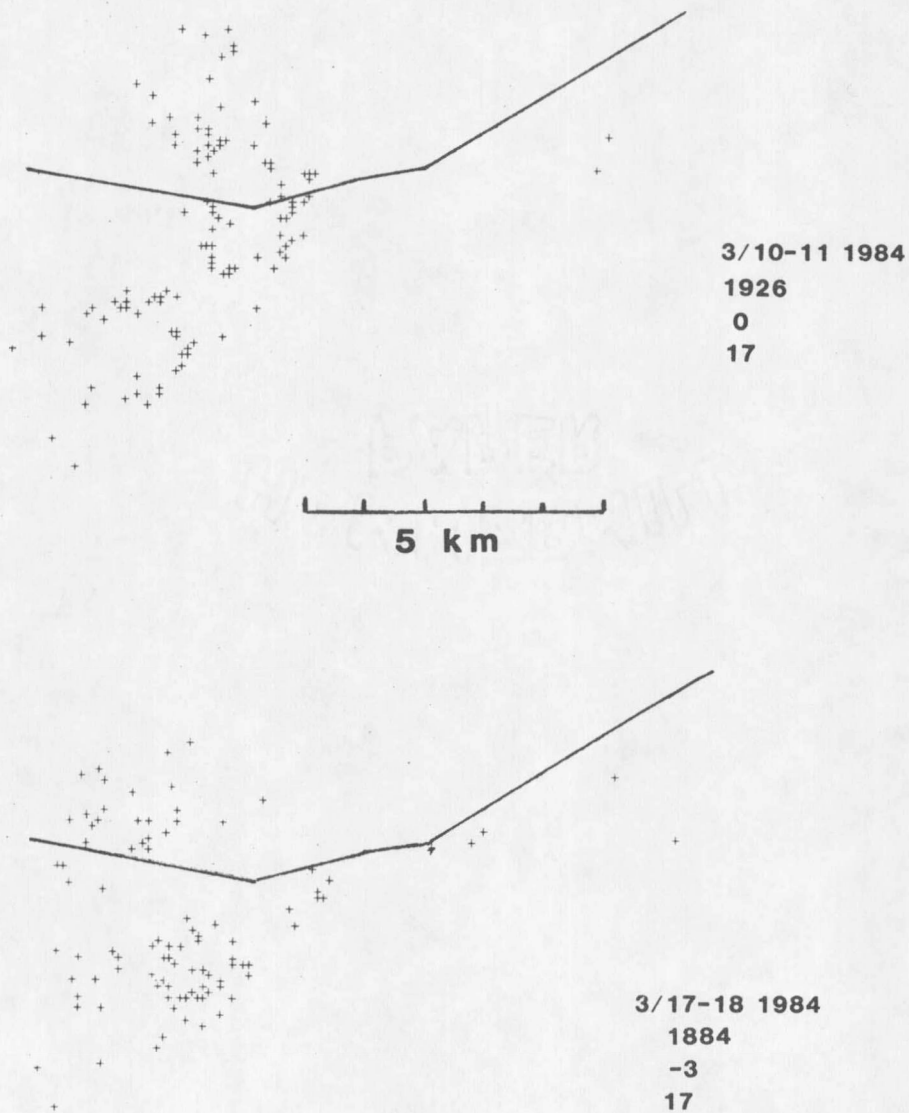


Figure 34. Radioed elk distribution during 24 hour monitoring sessions in March 1984. Under the date is given (top to bottom), mean elevation at elk locations (m), mean temperature over the period (C), and mean weekly snow depth (cm) on the N. Boulder winter range, MT.

