MONTANA STATE UNIVERSITY

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. Powerlihe 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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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 excitablity 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 km^2 (20 mi^2), 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

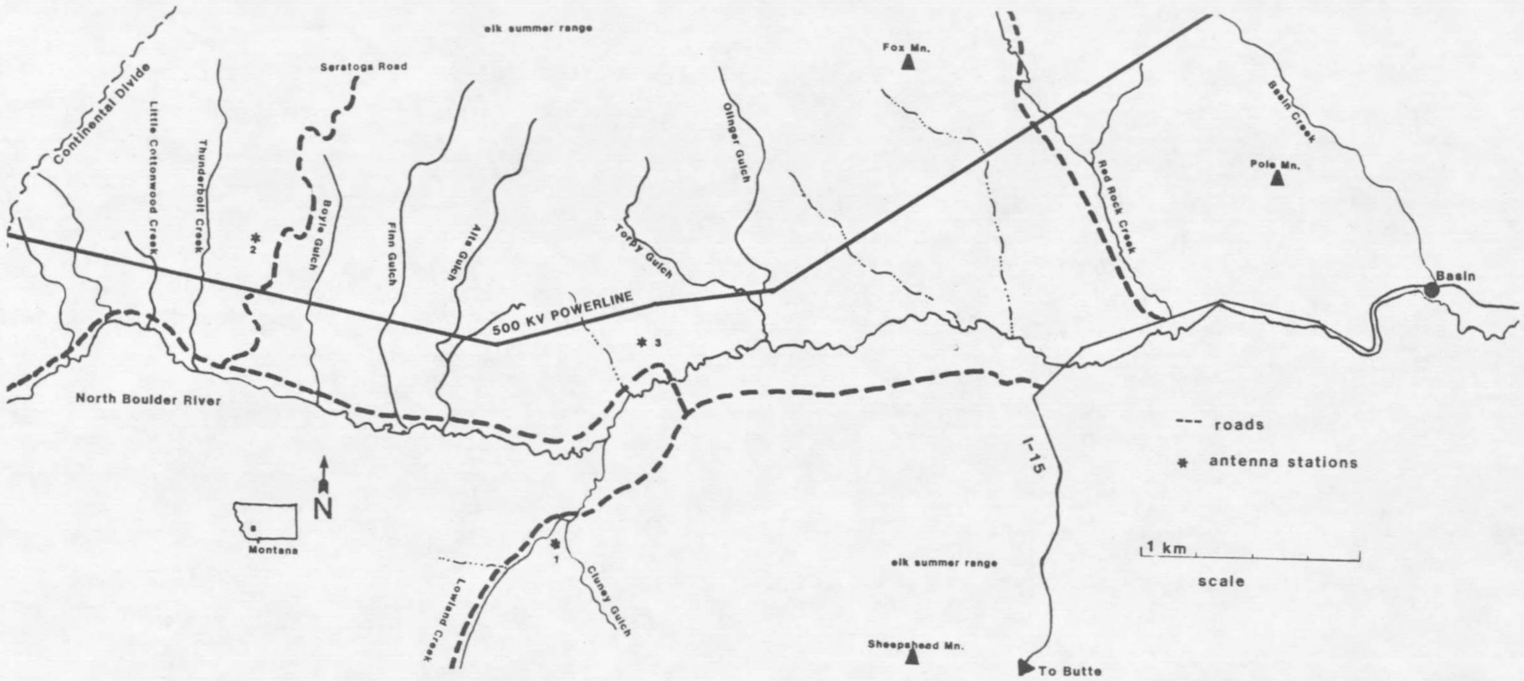

Figure 1. Map of the N. Boulder range showing location of the powerline, antenna stations, and open winter roads.

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 consistantly 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).

