ELK MIGRATION, HABITAT USE AND DISPERSAL IN THE UPPER EAGLE VALLEY, COLORADO

Summary Report 1986-1988

Conducted for:

Colorado Division of Wildlife
Eagle County
Homestake Water Project II
The Rocky Mountain Elk Foundation
U. S. Forest Service
Vail Associated

By:

William J. de Vergie
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and

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Fort Collins, Colorado 80523

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ACKNOWLEDGEMENTS

A study of the magnitude we report herein cannot be conducted without the cooperation a number of dedicated individuals. We have been fortunate to enjoy such cooperation throughout this study. Financial support for this phase of our work was generously provided by the Colorado Division of Wildlife (CDOW), Eagle County, Homestake Water Project II, The Rocky Mountain Elk Foundation and Vail Associates. The US Forest Service, Holy Cross Ranger District, provided some logistical support, personnel for various field activities and housing.

Initial impetus for this study came from the efforts of Division of Wildlife personnel Bill Andree and Gene Byrne who contributed throughout the study. John Ellenberger and John Seidel (CDOW) were instrumental in helping obtain funding and in designing the study. Craig Westcoatt and Bill Heicher of CDOW contributed considerable time during elk trapping as did numerous volunteers. Joe Frothingham (CDOW) piloted the aircraft for telemetry relocations. Drs. Gary White and Bruce Wunder of Colorado State University, and John Ellenberger served as members of de Vergie's graduate committee and aided in design, execution and analysis of this work. To all those whom we have failed to name in this acknowledgement; we appreciate your help.

The majority of this work was conducted in partial fulfillment for the requirements of a Master of Science Degree in Wildlife Biology at Colorado State University by Mr. William J. de Vergie. The text of this report constitutes the body of his thesis. The baseline data that de Vergie established is the foundation upon which we intend to design future research. Bill de Vergie dedicates this work to the memory of his father, Paul, who passed away in August, 1988.

ELK MIGRATION, HABITAT USE AND DISPERSAL
IN THE
UPPER EAGLE VALLEY, COLORADO

Executive Summary

Encroachment of technological man into pristine ecosystems is generally not accomplished without impacts to those systems and their components. The purpose of this work is to report migration and habitat use patterns, and the extent of juvenile dispersal in an elk (*Cervus elaphus*) population in the Upper Eagle Valley of Colorado. This elk population, approximately 650 animals, has experienced impacts from agriculture, mining, forestry and ski area development for a number of years. Thus, it is important for the reader to realize that we began a study of a population that was already experiencing pressure from human activities; the impacts of this pressure on elk is unknown. Results of our work are essential for decision makers in evaluating the impacts of their decisions on the elk population and baseline data presented will be used for design and evaluation of future impact studies.

Our study area, approximately 884 km^2, is 161 km west of Denver in Eagle and Summit Counties, Colorado, and encompasses Colorado Division of Wildlife Game Management Unit 45 and portions of units 44 and 371. The area is diverse in topography, ecological communities and land use patterns. Habitats include a spectrum of communities from montane forests to alpine systems. A principal land use in the area is commercial and residential development associated with ski areas. The Eagle River Valley contains two destination ski areas, Vail and Beaver Creek, one small ski area, Cooper Hill, and a new area, Arrowhead. A third destination ski area, Copper Mountain, lies on the eastern border of the study area. Interstate Highway 70 bounds the study area to the north. Expansion of an existing water project, Homestake, has been proposed for the area. Although forestry, skiing and other recreation activities occur throughout the area, much of the commercial and residential development has taken place in valley bottoms that once afforded prime winter range for big game animals.

Because of their concerns about impacts from intensive and extensive development on the elk herd in the Eagle River Valley, the Colorado Division of Wildlife began an investigation in 1984. In 1986, Colorado State University was contracted to expand and continue this study with specific objectives to:

1. Delineate current migration routes of elk herds;

2. Identify seasonally important ranges such as calving areas, and winter and summer ranges;

3. Generate carrying capacity estimates for the Dowd Junction winter range;

4. Evaluate fidelity and dispersal in adult and juvenile elk.

From 1985 through 1988, 191 elk were captured and marked, 40 elk

were fitted with telemetry collars and their movement and habitat use patterns were monitored. Nine elk calves (2 females and 7 males) were captured and fitted with telemetry devices. Elk not marked with telemetry devices were marked with eartags and/or individually recognizable neckbands. Elk were captured on winter ranges with corral and Clover live traps. Calves were captured in June with the aid of a helicopter. Telemetered elk were relocated, using a fixed-winged aircraft, a minimum of once per week from mid-May to July, once every 2 weeks from July to November, and approximately once per month from November to May. Additional relocations were made from the ground throughout the year. Relocation data were recorded in Universal Transverse Mercator Coordinates read from USGS topographic maps and then were entered into computer data storage and analysis programs. All relocation data are available from the authors.

Seasonal range locations and sizes were identified from results of both aerial and ground relocation data. Winter was defined as the period from 25 November to 10 April, calving season as the period from 15 May through 15 June and summer extended from 16 June to the end of August. Intervals from 11 April to 14 May and 1 September to 24 November were defined as periods of seasonal migrations.

Three major winter ranges were identified; Arrowhead, Dowd Junction-Two Elk Creek and Homestake. Other ranges may be available for elk during mild winters. During severe winters, elk appear to move from other ranges and congregate on the Dowd Junction-Two Elk Creek winter range. In all years, with one exception when heavy snowfall occurred, elk illustrated fidelity to winter ranges. Because we captured elk on winter range, our data contains a bias for these areas.

Calving areas and summer ranges were scattered across the study area. Elk captured at Arrowhead used Meadow Mountain, McCoy Park, Beaver Lake, and Spruce Saddle for calving areas. These same elk spent summer at Grouse Mountain, and McCoy Park. During 27 aerial and ground observations, an average of 72 elk were observed on Grouse Mountain with a range of 23 to 160 animals seen there. We speculate that activities associated with cabin and ski area construction displaced elk summering in McCoy Park during 1988.

Elk captured at the Dowd Junction-Two Elk winter range used the back bowls of the Vail Ski area, Wearyman Creek, Stafford Creek and Battle Mountain for calving areas. Two elk marked at the Dowd winter range moved southwest to an area near Half Moon trail head and Whitney Lake. Elk use in the Tigiwon-Half Moon area ceased with increased human activity in the area. The majority of elk trapped at the Dowd range spent summer in the vicinity of Stafford Creek. This area includes 5 drainages, Jacques Creek, Guller Creek, Stafford Creek, Smith Gulch and Wilder Gulch. During 31 relocations between 100-150 (median 100) elk were observed using this summer area. Three elk marked at Dowd Junction summered at Raggy-Ass Mountain where approximately 40 other elk also spent summer.

Elk captured at Homestake wintered on the hillside northwest of Homestake Creek between the gravel ponds and Whitney Creek. These elk calved in the wet meadows below Whitney Lake and No Name Road and near the mouth of East Fork of Homestake Creek. Summer range for Homestake elk was about 2.5 km southeast of Homestake Creek below Homestake Peak from Lost Lake south to the confluence of the East Fork of Homestake Creek and Isolation Lake. An average of 109 elk were observed scattered across this summer range during 21 observation periods.

Of the telemetered elk marked in 1986 and monitored for 2 or more years, 75% (12 of 16) returned to the same winter range where they were captured. The 4 animals that changed winter range were marked in February 1986. Four other elk marked at this time illustrated winter range fidelity. All 8 elk captured on the Dowd Junction range in January 1988 returned to this range by December 1988. Of the cows fitted with telemetry devices, 87.5% (14 of 16) returned to the same calving area they had used the previous year. Seven of 8 cows monitored for 3 seasons used the same calving areas in all years. Of the elk monitored for two years or more, 100% (16 animals) returned to the same summer range during consecutive years.

Cow elk monitored in our study demonstrated fidelity to seasonal ranges. Migration to and from ranges was variable. Spring migration depended upon the duration of snow accumulation, and elk generally followed the same routes from year to year. Fall migration began in September as elk left alpine meadows and moved into timber at lower elevations. Arrival on winter ranges was generally in late November and early December. Fall migration routes were not well documented. Counts of elk we report represent a lower bound estimate for numbers of animals using a particular range because the probability of sighting all elk is less than one.

Dispersal of elk to other ranges is an important facet of elk behavior, but the extent of this behavior is generally unknown. To evaluate this behavior we not only monitored movement patterns of adult cow elk, but also attached telemetry devices to neonatal calves. Two female and 7 male calves captured within a week of their birth were marked with expandable telemetry collars and we monitored their movements for 18 months. We defined dispersal as movement during year 2 away from a range used in year 1. This movement had to be in excess of the maximum diameter of the range used in year 1 and no overlap of year 1 and 2 ranges could exist. Eight of the 9 telemetered calves did not disperse as yearlings. Three did use different summer ranges in their second summer, but distances between ranges was small relative to home range size. The one calf that dispersed used the winter range at the Arrowhead Ski Area. Increased human activity may have caused this calf to disperse. We conclude that elk calves we monitored did not disperse. Location of the study area, barriers such as interstate highways and development, and the density of the elk population may have influenced the patterns we observed.

During fall 1987 and 1988 we sampled the Dowd Junction winter range to estimate its carrying capacity for elk. Forage was estimated using a doubling sampling technique and carrying capacity estimates were derived from forage biomass and published intake rates for elk. We also calculated estimates using values for metabolizable energy and nitrogen in these forages. These values, like the forage intake data were obtained form published literature. Forage biomass was 10% greater in 1988. Grasses and shrubs contributed approximately 87% of the total forage supply, but because of availability during winter they comprise 99% of forage for elk. Winter range carrying capacity estimates ranged from 152 to 212 elk; in recent years 125-150 elk have used this winter range.

Included in this report are details on all segments of this study and assumptions made during our analyses. Figures in this report delineate critical ranges and an appendix supplies maps for ranges used by each individual elk we monitored. Data from this segment of our work are summarized in tables. Our intent is that the results of this work be used to perpetuate the Eagle River Valley elk herd in the face of increased development and land uses for purposes other than wildlife habitats. We will use these results for comparison to results obtained from future studies in hopes of elucidating the response of elk to various types of disturbances.

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DESCRIPTION OF STUDY

Introduction

Knowledge of critical ranges and migration corridors used by big game species such as elk (Cervus elaphus) is vital when making management decisions that potentially impact habitats for these animals. Although elk migration patterns have been studied, little work has been conducted in the vicinity of ski areas. Increasing popularity of winter recreation in the United States results in Colorado receiving more recreational skiers every year. The upper Eagle River Valley is an area that contains the largest ski area developments in the United States and includes ranges for an elk population of approximately 650 (CDOW age and sex winter classifications 1987, Andree pers. comm.). Elk in this area may be subjected to the most intensive human development pressure of any elk population in Colorado. Three existing ski areas (Vail, Beaver Creek, and Cooper Hill) and one new ski area (Arrowhead) are located in this area. Expansion of existing ski areas, development of new areas, and construction of business and residential communities, and water development projects exert pressure on resident wildlife, especially big game.

Because of intense development activities, the Colorado Division of Wildlife decided, in 1984, to conduct a study to objectively and quantitatively describe the upper Eagle River Valley elk herd and provide information for wildlife managers and permitting agencies to make more enlightened wildlife decisions (Byrne and Andree 1987). A small trapping and monitoring project was conducted in 1985. In 1986 Colorado State University was contracted to continue this study as an objective third party. Additional funding was gathered and the study was expanded.

Goals of this study were to gather baseline data on elk migration and habitat use in the upper Eagle River Valley. Specifically we sought to:

1. Delineate current migration routes of the elk herds;
2. Identify elk winter and summer ranges;
3. Identify of the elk calving grounds;
4. Generate a carrying capacity estimate for the Dowd Junction winter range;
5. Identify the percent of radio collared cows that exhibit fidelity to seasonal ranges; and
6. Evaluate dispersal by male elk calves after their 18 months of life.

Results of this study will provide necessary information for managers to address the cumulative and off-site effects of development for mitigation or alternative wildlife plans.

Because of the design of this study, results are presented in three separate chapters. Chapter II identifies movement patterns and home ranges exhibited by telemetered elk. Chapter III addresses dispersal patterns of telemetered elk calves. Carrying capacity of the Dowd Junction winter range is discussed in Chapter IV. Each chapter contains an introduction, methods, results, discussion and literature section. Chapter V provides a summary and recommendations.

Description of Study Area

Location and Land Use

The study area lies approximately 161 km west of Denver, in Eagle and Summit Counties, Colorado and encompasses Game Management Unit (GMU) 45 and portions of GMUs 44 and 371 (Figures 1.1 and 1.2). The study area covers approximately 884 km^2, is an area of extreme topographic features ranging in elevation from approximately 2194 m to 4269 m and contains a large portion of the Holy Cross Wilderness Area.

Headwaters for the Eagle River and major tributaries including Two Elk Creek, Turkey Creek and Resolution Creek on the east; Homestake, Cross, Beaver, and Lake Creek on the west dissect the study area. Major developments are located at lower elevations on the north side of GMU 45, primarily along Interstate 70.