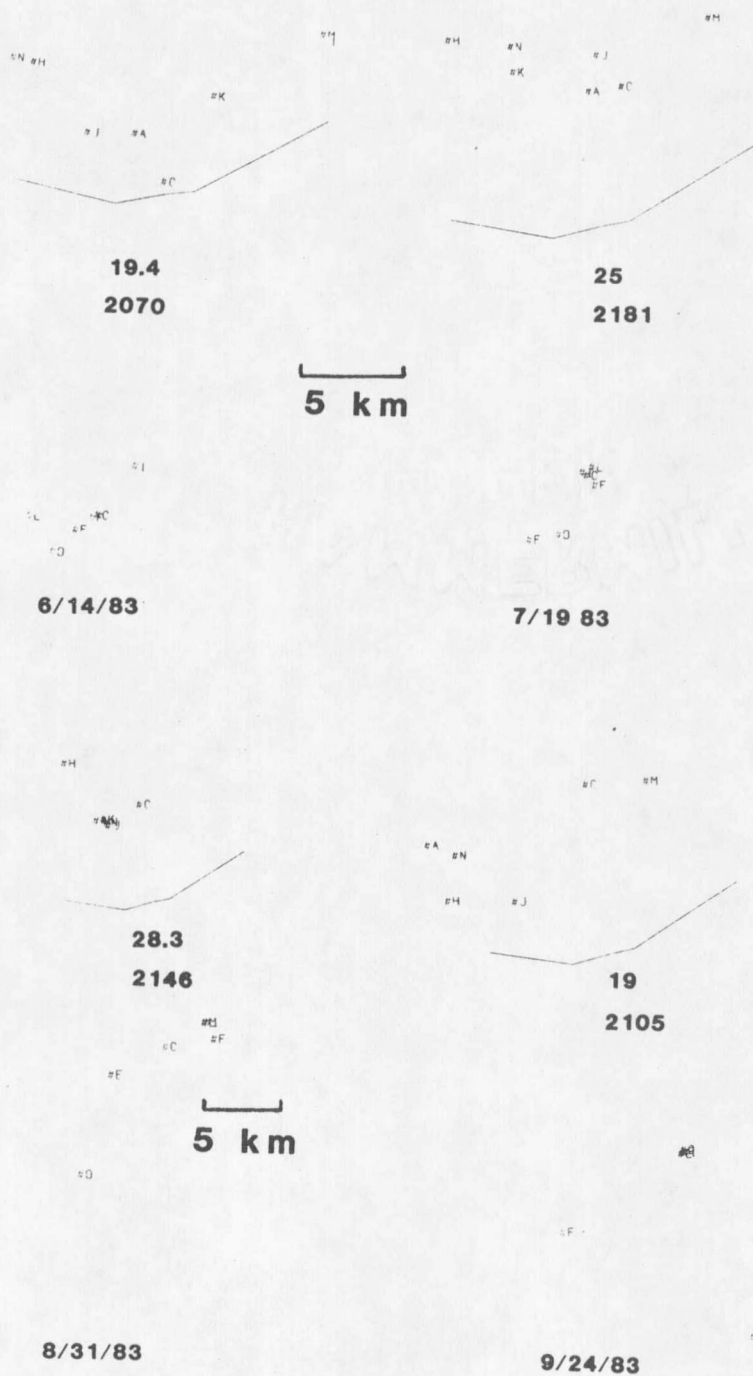
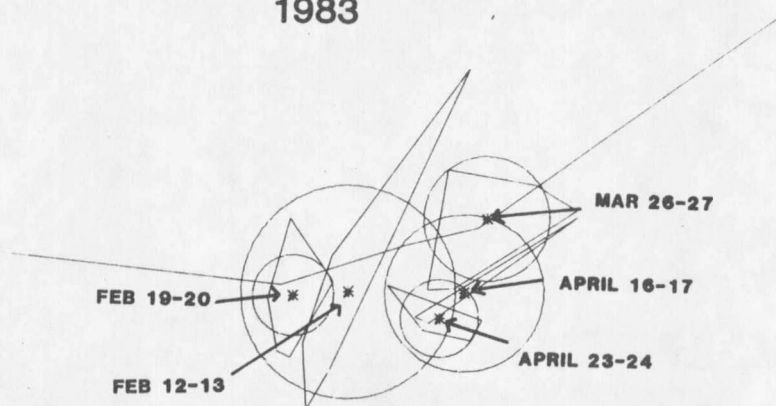


Figure 35. Radioed elk summer aerial relocations from June to September 1983. Under plot is given mean temperature (C) during flight and mean elevation (m) at elk locations.

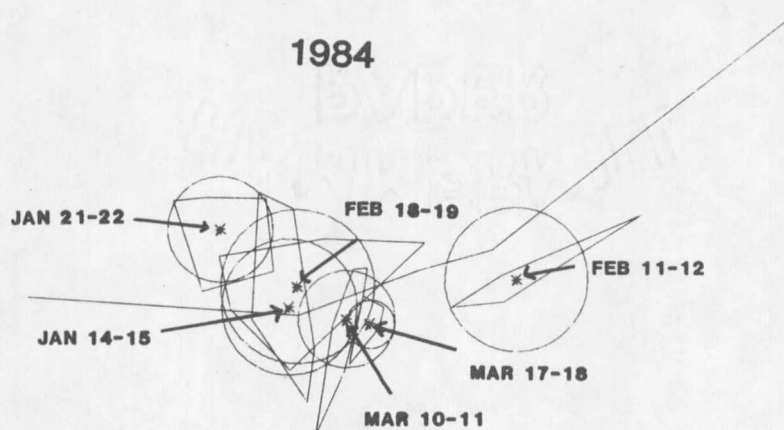
APPENDIX D

INDIVIDUAL ELK HOME RANGES DURING INDIVIDUAL
24 HOUR MONITORING SESSIONS

1983



1984



ELK#3

Figure 36. Polygons and standard diameters for each 24 hour session in 1983 and 1984 for radioed elk #3 on the N. Boulder winter range, MT.