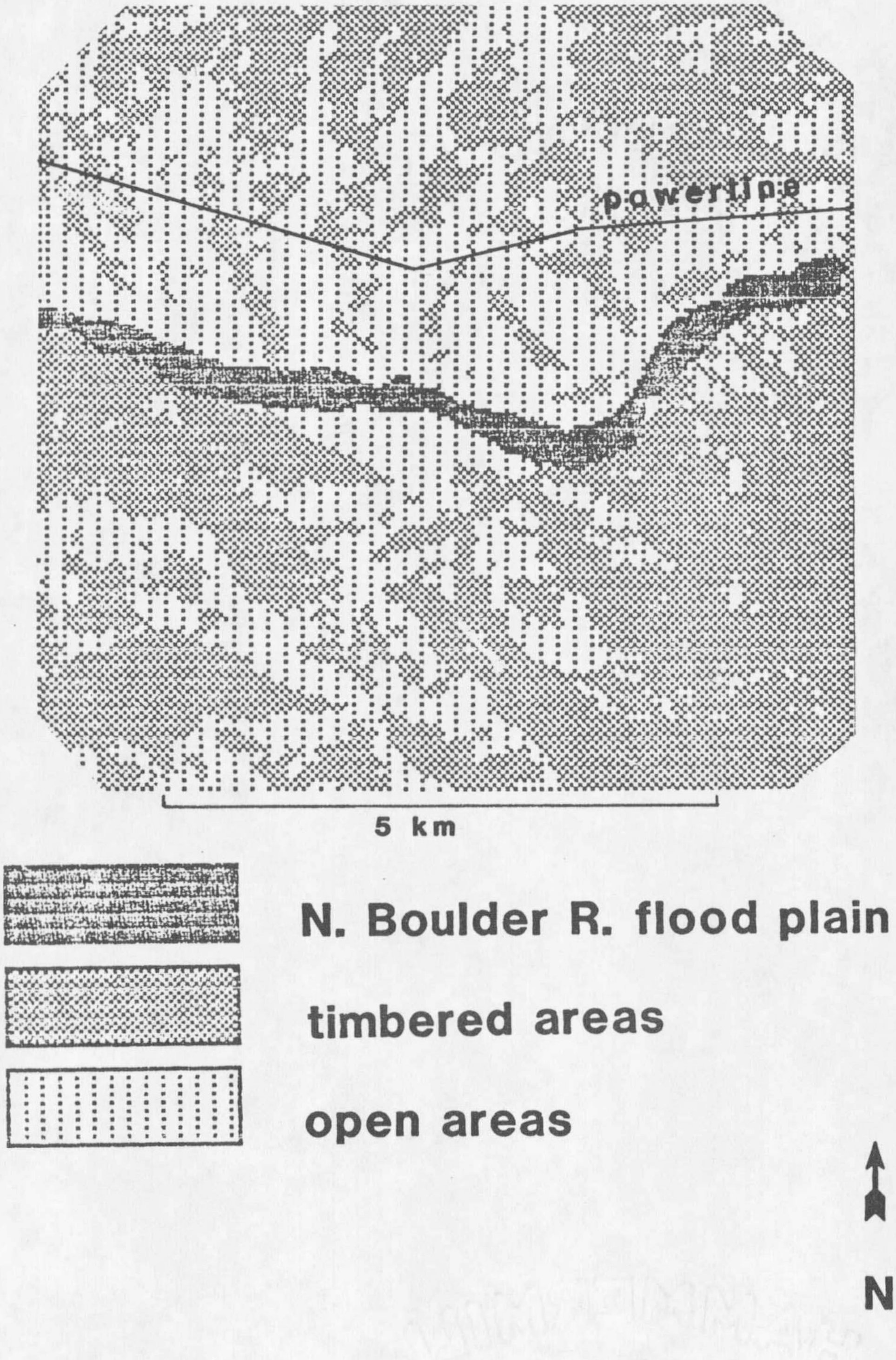

Figure 2. Map of the western two thirds of the study area and Lowland Creek showing distribution of major vegetation types.