The upper Eagle River Valley contains two destination ski areas, Vail and Beaver Creek, one smaller ski area, Cooper Hill and one new ski area, Arrowhead. One additional ski area, Copper Mountain, is located on the eastern edge of the study area in Summit county.

Vegetation

Subalpine and alpine regions along high ridges from 2800 m in elevation along subalpine streams to over 4000 m in alpine meadows provide summer ranges for elk. Four vegetation types occur on summer ranges and include willow-parks, spruce fir, krummholz and alpine

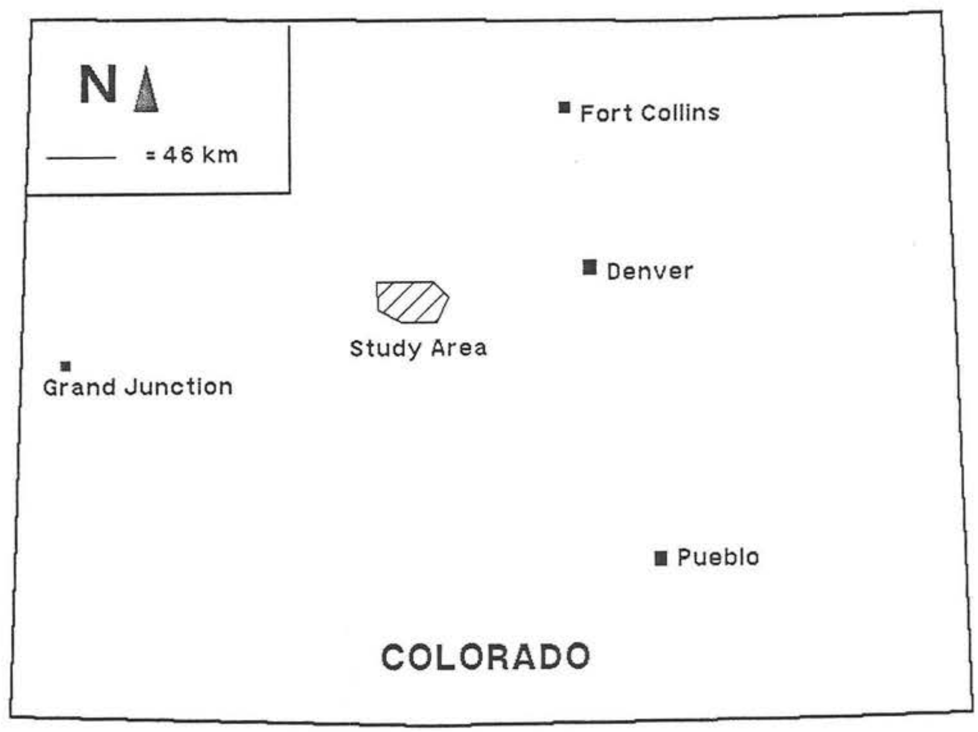

Fig. 1.1 Location of the upper Eagle River Valley study area in Colorado.

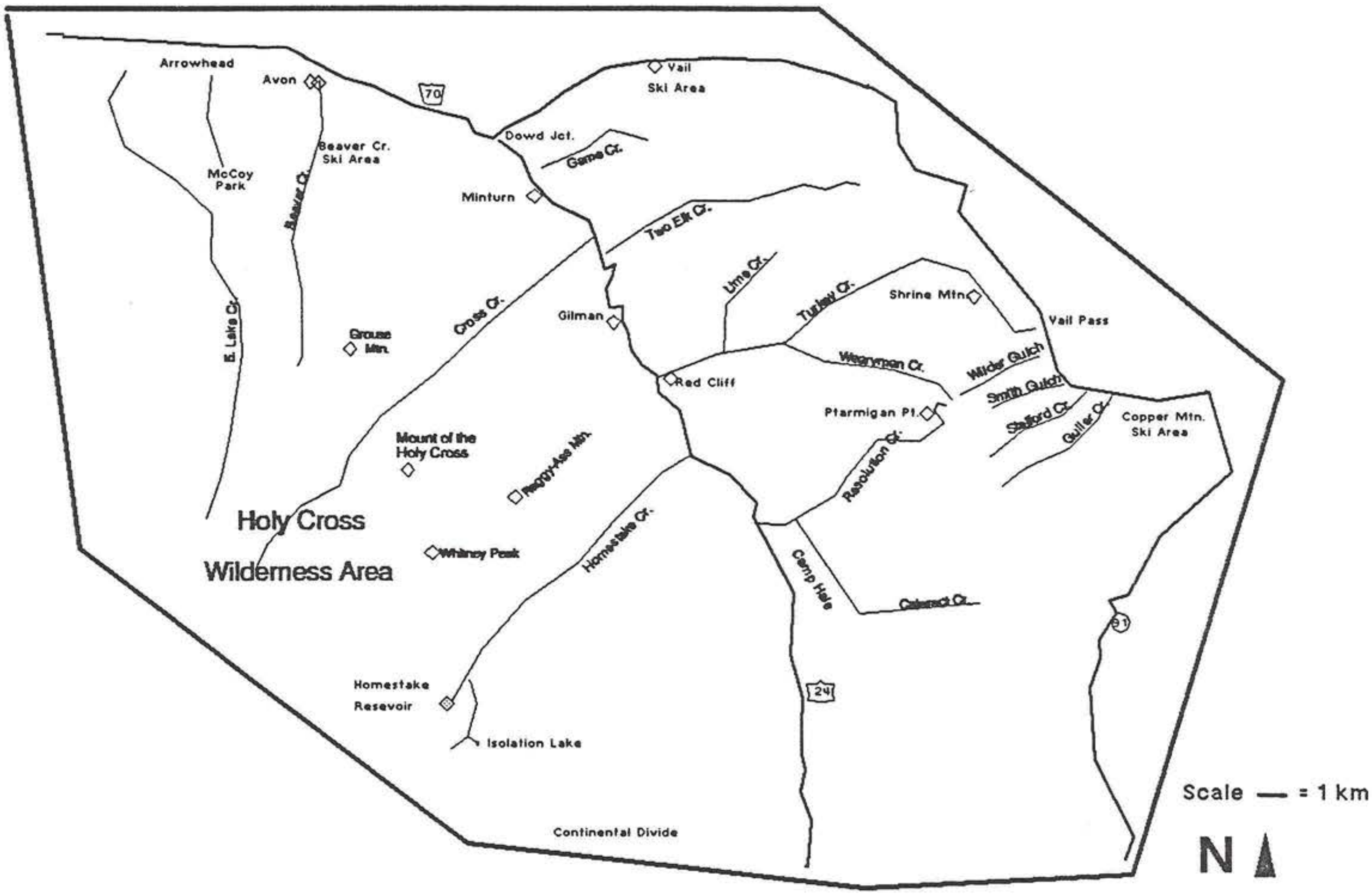

Fig. 1.2 Map of the upper Eagle River Valley study area in Colorado, including names and places referred to in the text.

meadows. Willow-parks, dominated by willows with an understory of sedges, occur along streams on glacial valley floors (3000 - 3300 m) in the subalpine zone. Valleys are dominated by spruce-fir (Picea engelmanii/Abies lasiocarpa) forests, and in open canopy of spruce-fir stands, an understory of graminoids and forbs are found. A transitional krummholz ecotone type (3300 - 3600 m) occurs between alpine meadows and the spruce-fir. Krummholz vegetation is an interspersion of stunted, wind-shaped conifers and willows. Alpine meadows occur above subalpine forests and krummholz ecotones occur on most ridges and peaks above 3600 m. Quaking aspen (Populus tremuloides), Douglas fir (Pseudotsuga menziesii), and lodgepole pine (Pinus contorta) dominate the upper montane zone between 2590 - 2795 m. Riparian willows (Salix spp.), moist meadows, and mountain grasslands also characterize this zone.

This study area contains at least three major elk winter ranges: Arrowhead, Dowd Junction, and Homestake. Elk winter in the lower montane zone which occurs between 2190 - 2590 m. Shrubs common on winter ranges include mountain snowberry (Symphoricarpos oreophilus), chokecherry (Prunus virginiana), serviceberry (Amelanchier alnifolia), and sage (Artemisia tridentata) with some rabbit brush (Chrysothamnus viscidiflorus). The understory is characterized by Alpine penstemon (Penstemon alpinus), mule's ear (Wyethia amplexicaulis), wheatgrass (Agropyron trachycaulum), cheatgrass (Bromus brizaeformis), and several species of bluegrass (Poa spp.).

Climate

The average annual precipitation is 46.7, 26.7, and 60.2 cm in Vail, Eagle, and Climax (National Oceanic and Atmospheric Administration

1987 and 1988). In 1986 and 1987, precipitation was below normal in all locations. A large portion of the precipitation occurs during winter in the form of snow. July is the warmest month with a mean daily temperature of 18.7^{o}C, and January is the coldest month with a mean daily temperature of -7.7^{o}C. Temperatures were normal during my study.

Geology

The study area is situated in a structural trough which stretches from Vail Pass to McCoy in north central Eagle County. Bedrock within this trough is the Minturn Formation of Pennsylvanian age and comprises all of the mountains and adjacent Gore Creek Valley, (Vail Valley), . The bulk of the formation consists of interfingering lenticular beds of sandstone, siltstone, shale and conglomerate, within which limestone and dolomite marker beds occur laterally (Tweto and Lovering 1977).

The formation is interpreted to have been deposited by rivers and streams transporting sediments into a narrow Pennsylvanian seaway which bordered the ancestral Rocky Mountains on the west. Through time, the seaway trough was filled with sands, shale, and conglomerates. Periodic incursions of the sea or slowing of deposition rates caused limestone beds to be deposited within the clastic sediments.

In eastern Eagle County, Minturn rocks are flanked on the northeast by the Gore Range Uplift and on the southwest by the Sawatch Range Uplift. Structural deformation and faulting have heaved and tilted the strata so that strike and dip of the beds varies widely from one area to another.

LITERATURE CITED

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Chapter II

MOVEMENT PATTERNS AND SEASONAL RANGE USE

Introduction

Colorado's upper Eagle River Valley has experienced some of the most intensive ski area development of any area in the United States. Steep, north-facing topography, affords ideal terrain for recreational skiing. This valley also comprises Colorado's Game Management Unit (GMU) 45, which contains approximately ~~650~~ 850 elk (CDOW age and sex winter classifications 1987, Andree, pers. comm.) that are likely impacted by ski area and associated developments. One small ski area, Cooper Hill, originated in the 1950's as a training facility for the Tenth Mountain Army Division. A second ski area, Vail, started operation in 1962. In the past decade the popularity of recreational skiing has increased; to accommodate this, Vail has expanded into the largest destination ski area in the United States. Additionally, in the early 1980's Vail and Associates developed a new area, Beaver Creek to the west. A fourth ski area, Arrowhead, was developed and opened for operation in December 1988.

Accommodations associated with these ski areas required construction of housing facilities, shopping centers, roads, and parking lots. Construction which occurred in valley bottoms reduced critical winter range for big game. Off-site development causes disturbance that includes increased traffic for construction, development of construction roads, timber cutting and chain saw activity for road and ski run development, timber burning, earth moving, noise, and human activity.

Additional development is proposed in the Homestake Valley.

Homestake Reservoir is a transmountain water diversion program that supplies water to the cities of Colorado Springs and Aurora, Colorado. Future expansion to the existing Homestake Water Project has potential to exert pressure on the elk population in the Homestake Valley because of increased year-round traffic associated with construction. These factors cause various impacts to elk either by harassment or habitat alterations.

Combining all of these development activities in a small area can exert considerable pressure on elk populations. In order to manage elk populations, information concerning movement patterns is necessary. Objectives of this segment of our study were to identify seasonal ranges (calving, summer, and winter) and determine migration patterns (routes and timing). This information will be useful to decision makers for management and perpetuation of this herd in the face of habitat alterations.