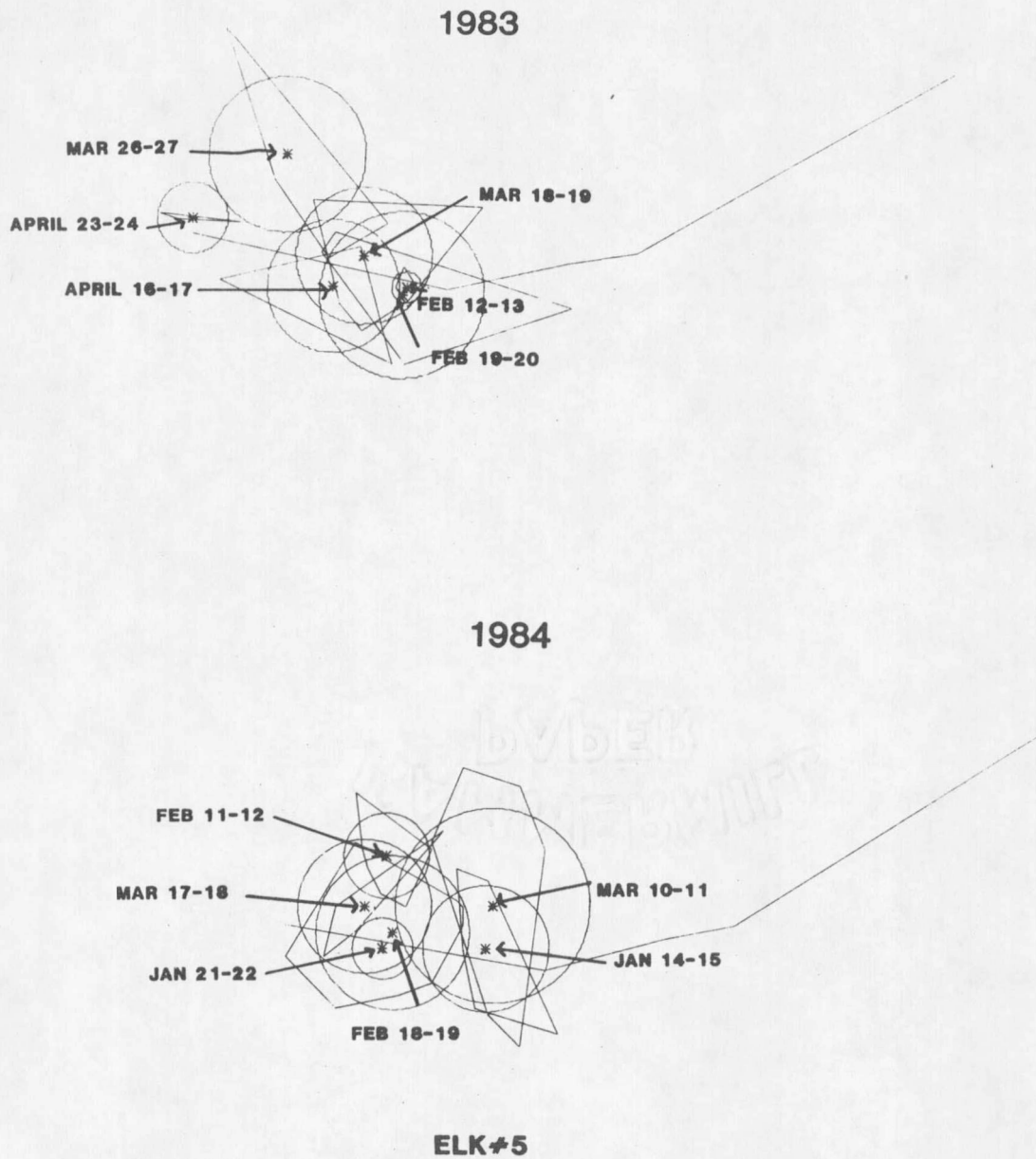


Figure 37. Polygons and standard diameters for each 24 hour session in 1983 and 1984 for radioed elk #5 on the N. Boulder winter range, MT.

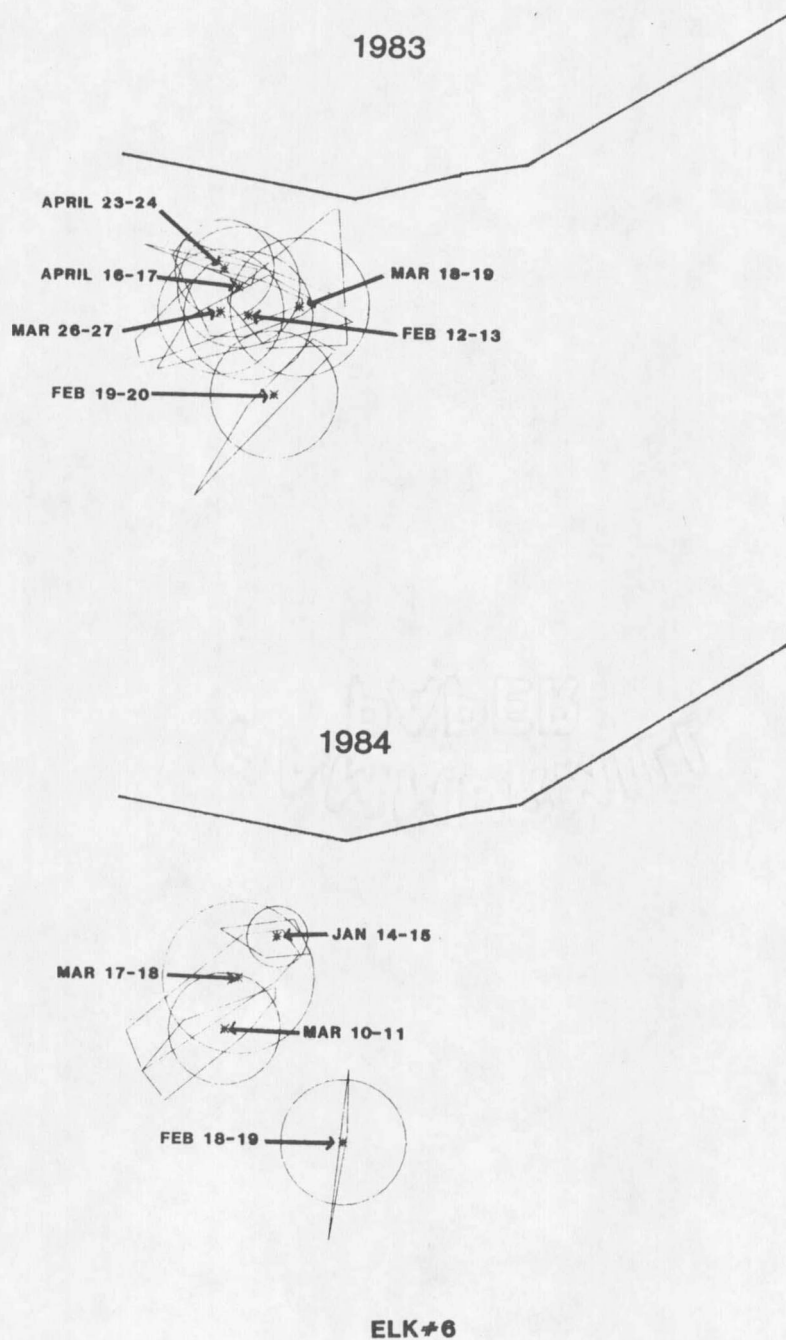
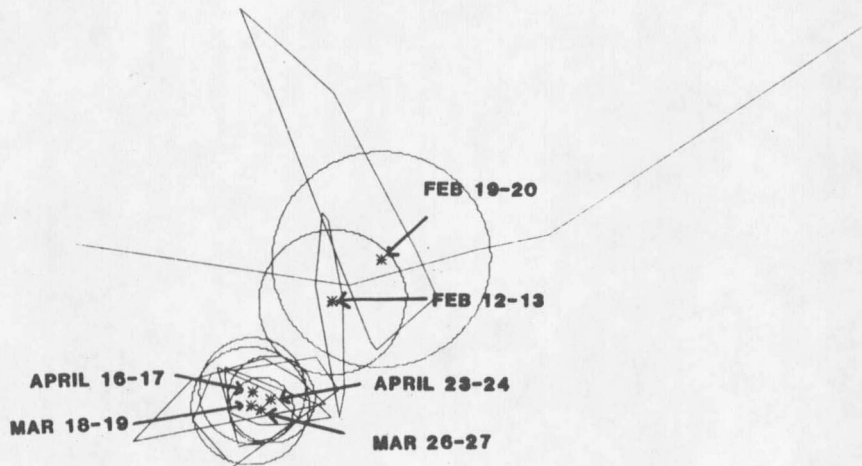