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

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

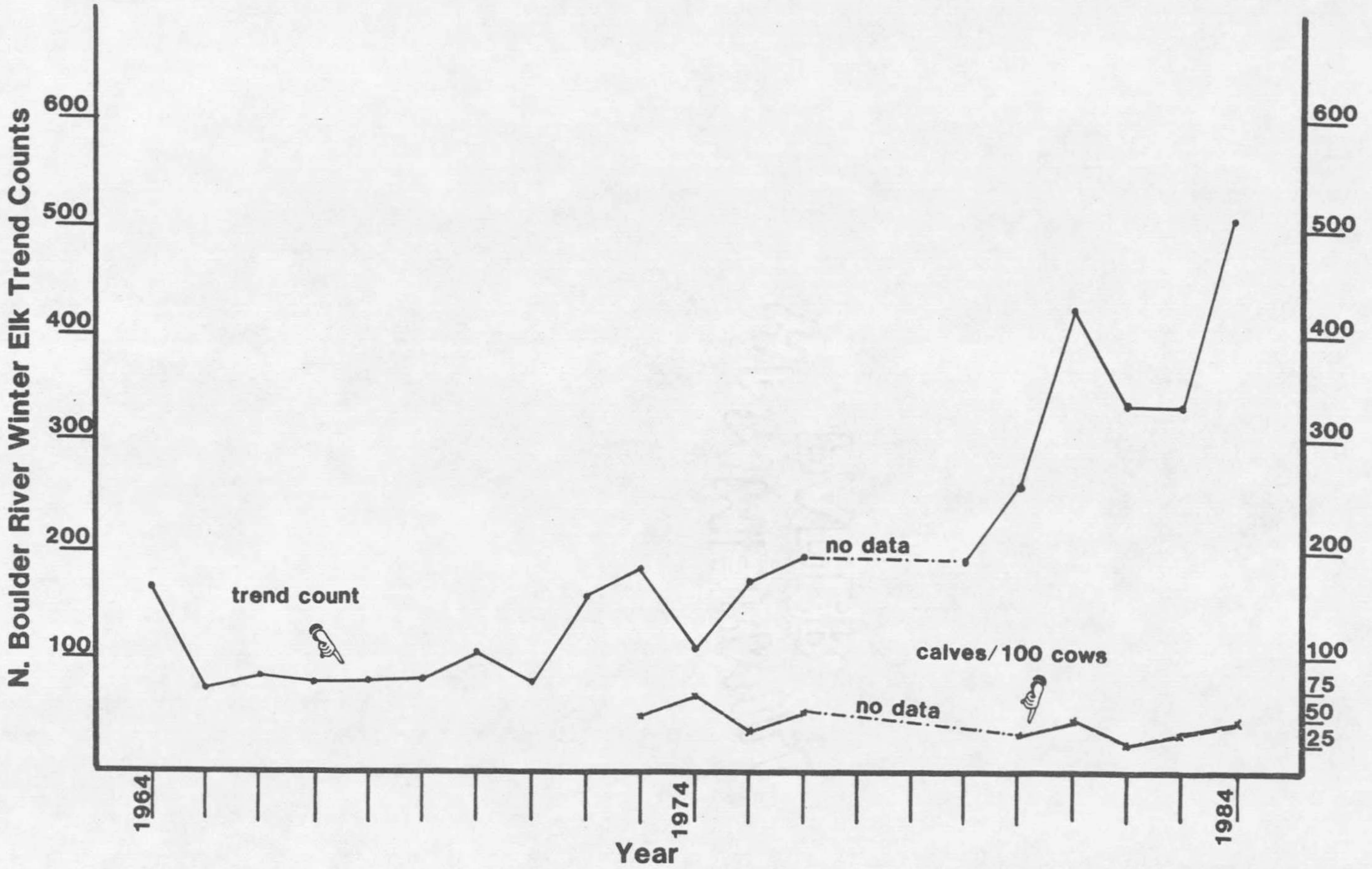

Figure 3. Calf/cow ratios and total number of elk during MDFWP winter trend flights on the N. Boulder winter range, Mt.