Methods

Elk Capture and Instrumentation

Elk were captured with a portable elk corral trap and six Clover traps (Clover 1956) modified for elk. From 1985-1988, 191 elk were trapped at 4 trap sites (Arrowhead, Dowd Junction, Two Elk Creek, and Homestake Creek) (Figure 2.1). All trap sites were prebaited with alfalfa hay and livestock salt. Portable corral traps were used at all locations except Dowd Junction in 1988. Three large Clover traps were used in conjunction with the corral trap at Homestake in 1988, and six Clover traps were used at Dowd Junction in 1988. To reduce stress on

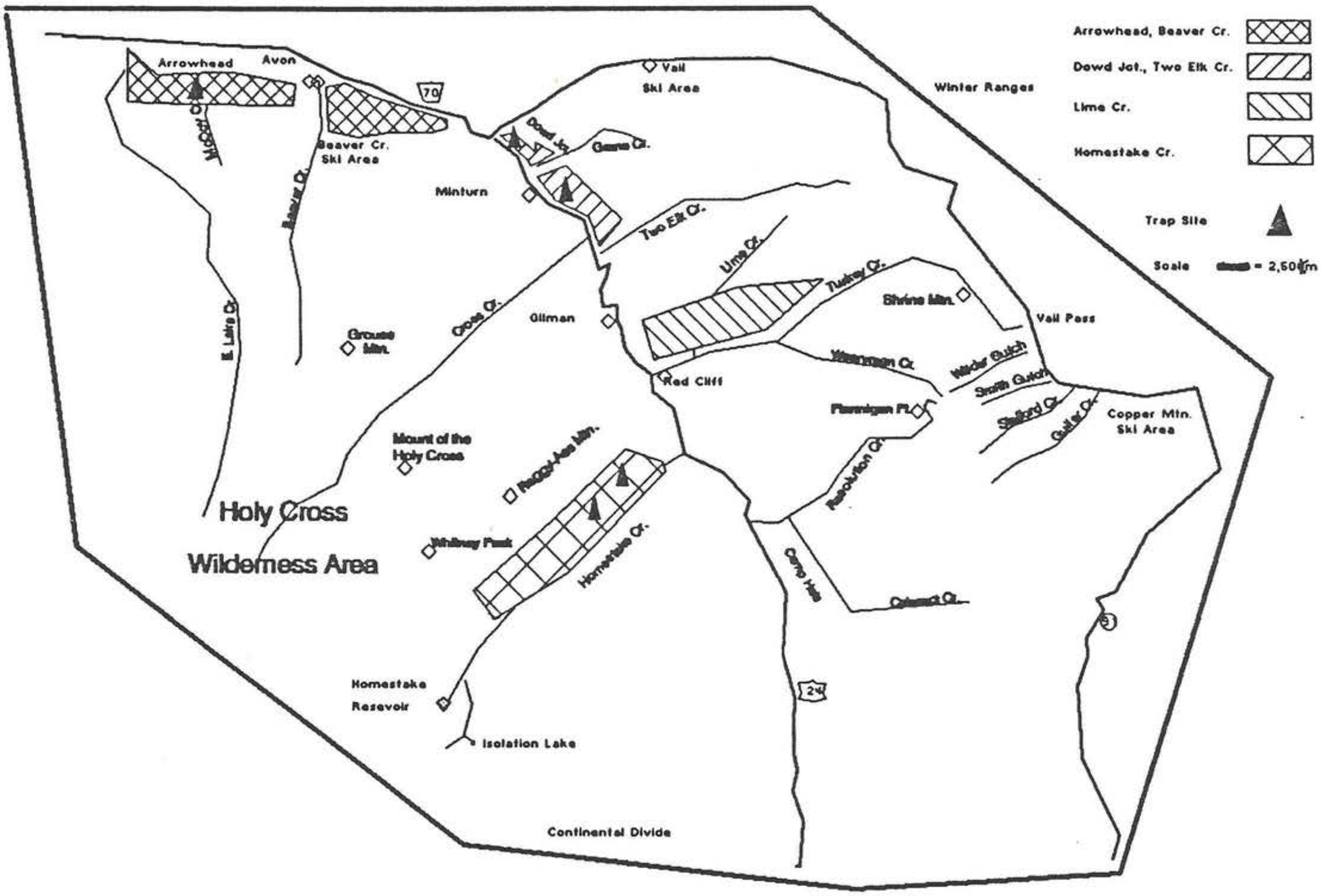

Fig. 2.1. Winter ranges used by radio-collared elk in the upper Eagle Valley study area.

captured elk, Clover traps were arranged so each trap was relatively hidden from the others. A crew of three or more people were used to handle elk in traps. Elk were manually handled without drugs, tagged, and quickly released.

Adult cows were fitted with collars containing a frequency specific transmitter and marked with Alflex eartags. Collars were adjustable big game telemetry collars, weighing approximately 500 g and were manufactured by Telonics, Inc., Mesa, Arizona. All transmitters operated in the 150-151 MHz frequency range. Transmitter units were weather sealed and powered by a lithium battery with a 3-year life expectancy.

Yearling and adult cows that were not equipped with telemetry devices were marked with a 4-inch-wide plastic collar and an ear tag. Four different colors of collars and ear tags were used; green (Homestake), white (Dowd Junction), and blue collars and yellow ear tags (Arrowhead). All trapped bulls and calves were ear tagged and released.

In January and February 1985, 84 elk were trapped and marked at 3 trap sites. Four adult cows were fitted with telemetry collars. An additional 42 elk were trapped in 1986 and 15 adult cows were fitted with telemetry collars (Table 2.1).

In June 1987, 9 newborn elk calves were captured using a Bell Soloy helicopter and fitted with telemetry collars. Two methods were used to capture newborn calves. Calves less than approximately 5 days old that exhibited the "hider" behavior (Lent 1971) when the helicopter flew over were captured and marked. For calves that did not exhibit the "hider" behavior, a Coda Net Gun fired from a helicopter was used.

Table 2.1. Number of individual captures for elk, from January 1985 to January 1988, in the Upper Eagle River Valley, Colorado.

Trap Location	Date	Calf M	Calf F	Yearling M	Yearling F	Adult M	Adult F	Total
Arrowhead	1/85	6	6	3	5	1	10	31
Dowd Junction	1/85	0	2	1	3	0	19	25
Two Elk Creek	2/85	5	5	0	4	0	14	28
Arrowhead	2/86	8	1	1	1	0	9	20
Dowd Junction	2/86	3	1	1	0	0	5	10
Back Bowls, Vail	5/86	0	1	0	0	0	0	1
Beaver Lake	6/86	1	0	0	0	0	0	1
Homestake Creek	12/86	1	2	0	0	0	9	12
China Bowl	6/87	3	1	0	0	0	0	4
Stafford Creek	6/87	2	1	0	0	0	0	3
McCoy Creek	6/87	1	0	0	0	0	0	1
Chicago Ridge	6/87	1	0	0	0	0	0	1
Homestake Creek	12/87	5	8	4	6	0	10	33
Dowd Junction	1/88	3	5	2	2	1	8	21
Total		39	33	12	21	2	84	191

Transmitter units used on elk calves were equipped with mortality sensors (motion sensors) with a normal pulse rate of 60 beeps per minute. If the telemetry collar was not moved within a preset 4 hour period, the mortality switch was activated and a pulse rate of 120 beeps per minute was emitted. Transmitters were fitted to expandable collars made of three inch fire hose (Bear 1986).

Relocation Techniques

Telemetered elk were relocated by air using a fixed-wing aircraft (Cessna 185) at least once a week from mid-May to July, once every 2 weeks from July to November, and approximately once per month from November to May. The receiving system was comprised of a Telonics model TR-1 scanner/programmer with companion TR-2 148-151 MHz receiver coupled with an "H" rotating directional antenna mounted in the belly of the plane. Based on observations made during visual relocations, this system provided accurate animal locations and receiving range depending on topography. During flights, the aircraft was manned by a pilot, myself and at least one observer responsible for mapping elk locations. Relocation flights were made between 0630 and 1230 hours depending upon weather conditions.

Telemetered elk were also relocated from the ground using a 2-element hand-held, directional Yagi antenna connected to the receiving system described above. Ground surveys were used to locate calving areas and to provide additional relocations between flights in order to delineate areas of seasonal use.

All relocations were recorded as Universal Transverse Mercator (UTM) coordinates read from USGS topographic maps. Data were entered into Reflex (Borland 1985) data base for easy access and manipulation.

Topographic maps of the study area were digitized and saved in Lotus 1-2-3 (Lotus Development Corporation 1985). UTM coordinates for each telemetered animal were plotted on computer generated maps of the study area by combining the compatibilities of Lotus 1-2-3 and Freelance (Lotus Development Corporation 1985) (Appendix 1).

Seasonal range locations and sizes were identified from results of aerial and ground relocation data. Winter, calving, and summer seasons were defined as periods from 25 November to 10 April, 15 May to 15 June, and 16 June to 30 August, respectively. Intervals from 11 April to 14 May and 1 September to 24 November represent spring and fall transition periods, respectively. Observations within these time periods were categorized accordingly.

Results

Elk population in GMU 45 can be divided into three herds, Arrowhead, Dowd Junction-Two Elk Creek, and Homestake, based on historical winter range (Byrne and Andree 1987) and our telemetry data. Results are given in terms of movement patterns away from the winter ranges where they were caught. Migration maps identifying movement patterns for individual elk are presented in (Appendix 1).

Four telemetered cows were tracked in 1985, 10 in 1986, 28 in 1987, and 36 in 1988. A total of 1744 relocations were made: 1046 (60%) were from the air and 698 (40%) were ground relocations. Visual observations of the telemetered animals were made on 401 (23%) of the relocations.

Arrowhead

Arrowhead winter range lies south of the Eagle River and stretches along U.S. Highway 6 from the mouth of Bachelor Gulch to E. Lake Creek (Figure 2.1). This range has been reduced from approximately 10 km^2 to 5 km^2 by development associated with the Arrowhead ski area. A small portion of the newly developed Arrowhead golf course and ski area is included in this winter range. Study of elk on the Arrowhead winter range involved only 6 telemetered elk; 1 adult cow in January 1985, 4 adult cows from February 1986 to December 1989, and 1 bull calf was added in December 1987. Forty-six observations were made from 1985-1988 and estimates for wintering populations averaged 100 elk in 1985 and 1986 (Andree pers. Comm.), and we observed an average of 50 elk in 1987 and 1988.

Winter Range.- - Cow B, marked in 1986, utilized the Arrowhead winter range from 20 November to 10 May during all three winters, 1986-88; cow C wintered on the hillside east of Beaver Creek golf course in 1986 and in Whiskey Creek in 1987 and 1988. Bull elk Cg (Table 2.2) was marked in Summit county in June 1987, traveled to Beaver Creek in November and wintered on the hillside east of the Beaver Creek golf course in 1987 and 1988. The one cow that was telemetered in January 1985 moved 9 km west to Belly-ache Ridge by late February, then used McCoy Park in summer. This cow returned to Arrowhead and died, possibly from a hunting wound (Table 2.2) in November 1985. Because all telemetry locations were obtained during daylight, few relocations were made on golf courses. However, elk were frequently reported using the golf courses at night.

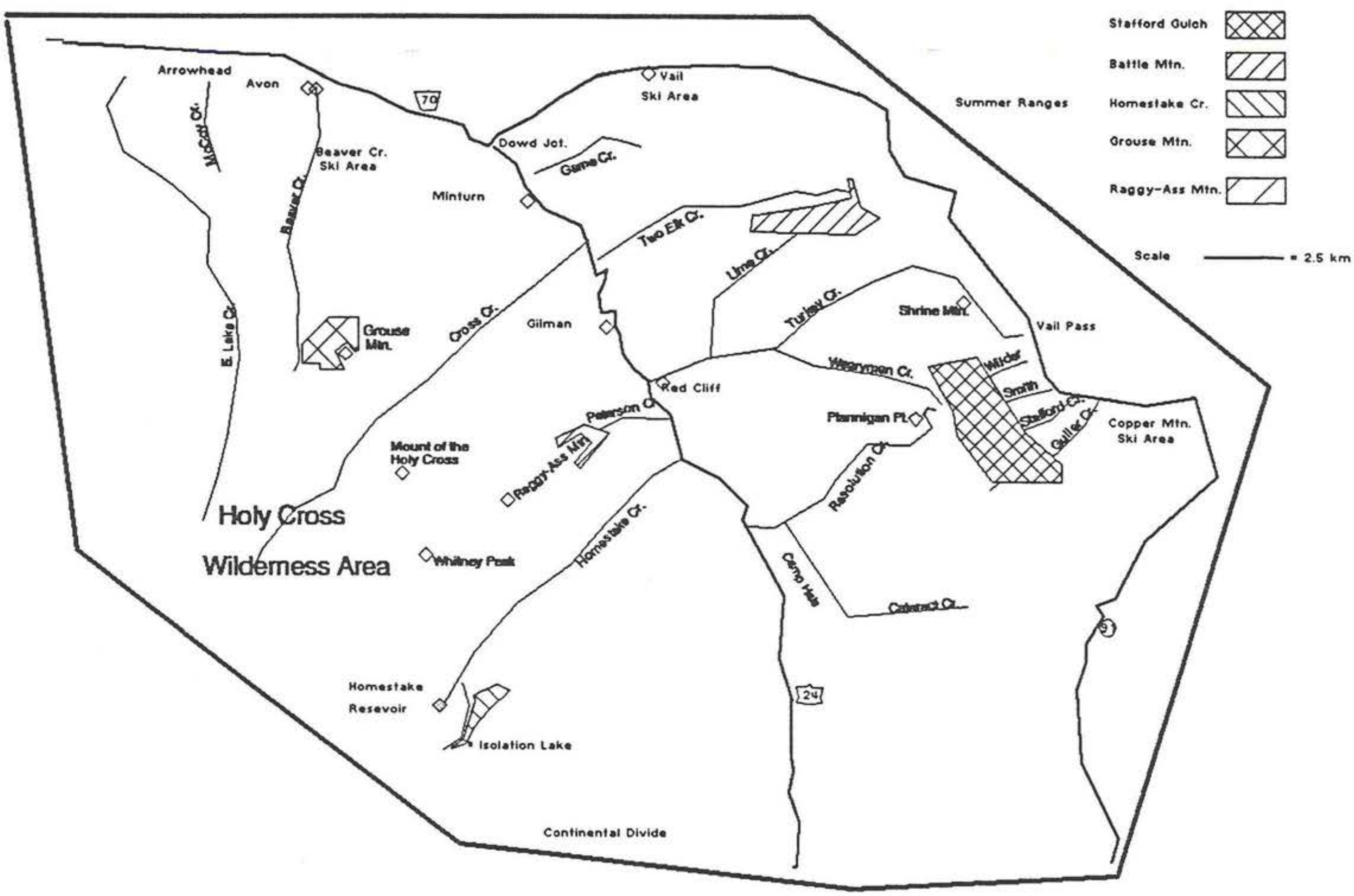

Fig 2.2. Summer ranges utilized by radio-collared elk across the upper Eagle River Valley study area in Colorado.