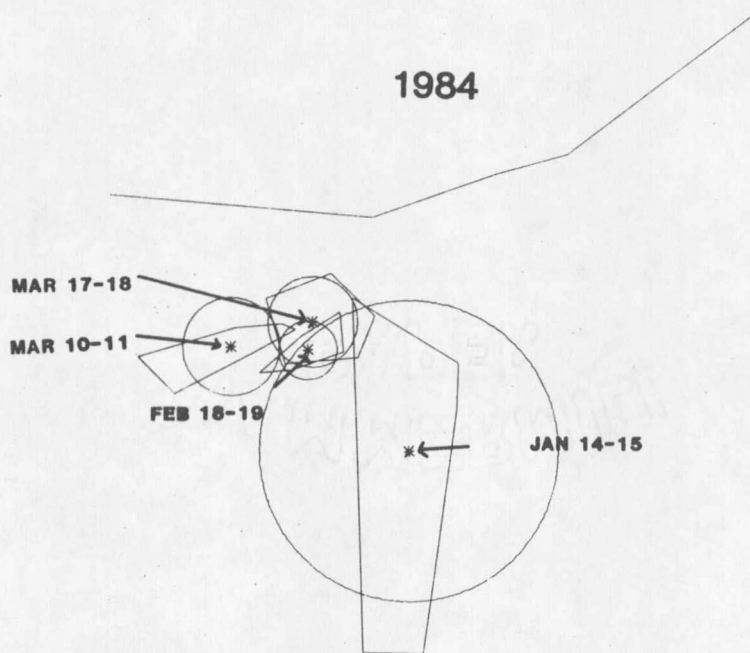
Figure 38. Polygons and standard diameters for each 24 hour session in 1983 and 1984 for radioed elk #6 on the N. Boulder winter range, MT.