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

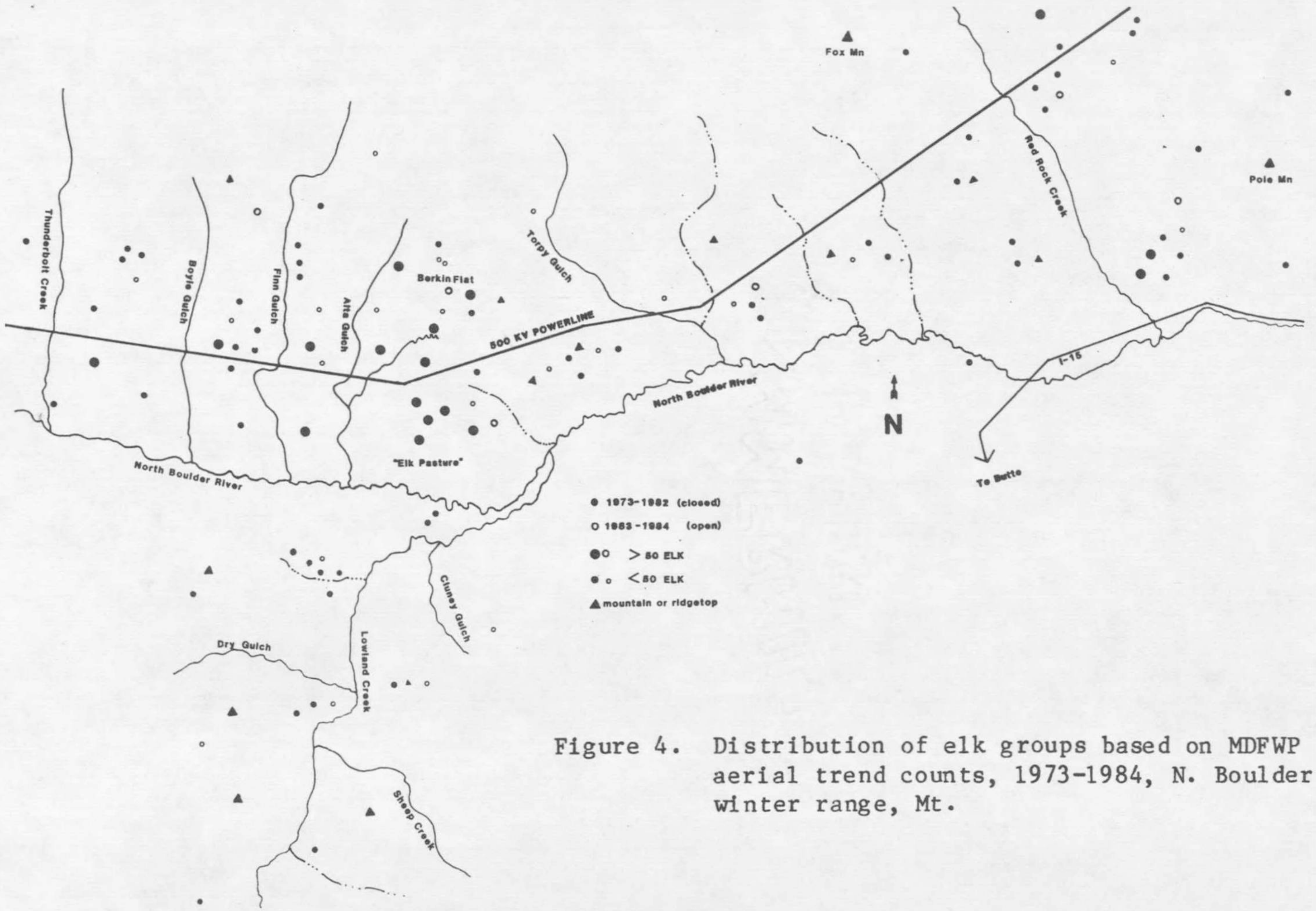

Figure 4. Distribution of elk groups based on MDFWP aerial trend counts, 1973-1984, N. Boulder winter range, Mt.