Table 2.2. Trapping information for all elk captured and fitted with radio-collars, from January 1985 through January 1988, in the Upper Eagle River Valley, Colorado.

Trap Location	Date	ID	Sex	Age	Status
Arrowhead	1/85	DD	F	A	Died 10/85 hunter wound
	2/86	A	F	A	Radio malfunction 3/87
	2/86	B	F	A	Alive 12/88
	2/86	C	F	A	Alive 12/88
	2/86	D	F	A	Harvested 10/86
Dowd Junction	2/86	E	F	A	Harvested 10/86
	2/86	F	F	A	Alive 12/88
	2/86	G	F	A	Alive 12/88
	2/86	H	F	A	Alive 12/88
	2/86	I	F	A	Alive 12/88
	1/88	V	F	A	Alive 12/88
	1/88	W	F	A	Alive 12/88
	1/88	X	F	A	Alive 12/88
	1/88	Y	F	A	Alive 12/88
	1/88	Z	F	A	Alive 12/88
	1/88	AA	F	A	Alive 12/88
	1/88	BB	F	A	Alive 12/88
	1/88	CC	F	A	Alive 12/88
Homestake Cr.	12/86	L	F	A	Radio malfunction 2/88
	12/86	M	F	A	Alive 12/88
	12/86	N	F	A	Alive 12/88
	12/86	O	F	A	Harvested 10/88
	12/86	P	F	A	Alive 12/88
	12/86	Q	F	A	Alive 12/88
	12/86	R	F	A	Alive 12/88
	12/86	S	F	A	Alive 12/88
	12/86	T	F	A	Harvested 10/88
	11/87	U	F	A	Alive 12/88
Two Elk Cr.	1/85	J	F	A	Harvested 9/87
	1/85	K	F	A	Harvested 10/88
	1/85	EE	F	A	Harvested 10/86
McCoy Park	6/87	Ca	M	C	Alive 12/88
China Bowl	6/87	Cb	M	C	Alive 12/88
	6/87	Cc	M	C	Alive 12/88
	6/87	Cd	F	C	Alive 12/88
	6/87	Ce	M	C	Alive 12/88
Stafford Cr.	6/87	Cf	M	C	Alive 12/88
	6/87	Ci	M	C	Alive 12/88
Smith Gulch	6/87	Cg	F	C	Alive 12/88
Chicago Ridge	6/87	Cj	M	C	Alive 12/88

Calving Areas.- - All four elk fitted with radio-collars in 1986, moved south from the winter range to different calving areas. Two elk, A and D, were monitored for only one year (Table 2.2). Cow A used Meadow Mountain during calving season and summer in 1986 before returning to Arrowhead in winter. Elk D utilized Mud Springs during calving season and summered in M^c^Coy Park before being harvested in Larkspur Bowl on the Beaver Creek ski area in October 1986. The other two telemetered elk used different calving areas but the same summer range. Cow B was relocated 7 times near Spruce Saddle on the Beaver Creek ski area during three consecutive calving seasons. And cow C used three different calving areas; Beaver Lake, M^c^Coy Park, and Meadow Mountain.

Summer Range.- - Grouse Mountain is located approximately 8 km south of the Beaver Creek ski area (Figure 2.2) and provides approximately 4 km^2 of alpine habitat. During 27 aerial and ground relocations an average of 72 elk were counted on this range from June 1 through 1 October 1986-88. Animal numbers observed ranged from 23 to 160 with a median of 100 elk observed 7 times. Both telemetered elk that survived through 1987, moved to Grouse Mountain by 10 June 1987 and 15 June 1988 and remained through the summers. Cow J, marked at Two Elk Creek, used Grouse Mountain in the summers of 1985-87 and bull Cg, marked in Stafford Creek, used Grouse Mountain during the summer of 1988.

McCoy Park is located on the western portion of the Beaver Creek ski area and south of Arrowhead (Figure 2.2) and includes approximately 2 km^2 of wet-meadow habitat. In 1987, 18 relocations were made with anaverage of 21 elk observed, and in 1988, 15 relocations were made with an average of 5 elk observed. Elk numbers in 1987 ranged between 0-65 with 1 observation of zero. In 1988, elk numbers ranged between 0-40 with 12 observations of zero elk. Elk were not observed in McCoy Park after 1 July, 1988. Cow C used McCoy Park in June 1987 and male calf A used the Park the entire summer 1987. No telemetered elk were in McCoy Park in 1988.

Dowd Junction - Two Elk Creek

The Dowd Junction winter range is located east of Colorado Highway 24 near the junction of the Eagle River and Gore Creek (Figure 2.1). This range includes 1.5 km^2 of winter habitat on U.S. Forest Service land and is described in further detail in Chapter IV. Based on 51 observations from 1986 -1988, an average of 89 elk used this range. Animal numbers varied between 13 and 149 elk with a median of 115 observed 17 times. Five and eight adult cows were captured and fitted with radio-collars at Dowd Junction in February 1986 and January 1988 respectively (Table 2.1).

Winter Range.- - One out of five elk fitted with radio collars in January 1986 at Dowd Junction (Table 2.2) returned to this range for three consecutive winters. One additional elk, cow F, used Dowd Junction in the winter of 1986 then used Lime Creek north of Red Cliff in 1987 and 1988. Cow G, marked at Dowd Junction, also wintered near Lime Creek in 1986-88. An average of 50 elk were observed in Lime Creek based on 11 observations from 1986-1988. Cow H used the hillside between Game and Two Elk Creeks during the winters of 1986-88. The fifth cow marked in 1986 was harvested in November 1986 (Table 2.2).

All eight elk fitted with radio collars in January 1988 returned to Dowd Junction by mid December 1988.

The two cows marked with radio collars at Two Elk Creek (Table 2.2) that survived through the first year after capture, returned to the hillside between Game Creek and Two Elk Creek on consecutive winters. Cow K used the Two Elk Creek range during four winters from 1985-88 and cow J used this range during three winters 1985-87.

Calving Areas.- - All five elk fitted with radio-collars at Dowd Junction in 1986 moved to different calving areas and each elk used the same calving area for three consecutive years. During calving seasons in 1986 through 1988, cow F was relocated 7 times on the hillside north of Wearyman Creek. Cow G was relocated on the south side of Copper Mountain 13 times. Elk I was relocated 6 times from 29 May through 25 June, in Summit county at the bottom of Stafford Creek, and cow H used wet meadows near Half Moon campground. During six relocations between 20 May and 2 June 1987-1988 an average of 26 elk, with a range of 6 to 42 animals, were observed using the meadows and clear cuts along lower Tigiwon Road between the U.S.F.S. gate and Bishop Gulch. After 3 June both years no elk were located in this area.

All eight elk telemetered in 1988 used Game Creek in April and May, then moved to the back bowls of Vail in late May. Six of these eight elk used Tea Cup and China Bowl and two used Sundown Bowl from 20 May through 15 June 1988. Of the three elk fitted with radio collars at Two Elk Creek, one radio malfunctioned (Table 2.2), cow K moved south to the wet meadows in Homestake near Whitney Lake during calving seasons 1985-88, and elk J was relocated 7 times near Buffalo Lake from 25 May through 6 June 1985-87.

Summer Range.- - Stafford Creek summer range lies in Summit County between Vail Pass and Copper Mountain. Included in this summer range are five drainages: Jacques Creek, Guller Creek, Stafford Creek, Smith Gulch, and Wilder Gulch, that drain to the east near I-70. During 31 relocations, between 100-150 elk with a median of 110, were observed utilizing this area from 1 June through 30 September. Majority of elk use occurred on approximately 7 km^2 of alpine habitat and 4 km^2 of timbered forest that lies below the Eagle-Summit County border.

Eight of the thirteen elk fitted with radio collars at Dowd Junction (Table 2.2) utilized the Stafford summer range. The three elk that were fitted with telemetry collars in 1986 used this range each summer from 1986-88. Two elk, one fitted with a radio collar at Dowd Junction in 1986 and one at Two Elk Creek in 1985, summered on Raggy-Ass Mountain on three and four consecutive years, respectively. Raggy-Ass Mountain supports approximately 40 elk during the summer months. The remaining telemetered cows from Dowd Junction used the Battle Mountain summer range that includes; Two Elk Pass, Commando, Pete's, Super Bowls, and Lime and Timber Creeks. This range is approximately 7 km^2 and lies southeast of the back bowls of Vail. Maximum number of elk seen on the Battle Mountain summer range during 5 aerial relocations was 61 in August 1988. Elk J marked at Two Elk Creek in 1985 used Grouse Mountain during three consecutive summers in 1985-87.

Homestake Creek

Homestake Creek lies approximately 6 km north of the Continental Divide in the southern end of the Holy Cross Wilderness area (Figure

2.1). The Homestake Range is comprised of 8 km^2 of winter habitat located in the valley bottom and including the hillside northwest of the creek. CDOW (age and sex winter classification 1987, Andree, pers. comm.) estimated between 200 and 250 elk used this area during a normal winter. Nine adult cows in December 1986 and one cow in December 1987 were fitted with radio-collars along Homestake Creek (Table 2.2).

Winter Range.- - All ten radio-collared elk used the hillside northwest of Homestake Creek between the gravel ponds and Whitney Creek in the winters of 1987 and 1988. Elk U was not marked until November 1987, thus, data were collected for only one winter season. The other nine telemetered cows utilized Homestake winter range for two consecutive seasons. Six of these elk used the south side of the creek in late November and early December before moving up in elevation in mid-December. All ten used this range through April before moving up in elevation following snow melt.

Calving Area.- - Six of nine elk, fitted with radio collars in 1986 moved up to the wet meadows below Whitney Lake during calving season in 1987. Two moved south of Homestake Creek to the wet meadows 0.5 km west of No Name Road, and one used the area near the mouth of East Fork of Homestake Creek. Seven of these cows returned to the same calving area they used the previous year. Cows P and U joined six telemetered cows at Whitney Lake. The radio transmitter on cow L malfunctioned (Table 2.2).

Summer Range.- - Summer range for the Homestake elk herd was located approximately 2.5 km southeast of Homestake Creek below Homestake Peak. This range includes approximately 5 km^2 of alpine meadows stretching above Lost Lakes south to the confluence of the E. Fork of Homestake Creek and Isolation Lake. An average of 109 elk were observed scattered across the alpine during 21 relocations made between 1 June and 15 September 1987-88. Elk numbers observed ranged between 25 and 150 elk.

Eight cows (M through T) marked in December 1986 utilized the Homestake Peak summer range for two consecutive years 1987-88. Five cows migrated south to the confluence of E. Fork Homestake Creek and Isolation Lake by 5 June and two cows migrated to the same area by 17 June 1987. In 1988, six of these seven cows returned to this area by 10 June. The summer location for cow L in 1988 was unknown due to a radio malfunction. All telemetered cows traveled back and forth between Isolation Lake and Lost Lakes during the remainder of the summer. Two Cows moved from No Name Road to the east end of Lost Lakes where they spent the summers of 1987 and 1988.

Seasonal Range Fidelity

Of the elk fitted with radio collars in 1986 and monitored for two or more years, 75% (12 of 16) returned to the same winter range they had used the previous winter. Six areas were identified as winter ranges (Figure 2.1) based on fidelity information. Four of the 8 (50%) elk marked in February 1986 shifted winter range locations from the area where they were trapped to alternate winter ranges during two or more consecutive years. All eight elk radio collared at Dowd Junction in January 1988 returned to this range by late December 1988.

Calving areas were identified based on relocation data collected during the calving period of 15 May through 15 June. Of the cows fitted with radio collars for two or more years, 87.5% (14 of 16) returned to the same calving area they used the previous year. Seven out of eight (87.5%) of the cows monitored for three years used the same calving area that they had used in previous years. Calving areas were spread across the study area and were generally located on slopes with a southern aspect and had water within approximately 400 m. Two radio-collared cows migrated through snow covered passes for three consecutive years to return to a specific calving area.

Three large and two smaller summer ranges (Figure 2.2) were used by all telemetered elk. Of the elk monitored for two or more years, 100% (16 of 16) returned to the same summer range during consecutive years.