123

1983



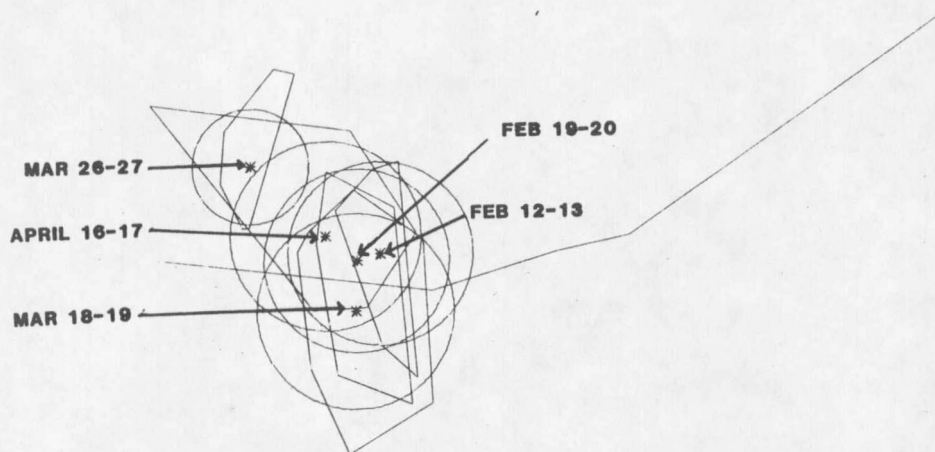
1984



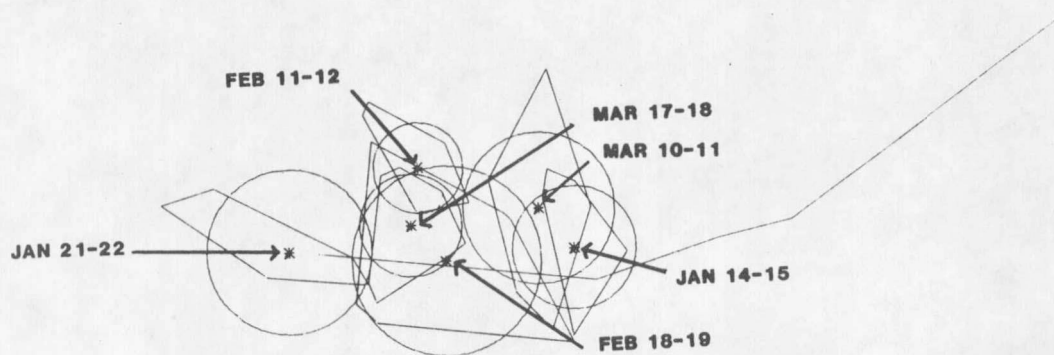
ELK#7

Figure 39. Polygons and standard diameters for each 24 hour session in 1983 and 1984 for radioed elk #7 on the N. Boulder winter range, MT.

1983



1984



ELK#8

Figure 40. Polygons and standard diameters for each 24 hour session in 1983 and 1984 for radioed elk #8 on the N. Boulder winter range, MT.

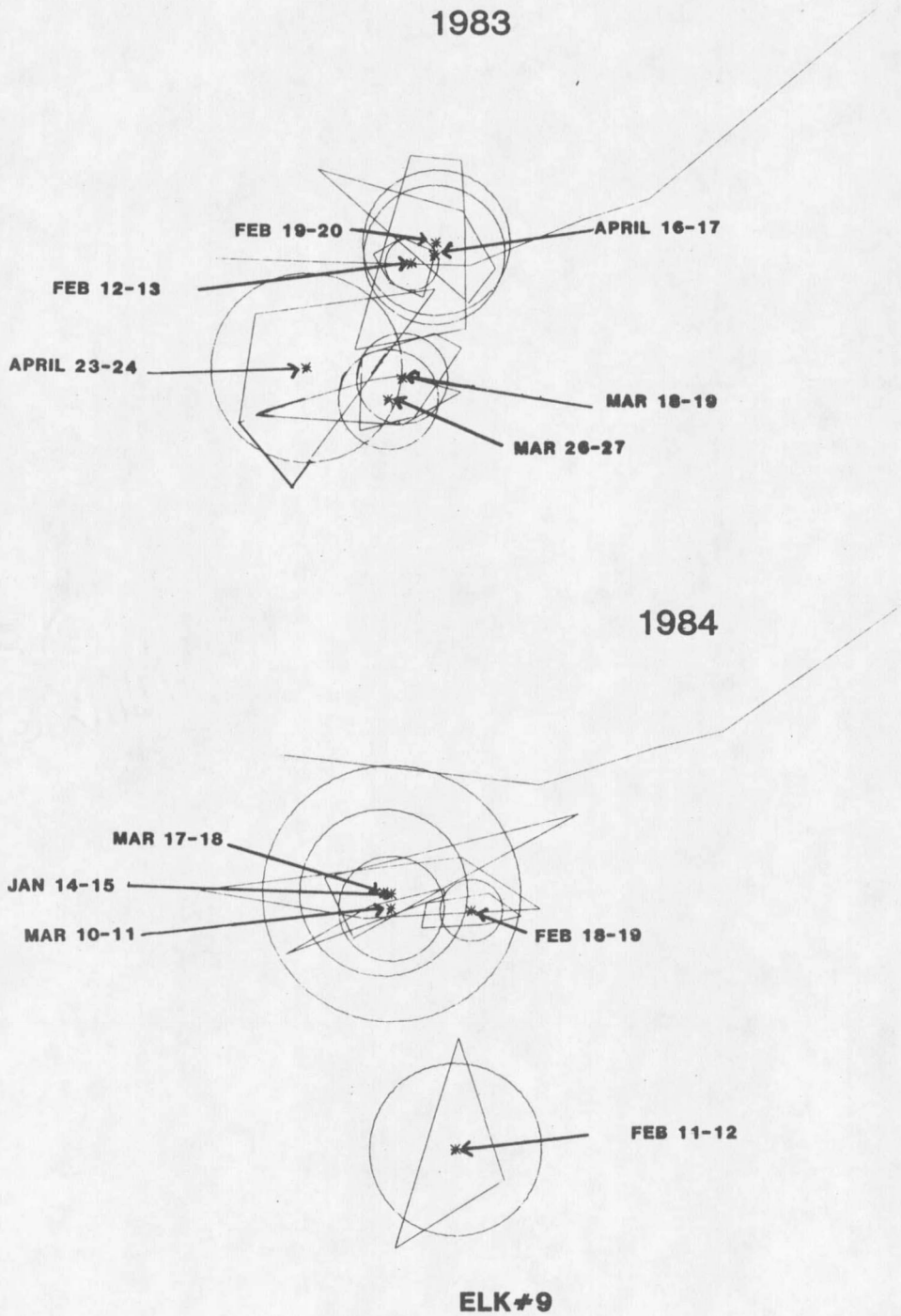


Figure 41. Polygons and standard diameters for each 24 hour session in 1983 and 1984 for radioed elk #9 on the N. Boulder winter range, MT.