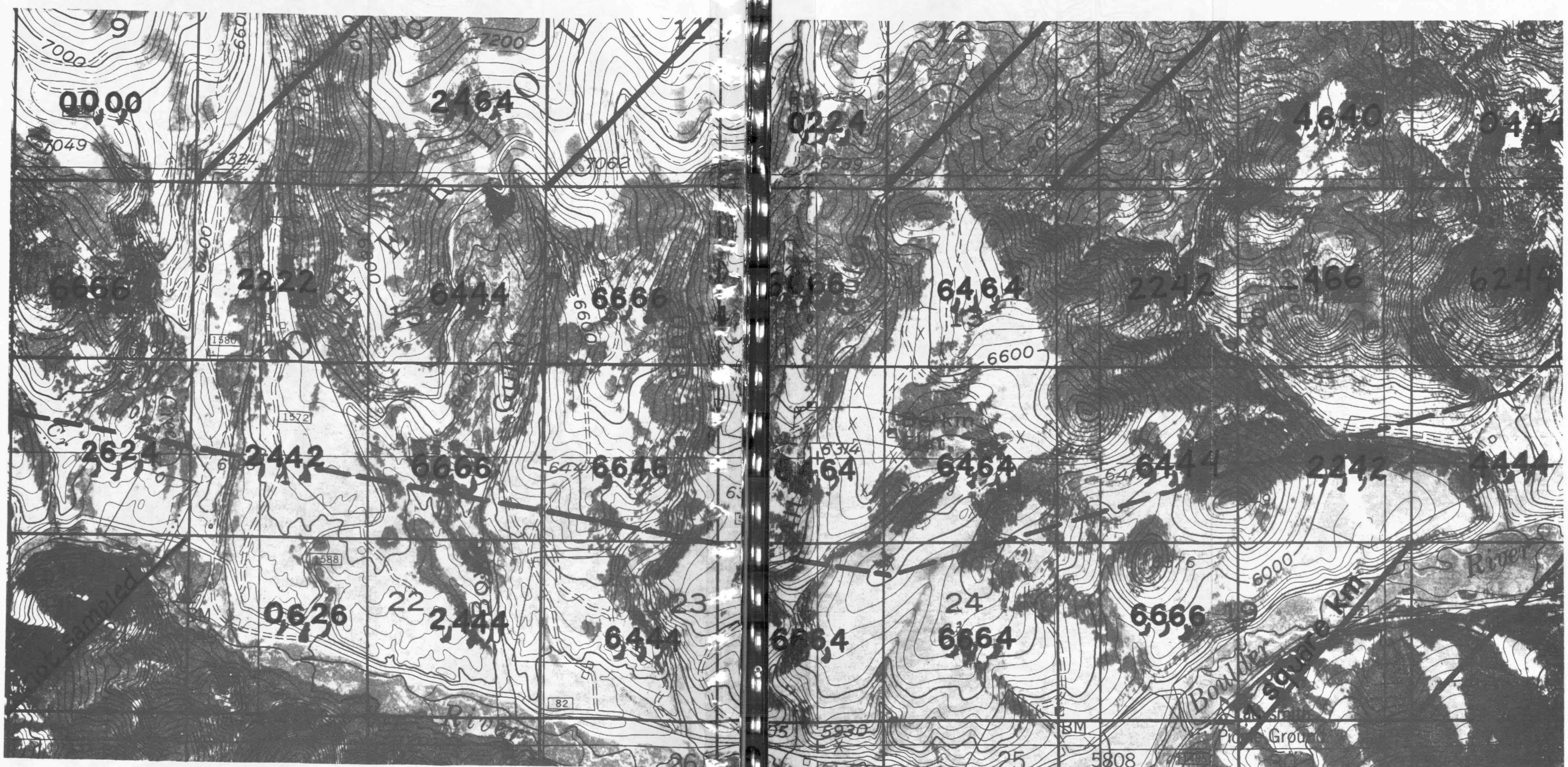

Figure 5. Relative densities of pellet groups per square km on the western end of the N. Boulder winter range in 1975, 1982, 1983, and 1984. High=6, medium=4, low=2 (Cole 1975).