Discussion

Seasonal Movements and Migration

At least three, somewhat distinct, elk herds can be recognized in the Upper Eagle River Valley as indicated by the results of seasonal movements and fidelity to seasonal ranges exhibited by telemetered elk. Herds were identified by winter ranges: Arrowhead, Dowd Junction-Two Elk Creek, and Homestake Creek; and appear to be almost completely segregated during winter. Isolated instances of herd overlap during spring occurred at Whitney Lake and during summer near Grouse Mountain in 1986-88. However, marked elk that shared ranges generally returned during fall and winter to the range on which they were marked. Exceptions to this pattern were noted only during the 1986 when severe winter weather likely forced elk to move from some winter ranges to concentrate on the Dowd Junction winter range. Other studies have reported similar patterns of herd segregation during winter and limited overlapping on spring and summer ranges (Craighead et al. 1972, Shoesmith 1979 and Young 1982).

Winter range is one of the limiting factors for elk on most ranges (Lyon and Ward 1982) and the upper Eagle River Valley is no exception. During winter, elk are confined to small areas in the lower elevations. Because of the development in the Gore-Eagle Valley, critical winter ranges for elk have been reduced by approximately 60% from approximately 31 km^2 to 13 km^2. This estimate is based on historical Colorado Division of Wildlife reports of winter range use in the Gore-Eagle Valley and reductions were inferred from areas of developments. Development of the Arrowhead and Beaver Creek golf courses and ski areas alone have eliminated approximately 5 km^2 of low elevation habitat. Areas traditionally used by elk are presently unaccessible because of fences, houses, or human harassment. We speculate these alterations have caused elk wintering in the Arrowhead area to disperse to areas higher in elevation and less accessible by humans. Suitability of alternate wintering areas is currently unknown.

The Dowd Junction elk population also occupies a restricted winter range. With I-70 bordering on the north, the town of Vail and the ski area to the east, Minturn and Beaver Creek to the west, and steep rugged mountains to the south, this herd has been limited in their winter movements. It appears that during severe winters when snow is deep, small groups of elk that winter on nearby hillsides during milder winters, migrate to Dowd Junction winter range as a last refuge. Herd numbers above carrying capacity during consecutive years could cause resource damage. Carrying capacity and resource availability are discussed in more detail in Chapter IV.

Movement patterns we observed during winter were small and localized and Wright (1983) suggested these movements were directed toward resource utilization. Hazards on this winter range include harassment from stray dogs and accidents with trains along the Eagle River.

The Homestake winter range is relatively unaffected by human activities. Because this range is located within the Holy Cross Wilderness, human development is restricted to small parcels of private land located along the valley floor and activity is limited to snowmobile and cross-country ski recreation along the valley bottom. According to CDOW (age and sex winter classification 1987, Andree, pers. comm.) information, the elk herd is slowly increasing.

Movement patterns from winter to summer range were consistent throughout our study area. All elk we monitored, regardless of winter range, migrated in a southerly direction to higher elevations during summer. Weather and, especially snow depth, seems to play an important role in the instigation of migration. This information is consistent with results of Anderson (1958), Leege and Hickey (1977), Lovaas (1970), and Picton and Picton (1975). Adams (1982) reported that some elk even forge through deep snow to get to summer range. Elk have been observed following the snow melt line feeding on the green succulent forage (Murie 1951, Boyd 1970). Spring migration in my study occurred in incremental movements toward the summer range. In late May, Dowd Junction elk moved up Game Creek into South Game Creek until they were able to cross over ridge tops and move into transition areas where groups begin to separate. Calving areas were usually located in secluded areas with southern aspects within approximately 400 m of water, and were separated from human disturbances. Elk we monitored from all 3 herds exhibited strong fidelity to calving areas in 1985-88. The exception was elk in the Tigiwon Road which moved during calving season and avoided using this area below Tigiwon Lodge after 3 June. We speculate elk use near the lodge diminished because the U.S.Forest Service began cutting timber and the road was opened to the public on 1 June 1987 and 1988.

Telemetered elk showed strong fidelity to particular summer ranges. During summer elk utilized high mountain areas that provide quality forage and escape from the nuisance of insects (Darling 1937, Johnson 1951). Movements up to 10 km to higher elevations and an increase in group size occurred in mid-June. However, a few small groups moved short distances, approximately 3 km, from calving areas to summer ranges. Daily movements during summer were short and localized and generally represented movements between feeding and resting sites.

McCoy Park was one exception where elk did not exhibit summer range fidelity. Elk numbers were drastically reduced from 375 elk seen during 18 relocations in 1987 as compared to 76 elk seen during 15 relocations in 1988. We speculate this reduction is influenced by the construction and activities associated with Trapper's Cabin and the increased summer development on Arrowhead. These new summer activities may have disrupted traditional elk movements.

Movements to lower elevations and increased use of timbered areas occurred in late August and early September and were related to the timing of the rut. Our observations are consistent with Altmann (1956) and Dalke et al. (1965). During the hunting season elk remain in small groups and utilize stands of dense timber. After the hunting season, elk begin to congregate and continue movement toward winter range. Elk returned to their respective winter ranges by 25 November during all years of my study. We do not know whether elk use the same migration routes used during fall compared to spring.

Elk numbers observed in this study are based on our best estimates made during relocations. Estimates are expected to be lower than actual numbers because of sightability factors. Samuel et al. (1987) reported that group size and percent vegetation cover were the primary factors influencing observability. Because aerial relocations represented 60% of our telemetry data, group sizes could be underestimates by 30% because of observability factors. However, all results are presented as minimum numbers observed without correction factors.

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Chapter III

DISPERSAL OF ELK CALVES

Introduction

Dispersal is a three-dimensional phenomenon that includes direction, distance and time. Elder (1977) and Howard (1960) defined dispersal as movement by an individual from the vicinity of the natal site to a place where it reproduces or would have reproduced if it had survived and found mates. Movements away from an animal's birthplace before attaining reproductive maturity was defined by Greenwood (1980) as natal dispersal, and Lidicker (1975) added that this movement is a permanent shift in home range.

The importance of understanding dispersal, as a means of lowering animal population densities, is becoming apparent. Lidicker (1975) suggested that both saturation (density-dependent) and presaturation (density-independent) components influence the occurrence of dispersal among vertebrates. Gregory and Cameron (1988) described saturation dispersal occurring when populations are at or near carrying capacity and social subordinates are forced to disperse by aggressive social interactions; and presaturation dispersal occurs in non-crowded areas by individuals in good physical condition.

Little is known about dispersal patterns of elk calves. Migration patterns of elk have been reported (e.g., Boyd 1970, Craighead et al. 1973, Edge et al. 1985, Knight 1970, White 1981, and Wright 1983) but none of these studies addressed the question of dispersal. Bunnell and Harstad (1983) studied dispersal of black-tailed deer and noted that this movement is out of an area larger than a home range and that it exhibits no predictable return (i.e., excluding migration). Gasaway et al. (1980) emphasized that dispersal of moose appears to be associated with relatively high population density. Since many elk populations are managed at various carrying capacities it is difficult to determine if saturation or presaturation factors influence dispersal.

Do elk calves move from their natal range as yearlings? This question and many others have been asked for years but no attempt has been made to find the answers. We addressed this question by fitting newborn elk calves with radio collars and monitoring their movements for 18 months. We identified seasonal range use, migration patterns and timing of movements. Our objective was to determine the extent of dispersal in elk during their first 18 months of life.

To date, no method exists for quantitatively evaluating dispersal. In this study, dispersal will be measured using criteria from known animal movements patterns in relation to previously identified seasonal ranges. We defined dispersal as an elk's movement during year 2 to a different seasonal range than used in year 1. Different seasonal range is defined as a new range in year 2, greater in distance from its year 1 seasonal range than the maximum distance across this first seasonal range. No overlap can occur between the 2 seasonal ranges (Figure 3.1).

<u>Methods</u>

Elk Capture and Instrumentation

For calves that exhibited the "hider behavior" (Lent 1971), we used a helicopter to hover over the calf until it laid down. Then it was captured. For older calves, a Coda Net Gun was used from the helicopter. All calves were marked with Alflex eartags, fitted with an

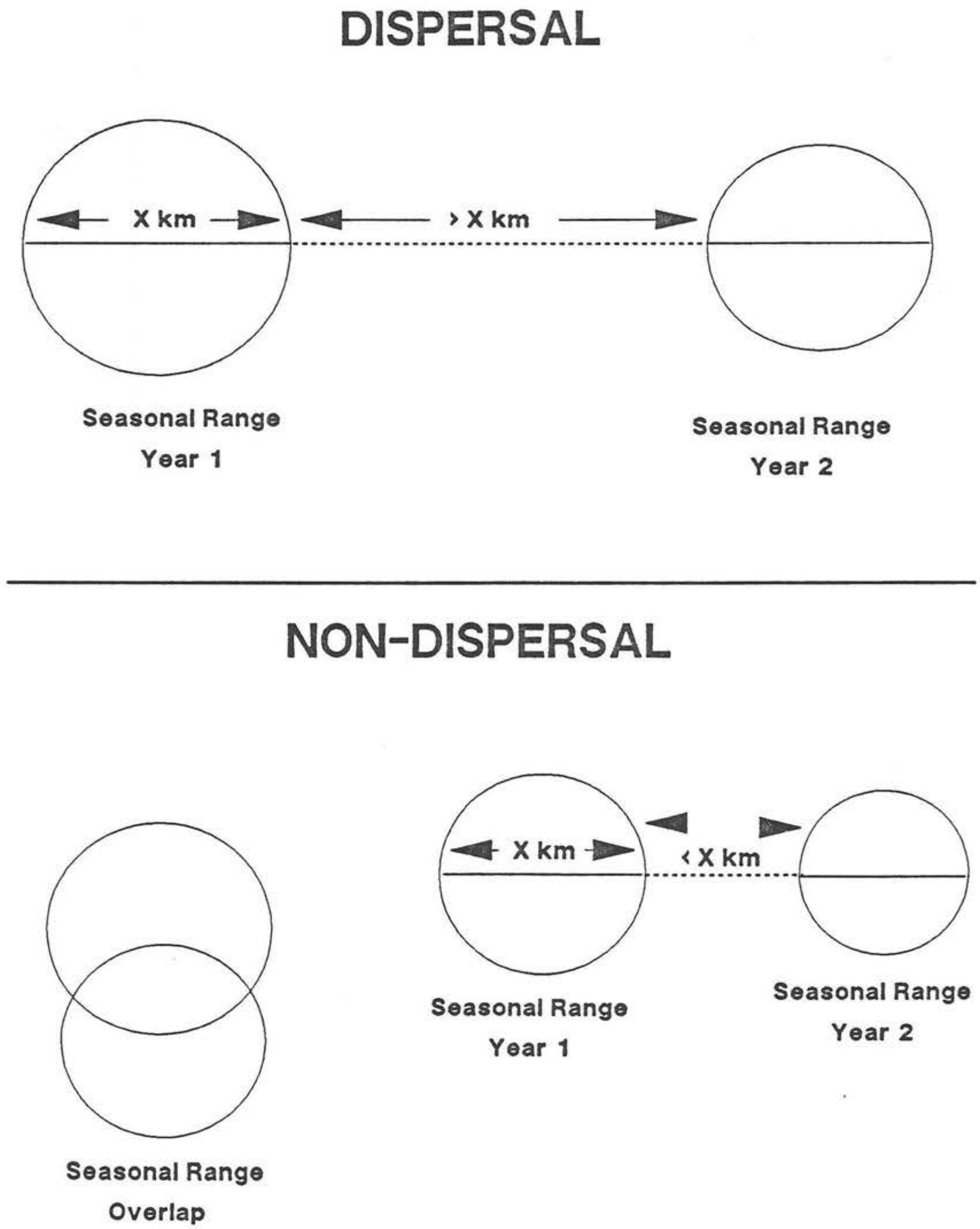

Fig. 3.1. Criteria used to ascertain dispersal of yearling radio-collared elk in the upper Eagle River Valley, Colorado.

expandable telemetry collar (Bear 1986), identified by sex, and released. Total handling time for each calf did not exceed ten minutes and there was no mortality caused by trapping and handling methods.

Equipment

Expandable radio collars were constructed using a design we modified from Bear (1986). Fire hose was used as collar material and elastic was sewn on the fire hose to allow collars to expand. Transmitter units used on elk calves were equipped with mortality sensors (motion sensors) with a normal pulse rate of 60 beeps per minute. If the telemetry collar was not moved within a 4 hour period, the motion sensor increased the pulse rate to 120 beeps per minute. Transmitter packages were weather sealed, and were equipped with a lithium battery with a 2-year life expectancy. Transmitters were fitted directly to fire hose collars with pop rivets. Telemetry packages weighed approximately 500 g.

Relocation Techniques

Telemetered elk calves were relocated from the air using a fixed-wing aircraft (Cessna 185) at least once a week from mid May to July, once every 2 weeks from July to November, and approximately once per month from November to May. The receiving system consisted of a Telonics model TR-1 scanner/programmer with companion TR-2 148-151 MHz receiver coupled with an "H" rotating directional antenna mounted in the belly of the plane. This system provided animal locations and excellent receiving range depending on topography. During flights, the aircraft was manned by a pilot and at least two observers, one responsible for mapping elk locations. Relocation flights were made between 0630 and

1230 hours depending upon weather conditions.