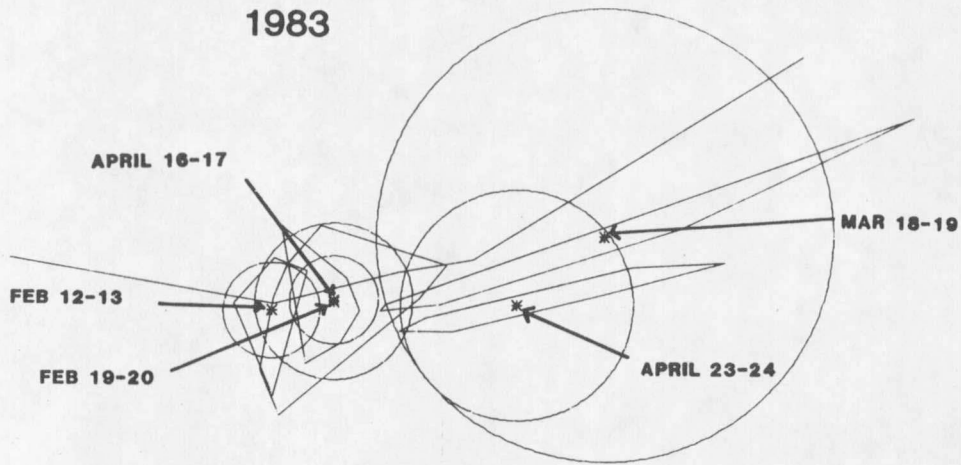
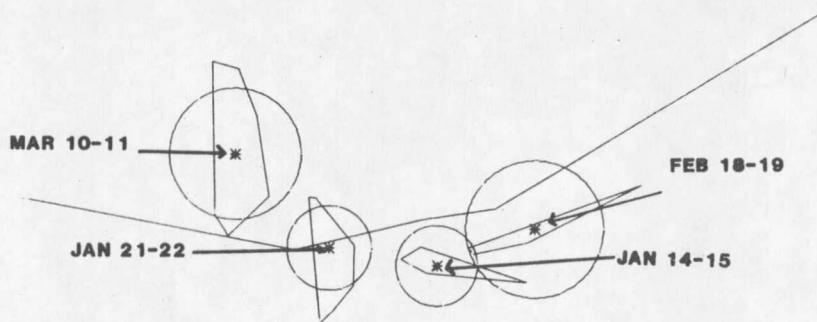
1983**1984****ELK #11**

Figure 42. Polygons and standard diameters for each 24 hour session in 1983 and 1984 for radioed elk #11 on the N. Boulder winter range, MT.

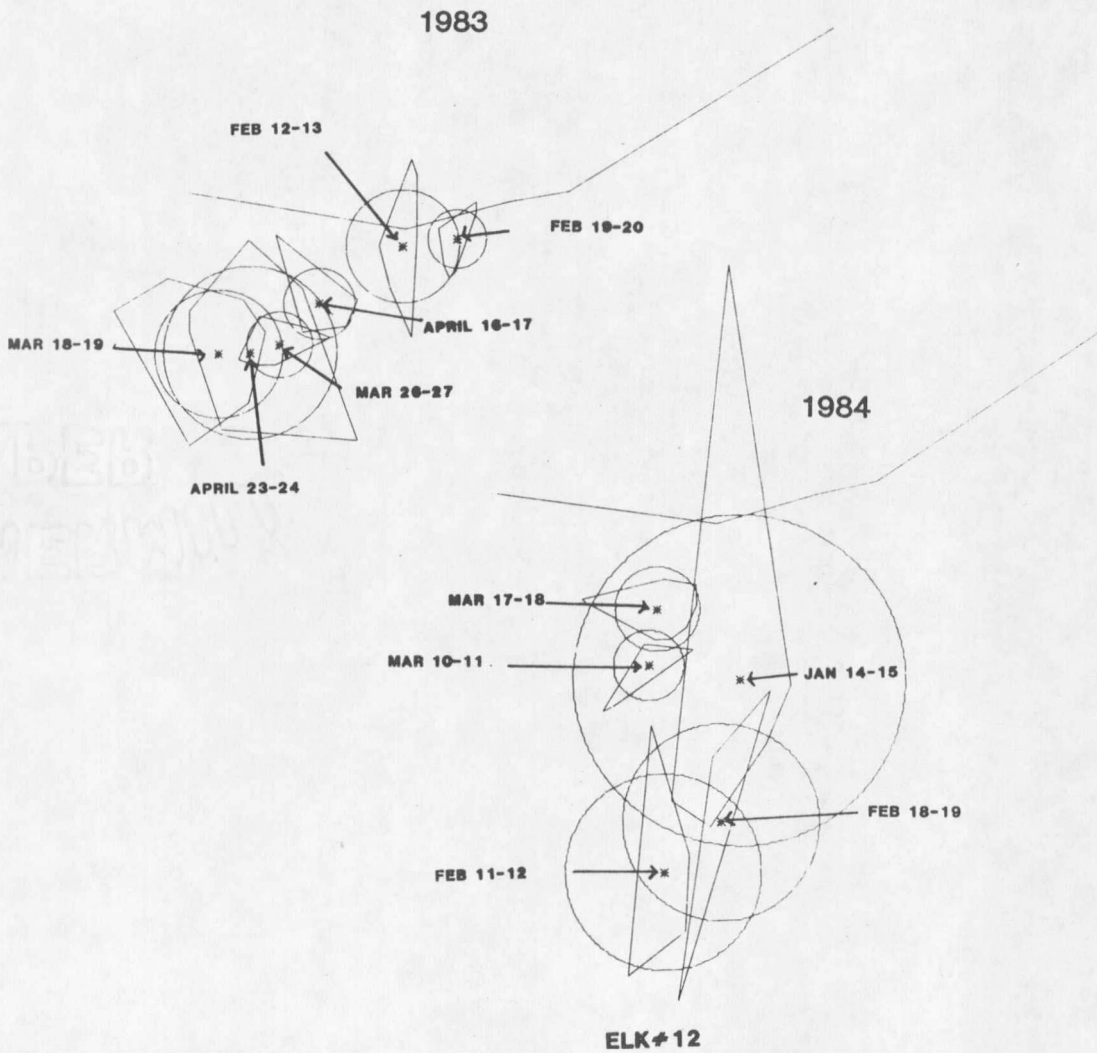


Figure 43. Polygons and standard diameters for each 24 hour session in 1983 and 1984 for radioed elk #12 on the N. Boulder winter range, MT.