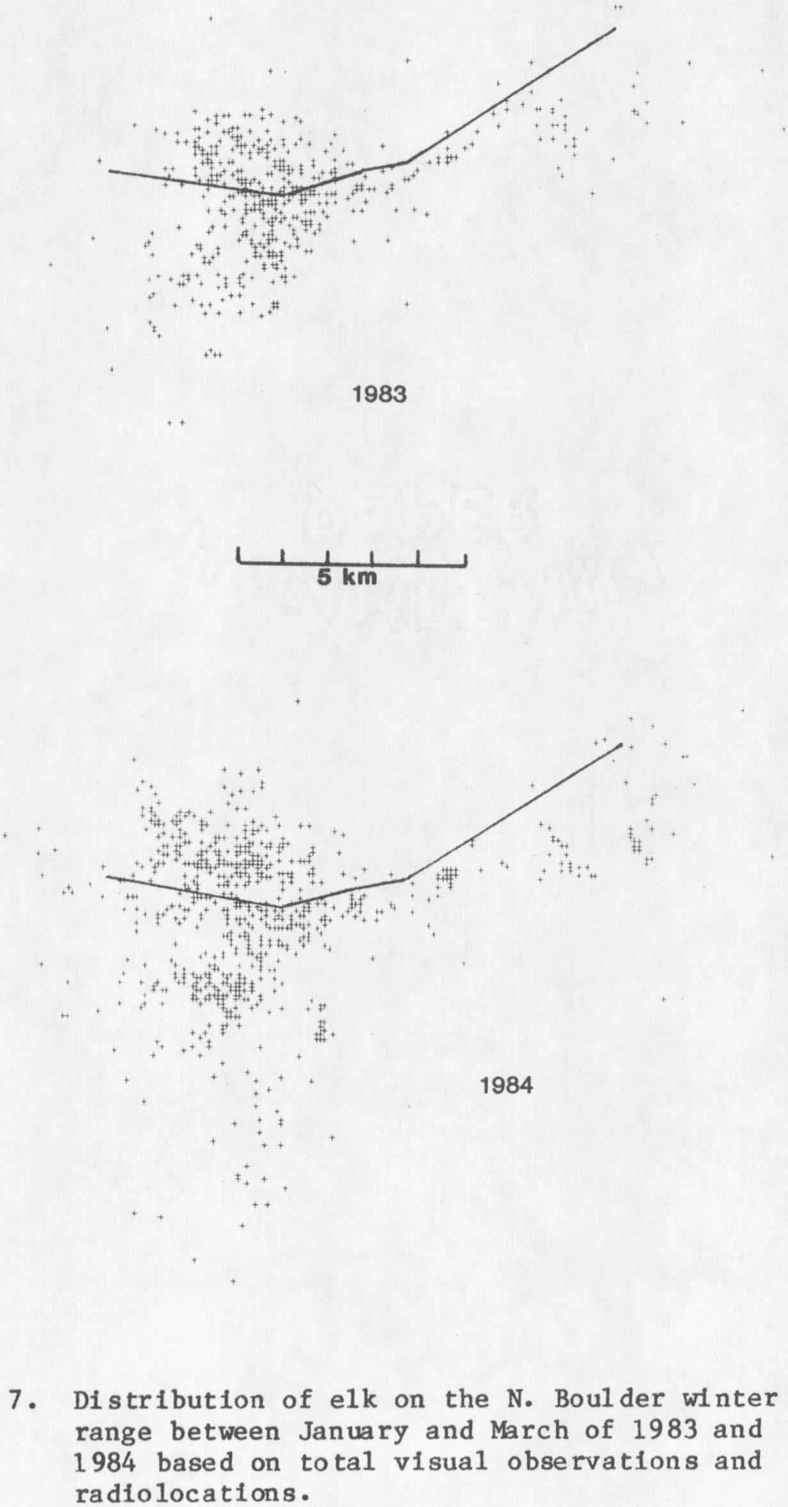

Figure 7. Distribution of elk on the N. Boulder winter range between January and March of 1983 and 1984 based on total visual observations and radiolocations.

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] 1983 N=303	1984 N=410	% Marked elk [2] 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 km^2 and 147 km^2 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).