Ground relocations were conducted using a 2-element hand-held directional Yagi antenna. Ground surveys were used to provide additional relocations between flights in order to delineate areas of seasonal importance. All relocations were recorded as Universal Transverse Mercator (UTM) coordinates taken from USGS 7 1/2 minute topographic maps. Data were entered into a data base constructed with Reflex (Borland 1985).

Data Analysis

Our study included identifying seasonal ranges and movement patterns exhibited by adult cow elk in Game Management Unit (GMU) 45 (Chapter II). These data were used as reference for timing of herd migration. Telemetry data for calves were compared with data from adult cows to determine if elk calf movements deviated spatially or temporally from adult patterns.

Relocation data from June 1987 through March 1988 for 7 male and 2 female calves were used to identify seasonal range utilization by each calf during the first ten months of life while the calf was assumed to be with its mother. This time frame was selected to represent the period from birth through the first winter. Data after March 1988 were presumed to be movements exhibited by the calf independent of its mother. Minimum area polygon (Mohr 1947) was implemented from program HOMFR (White and Garrott 1987) as a home range estimator to calculate summer and winter seasonal range sizes, maximum X and Y distance within seasonal ranges, coordinates around seasonal ranges, and mean coordinates for each seasonal range. For each calf, data from year 2 was compared to year 1 for summer and winter ranges separately to determine if there was a change in seasonal ranges. If ranges did not overlap, distances between mean location of ranges and closest location between each range were measured. Year 1 was identified as 1 June 1987 through 30 March 1988 and year 2 was 1 April 1988 and continued through the duration of the study ending in December 1988.

Results

Nine newborn elk calves were captured and fitted with radio collars; 4 in China Bowl (3 males and 1 female), 3 in Stafford Gulch, (2 males and 1 female), 1 male in McCoy Park, and 1 male on Chicago Ridge (Fig. 3.2). No radio collars were lost and all 9 elk survived the duration of this study. A total of 406 relocation estimates were obtained with a mean of 45 and a range of 42 to 51 for each animal.

All monitored elk calves were migratory with distinct summer and winter ranges. Telemetered elk began leaving summer ranges the first week of September and all were located on winter ranges by 25 November. Fall migration appeared to be correlated with the beginning of hunting season in September 1987 and 1988. Elk began migrating from winter ranges in April and were located on summer ranges by the second week in June. Timing of migration was similar for both years.

Three types of movement patterns were exhibited: (1) dispersal in year 2 from summer and winter range used in year 1, (2) dispersal to a different summer range in year 2 and fidelity to winter range, and (3) fidelity to both summer and winter ranges. Of the 9 calves monitored in this study, 1 dispersed to a new home range, 3 reduced their home range during year 2 utilizing a different summer range but the same winter

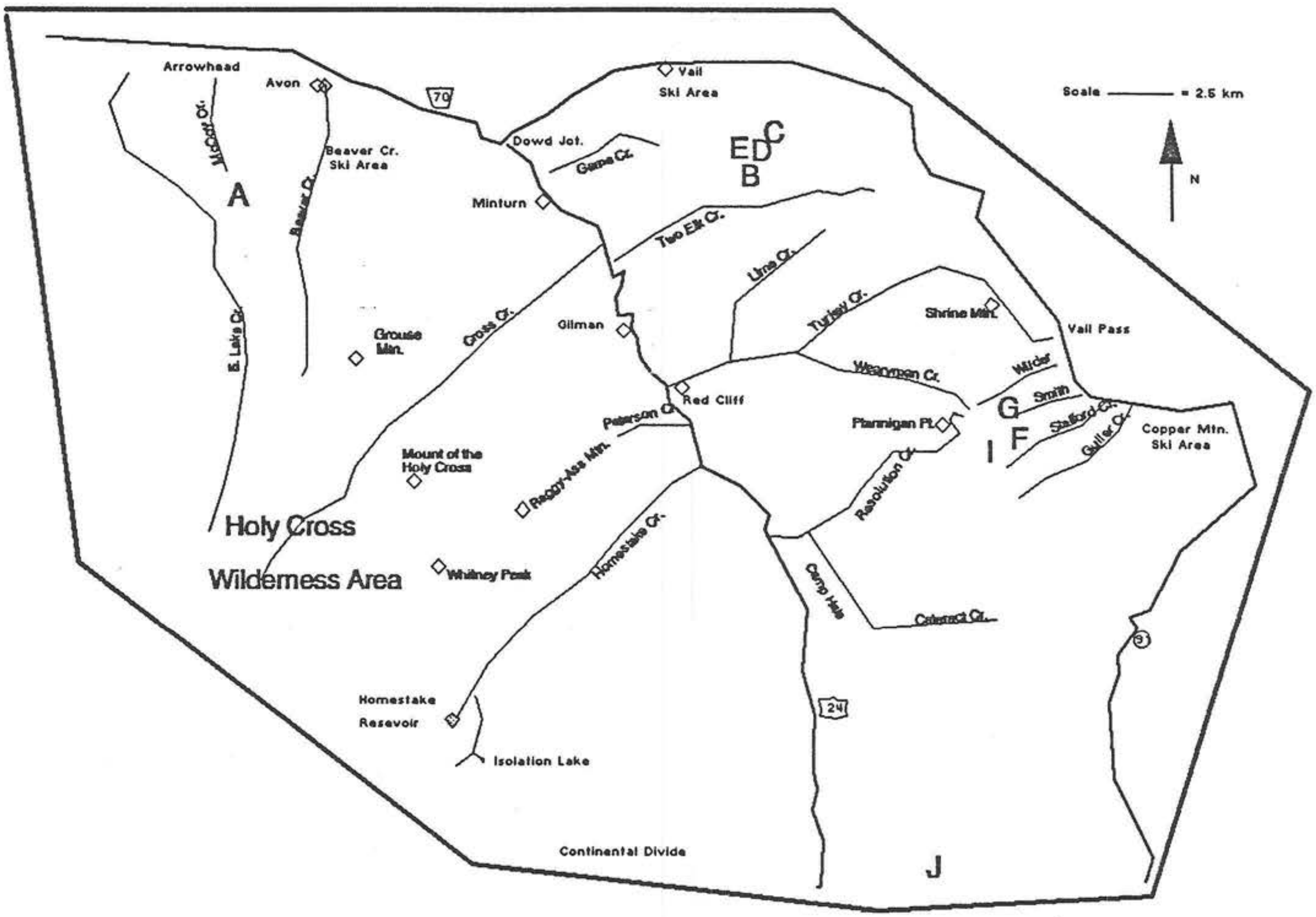

Fig. 3.2. Map of study area identifying sites where newborn elk calves were captured and fitted with radio-collars.

range, and the other 5 used the same summer and winter ranges both years (Figures 3.3 - 3.11).

One male, calf A, dispersed in year 2 from the summer and winter range used in year 1. Calf A (Figure 3.3) was captured in McCoy Park (Figure 3.1) in June 1987 and used this area throughout the summer before migrating north to Arrowhead in late November. In mid-February, this calf migrated approximately 9 km west and used a different range during the remainder of winter. In year 2, calf A moved higher in elevation and continued to use Belly-Ache Ridge through the summer. Straight line distance between mean seasonal locations for the two summer ranges was 16.7 km and the distance between closest locations among ranges was 11.6 km. Maximum distance across summer ranges used by calf A was 5.1 km. This calf returned to the same portion of Squaw Creek utilized during the latter portion of the previous winter. Distance between mean locations on consecutive winter ranges was 8.7 km and maximum distance across winter ranges was 4.8 km. One radio-collared adult cow, monitored during this study, showed similar movement patterns between Arrowhead and Squaw Creek winter ranges, but this cow returned to Arrowhead.

Three calves dispersed to different summer ranges in year 2 but showed fidelity to winter range sites. Male calf F (Figure 3.8) was captured in, and utilized Stafford Gulch during summer 1987 and migrated approximately 24 km north to winter near Beaver Creek. During year 2, calf F used a different summer range from the previous year but utilized the same winter range both years. Straight line distance between mean locations for the 2 summer ranges was 22.7 km and maximum distance

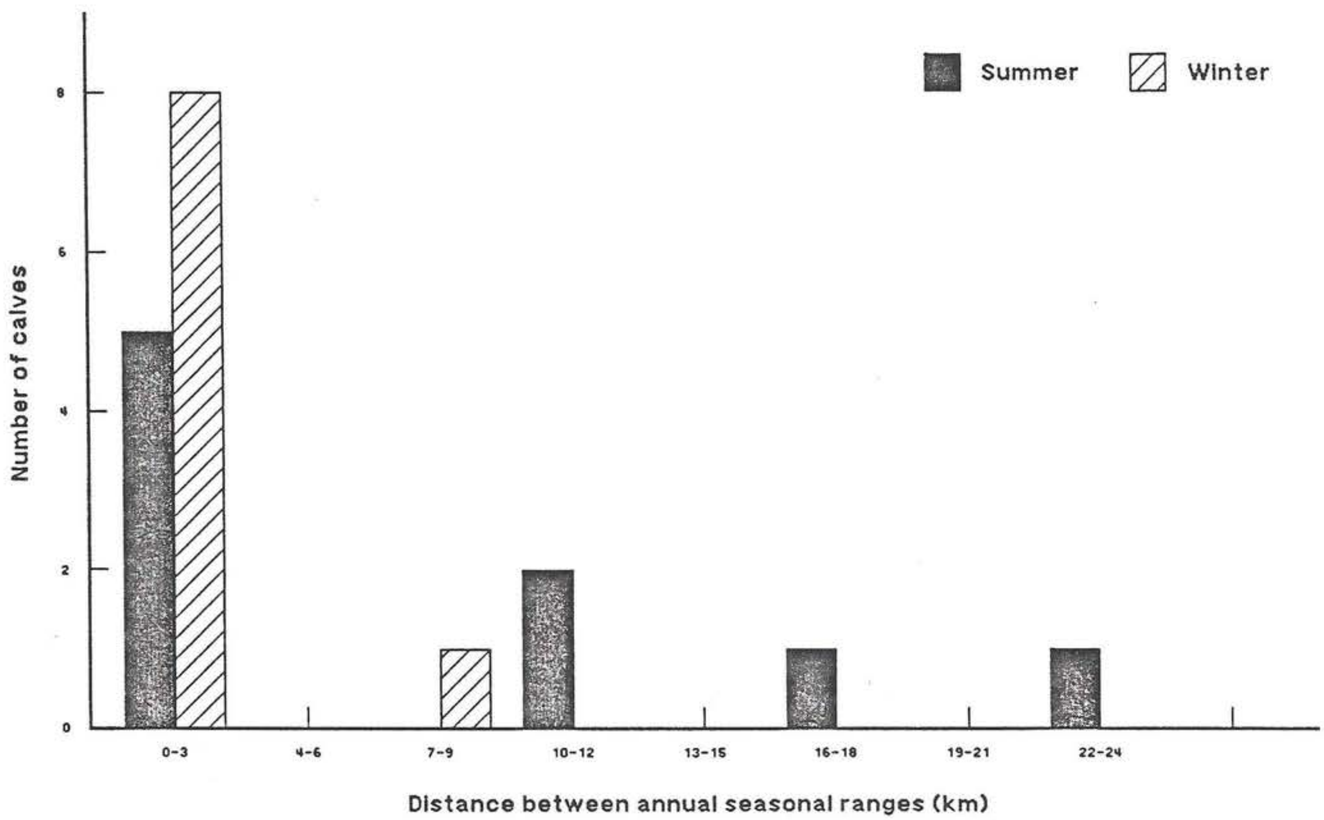

Fig. 3.3. Distance between annual mean range locations by season for radio-collared elk calves in the upper Eagle River Valley, Colorado.