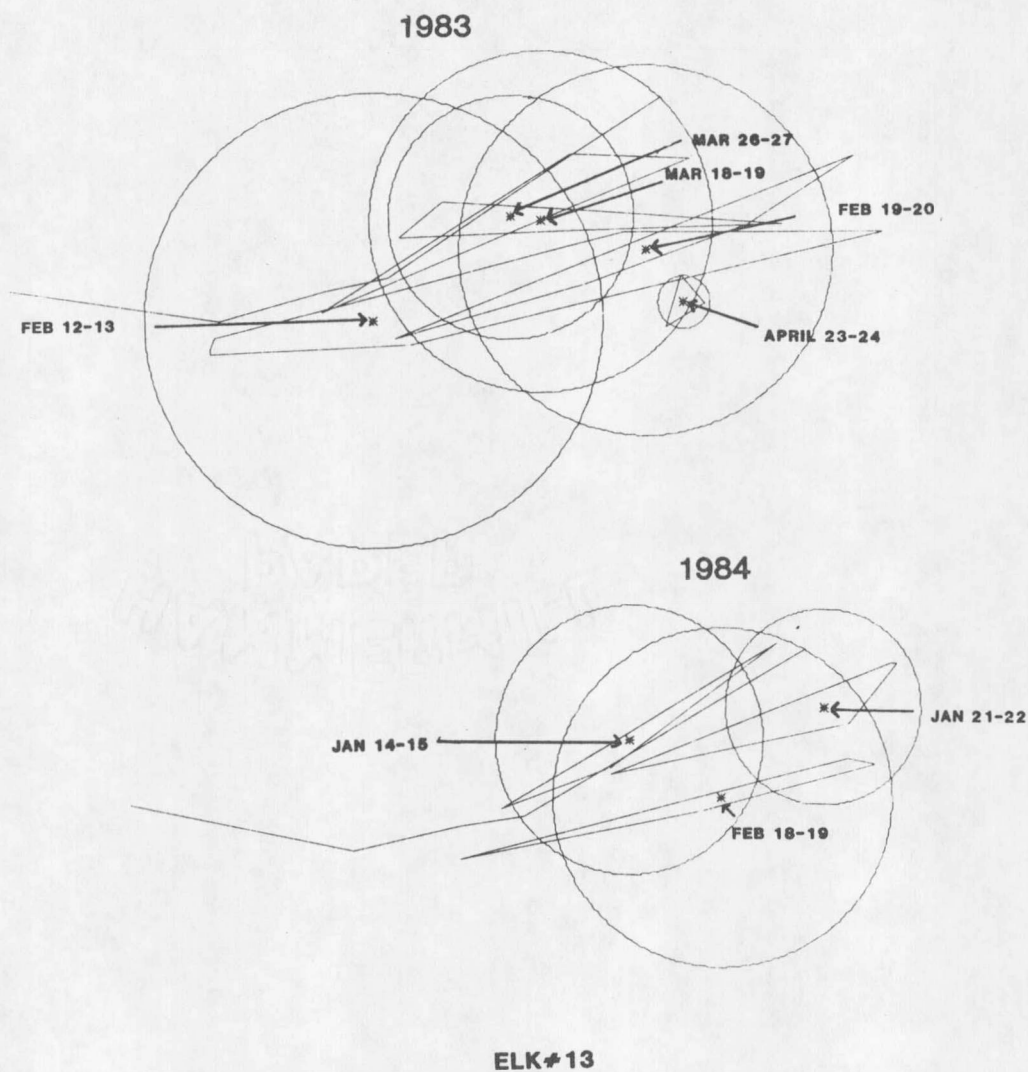
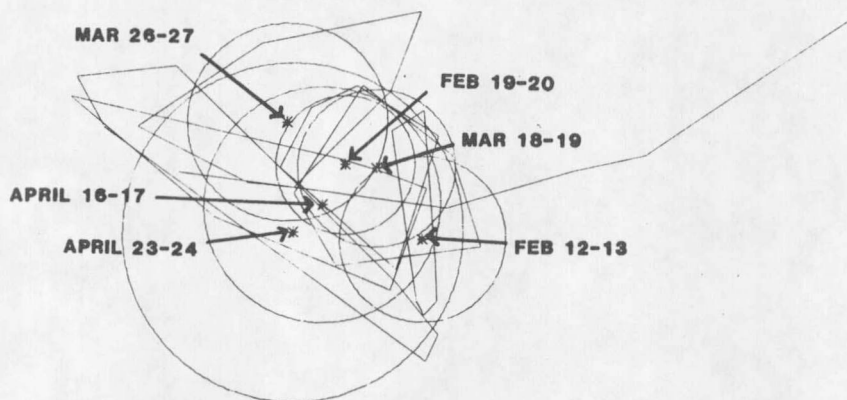
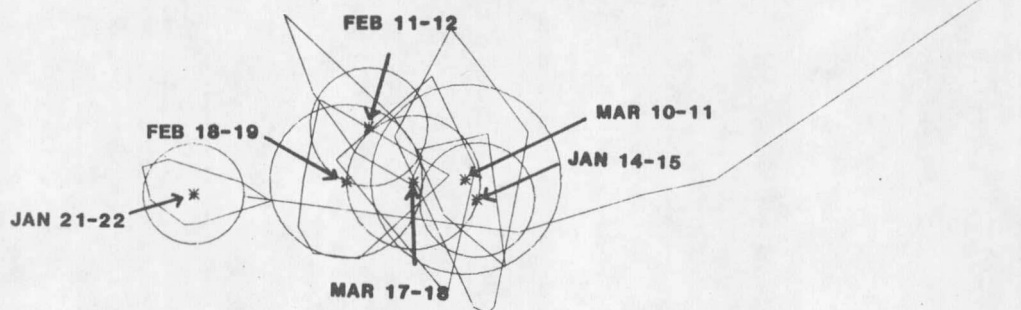