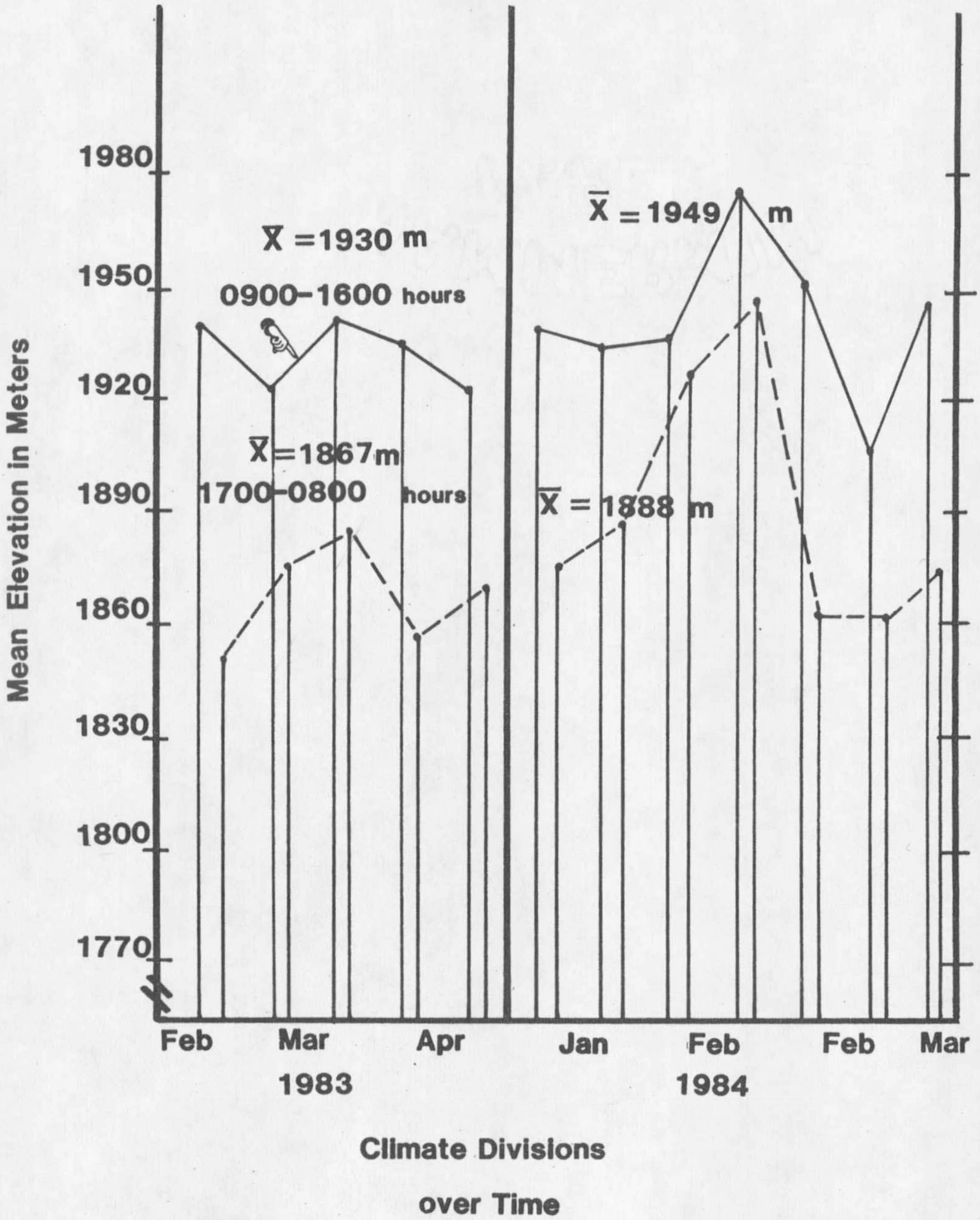

Figure 8. Mean elevation of marked and unmarked elk locations for daytime and evening through early morning periods during each climatic division or period of similar weather based on Butte temperature and precipitation data.

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