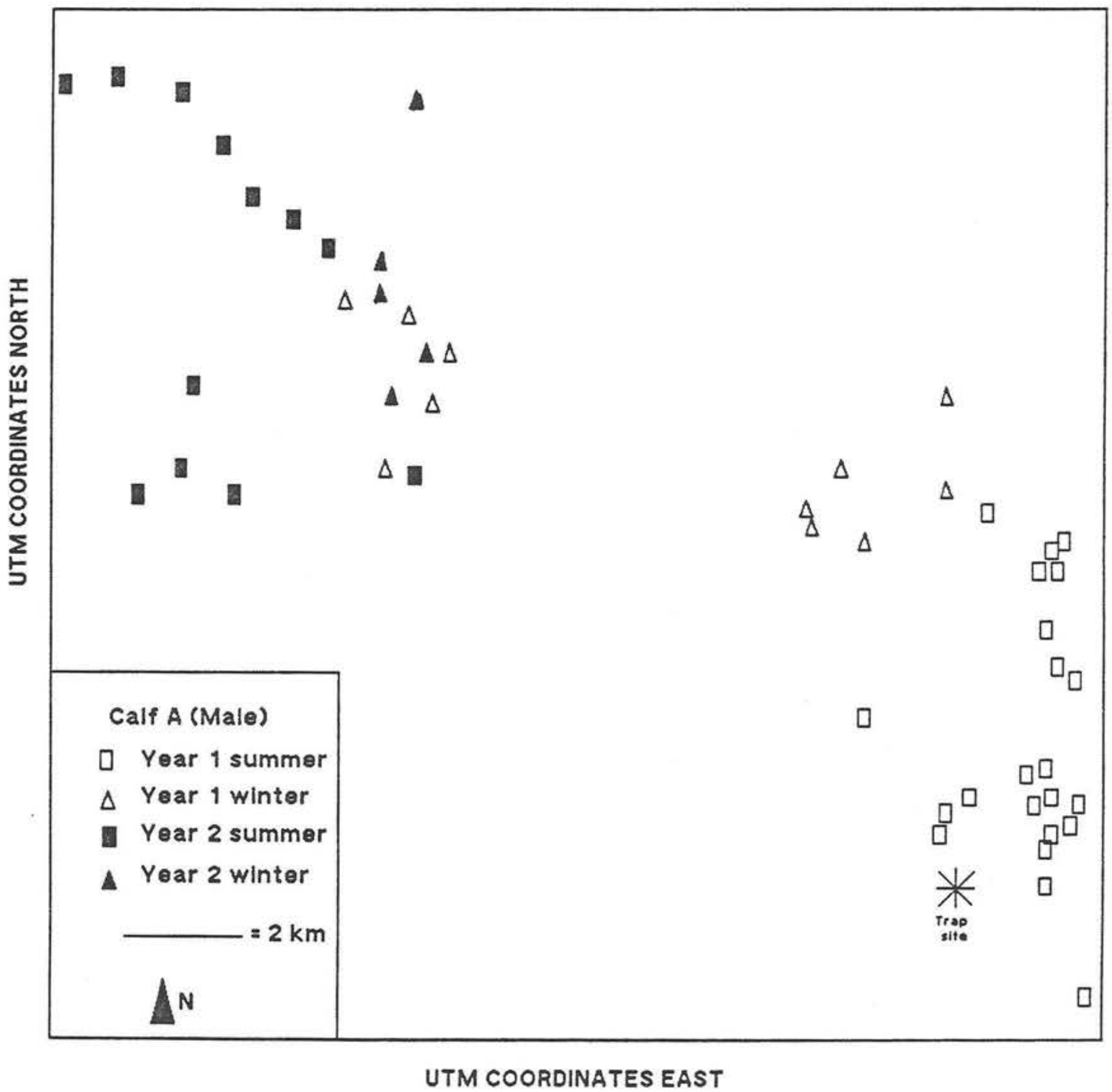

Fig. 3.4. Estimated locations for calf A from June 1987 through December 1988 in the upper Eagle River Valley, Colorado.

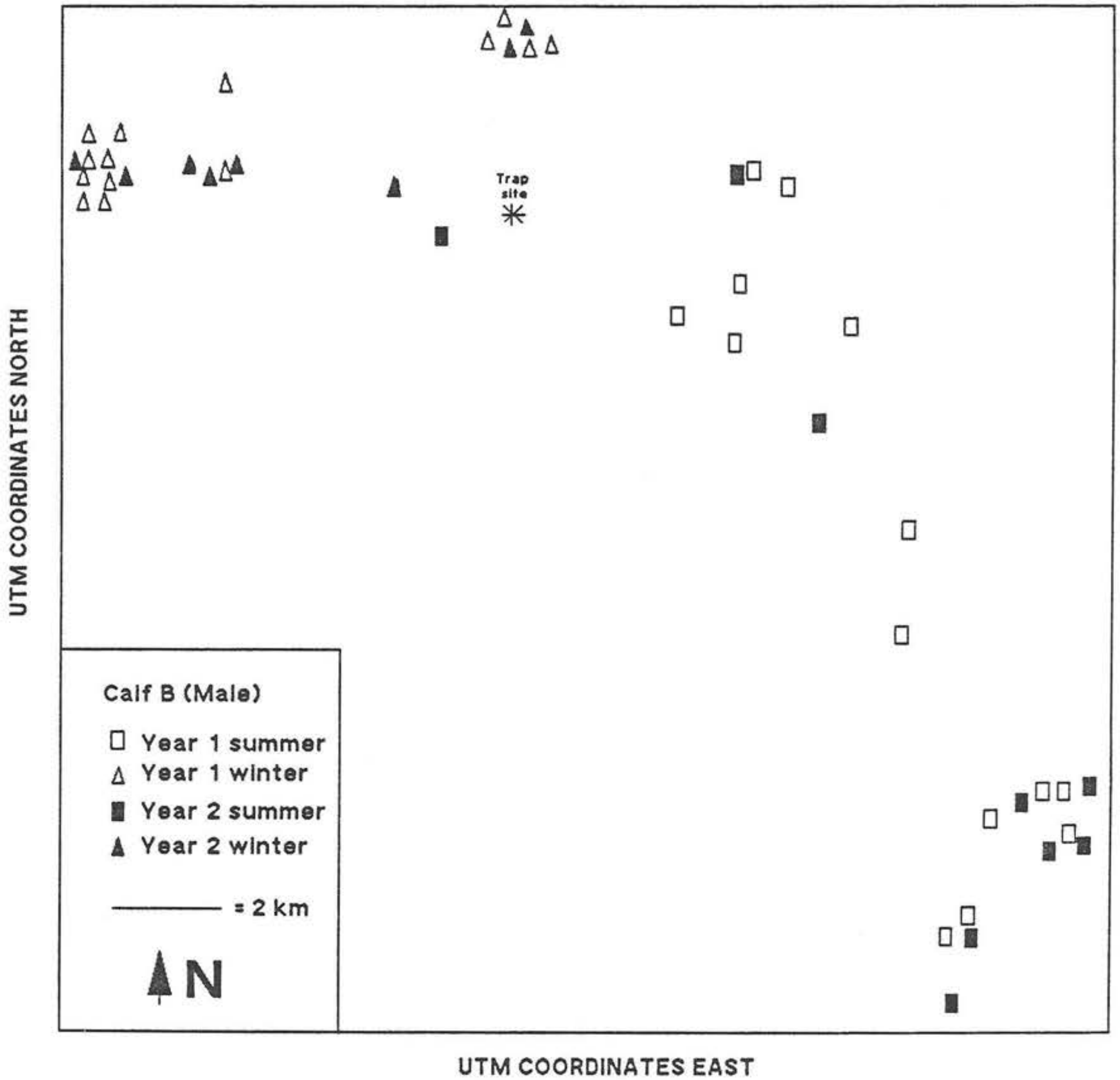

Fig. 3.5. Estimated locations for calf B from June 1987 through December 1988, in the upper Eagle River Valley, Colorado.

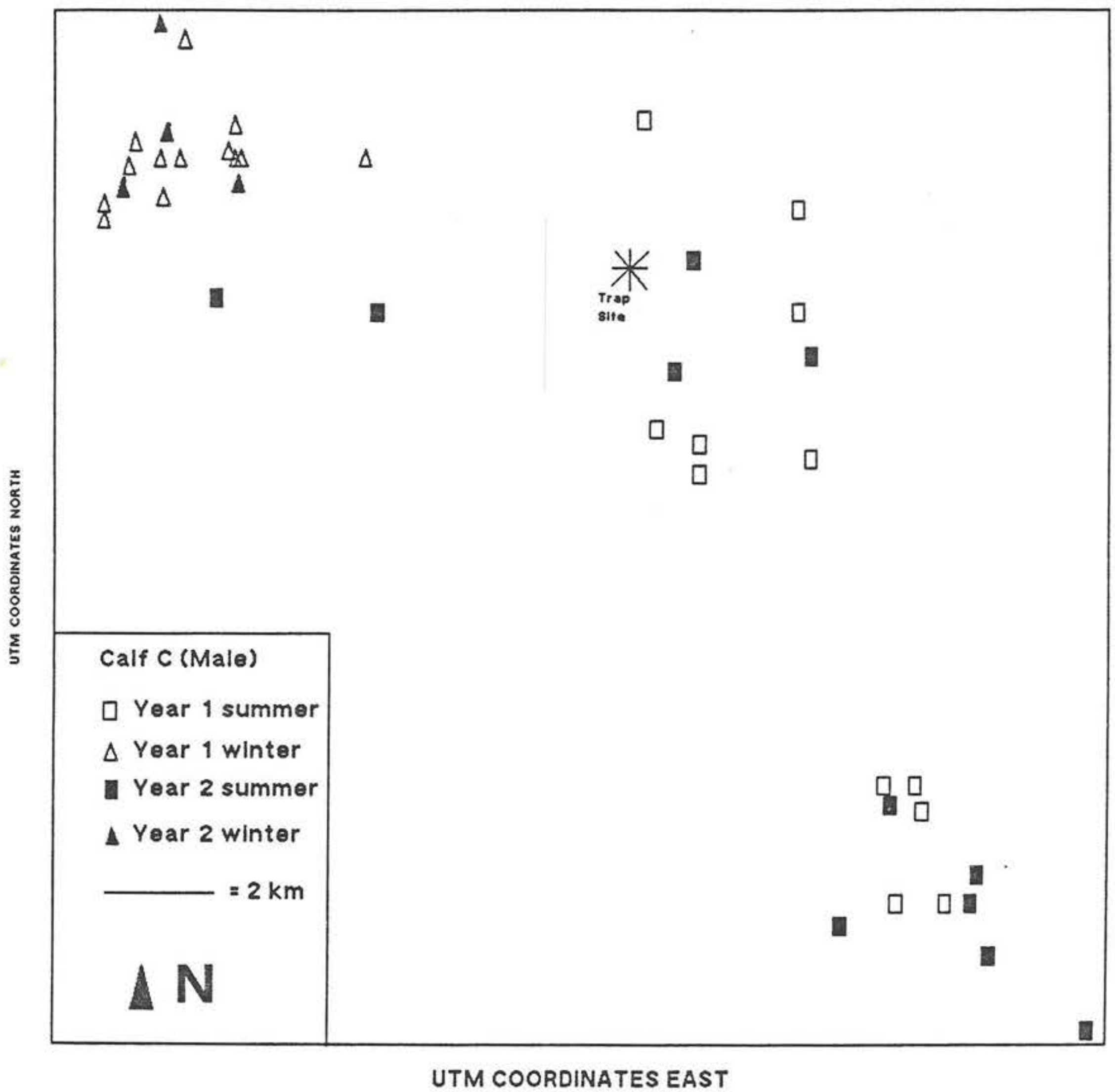

Fig. 3.6. Estimated locations from calf C from June 1987 through December 1988, in the upper Eagle River Valley, Colorado.

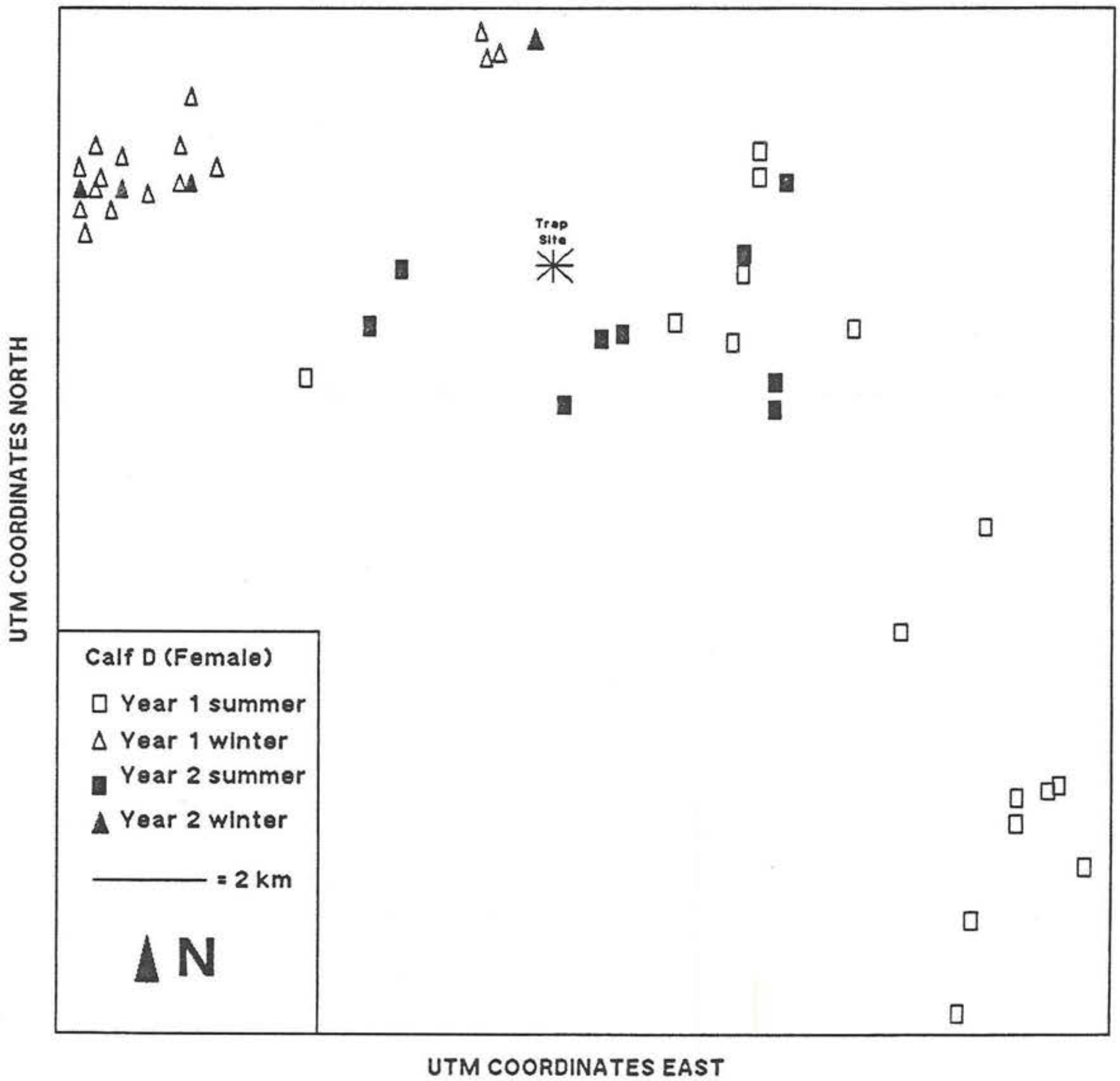

Fig. 3.7. Estimated locations for calf D from June 1987 through December 1988, in the upper Eagle River Valley, Colorado.