Figure 44. Polygons and standard diameters for each 24 hour session in 1983 and 1984 for radioed elk #13 on the N. Boulder winter range, MT.

1983



1984



ELK#14

Figure 45. Polygons and standard diameters for each 24 hour session in 1983 and 1984 for radioed elk #14 on the N. Boulder winter range, MT.

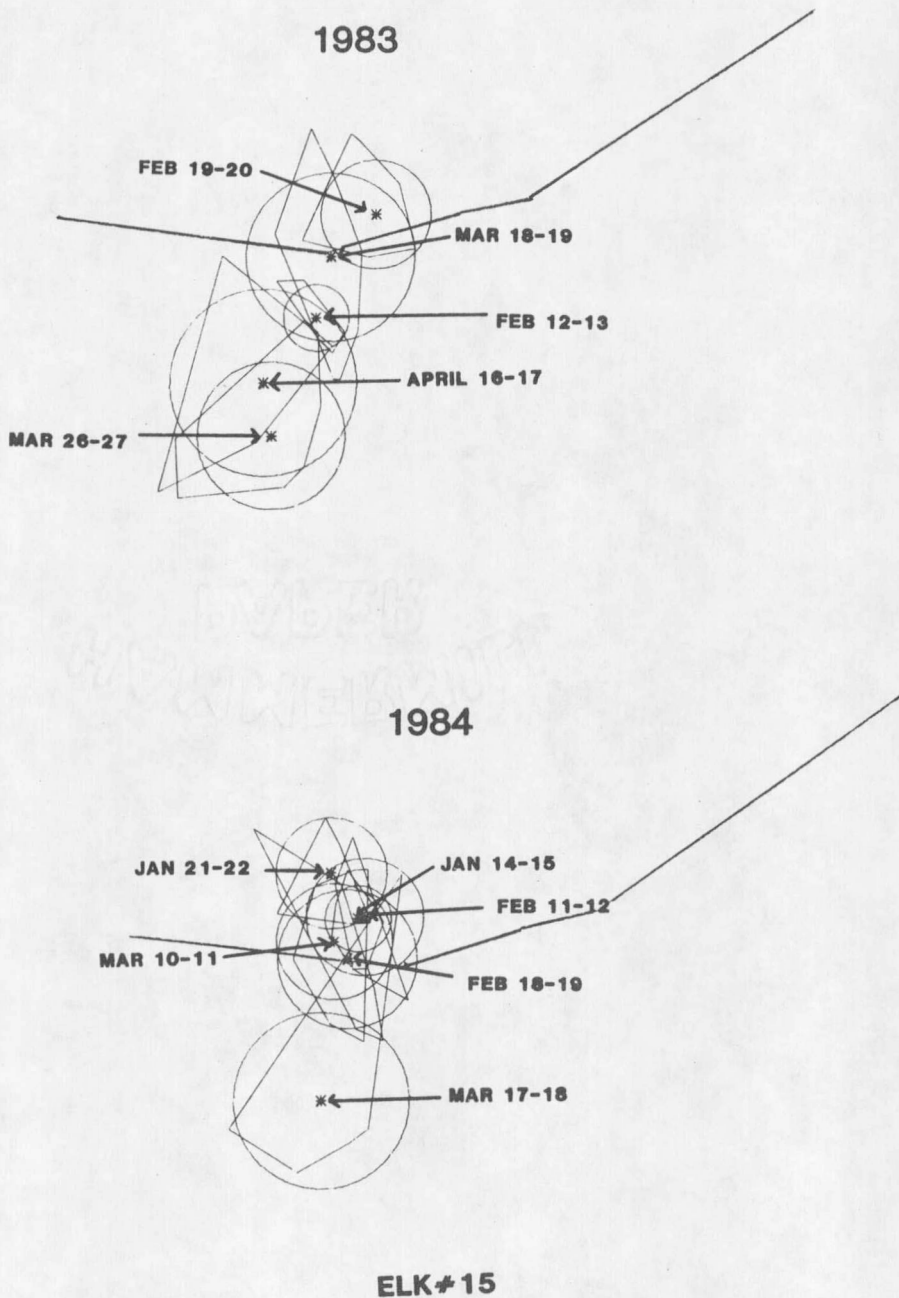


Figure 46. Polygons and standard diameters for each 24 hour session in 1983 and 1984 for radioed elk #15 on the N. Boulder winter range, MT.

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