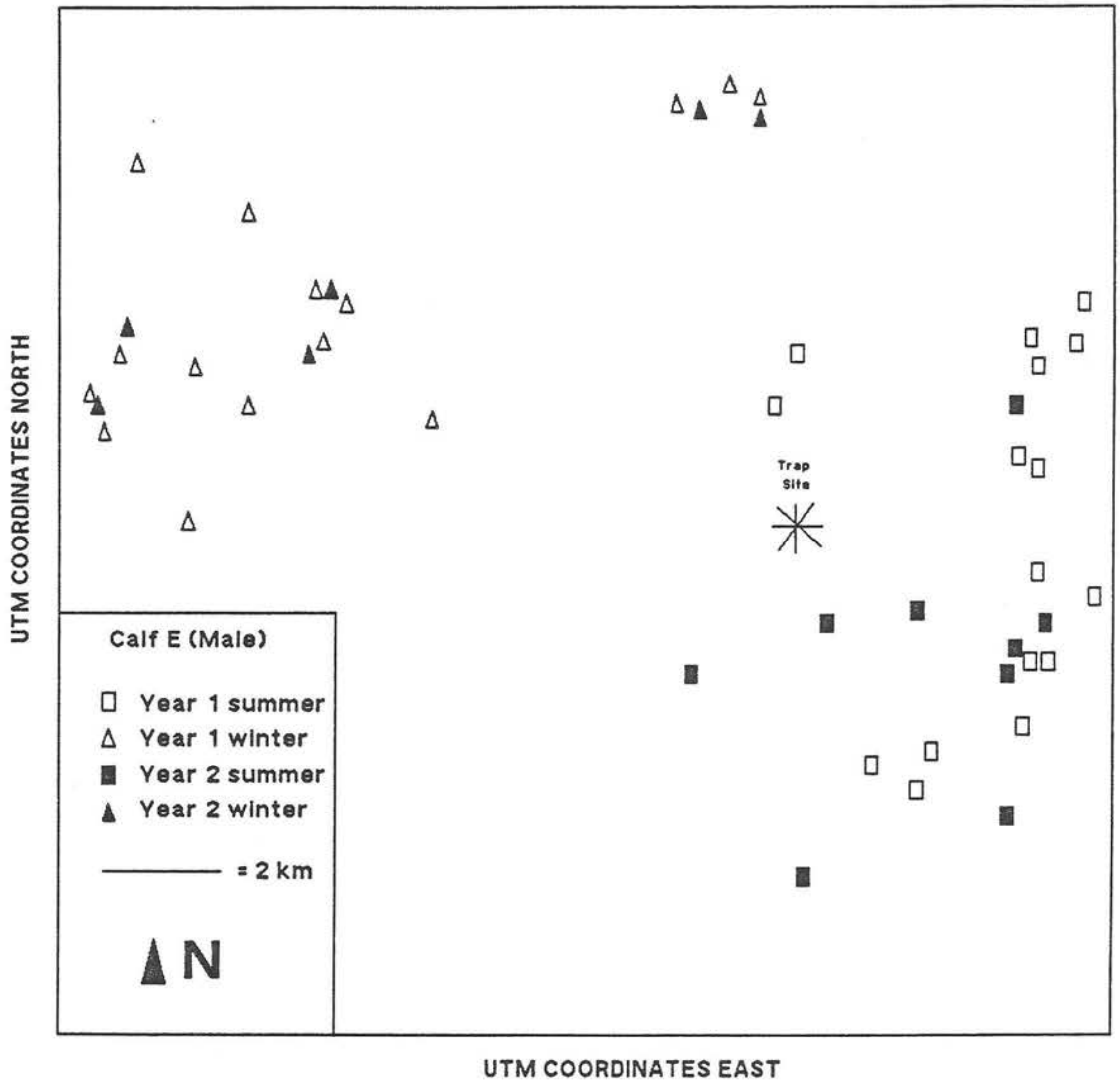

Fig. 3.8. Estimated locations for calf E from June 1987 through December 1988, in the upper Eagle River Valley, Colorado.

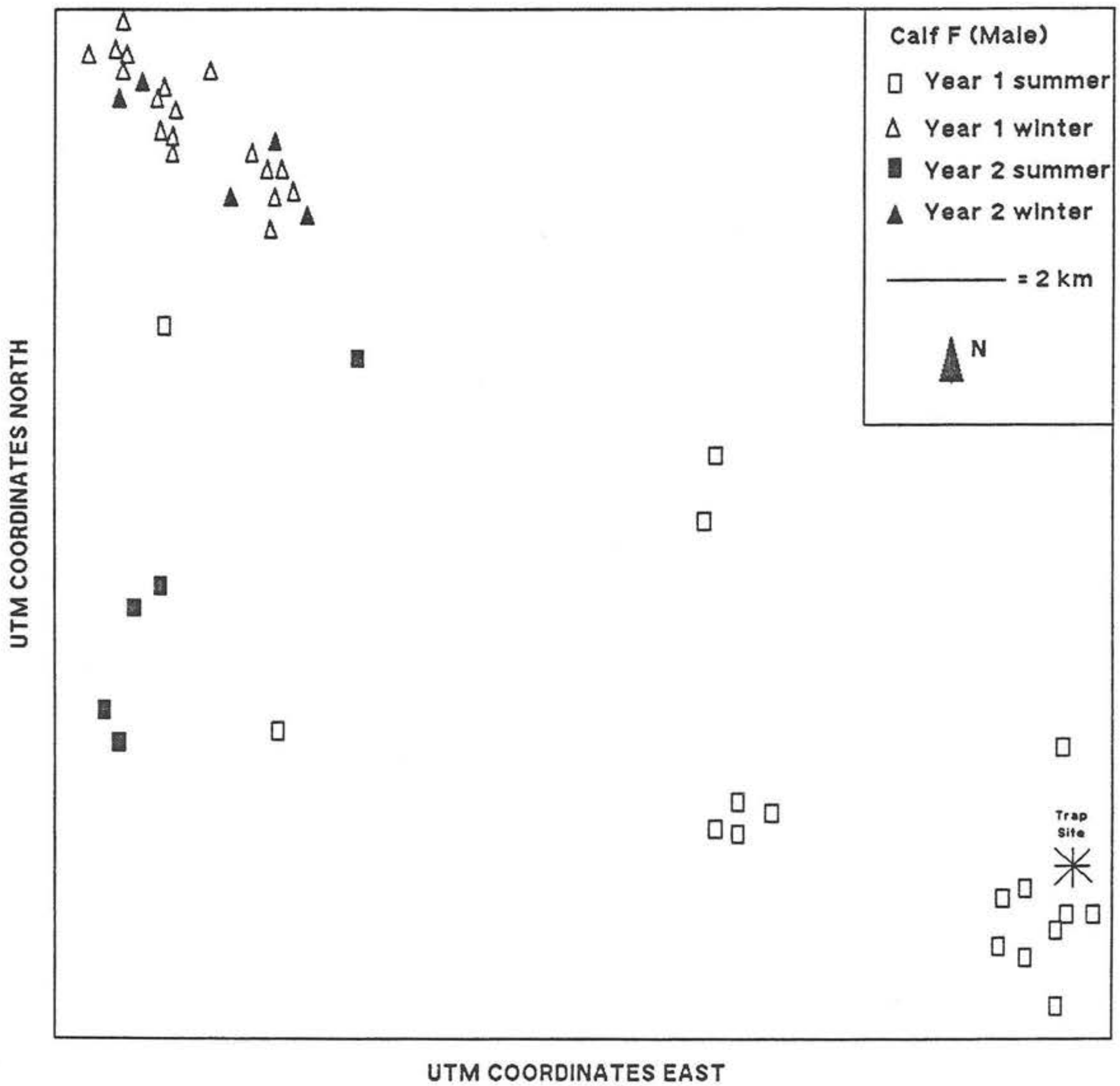

Fig. 3.9. Estimated locations for calf F from June 1987 through December 1988, in the upper Eagle River Valley, Colorado.

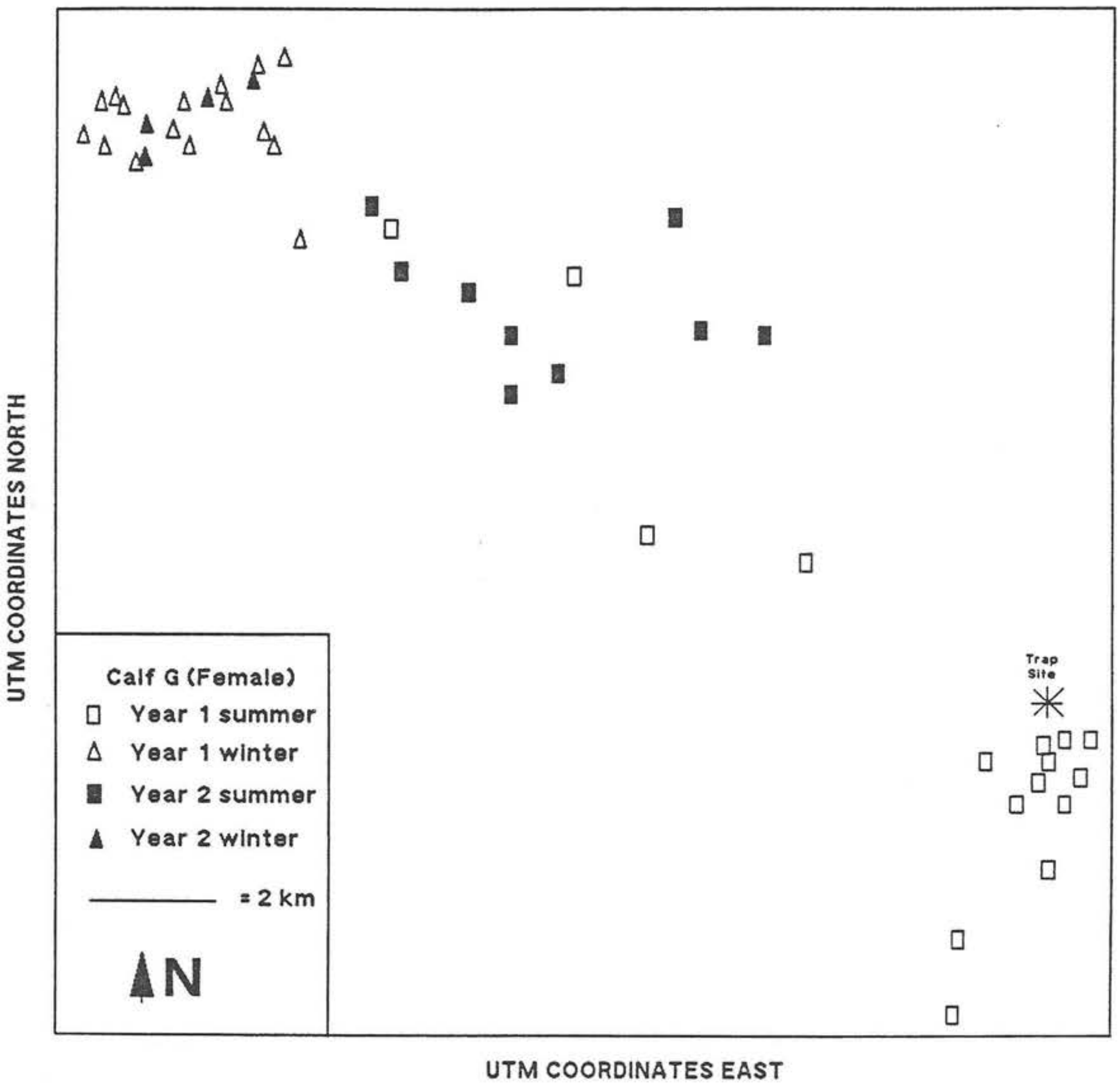

Fig. 3.10. Estimated locations for calf G from June 1987 through December 1988, in the upper Eagle River Valley, Colorado.

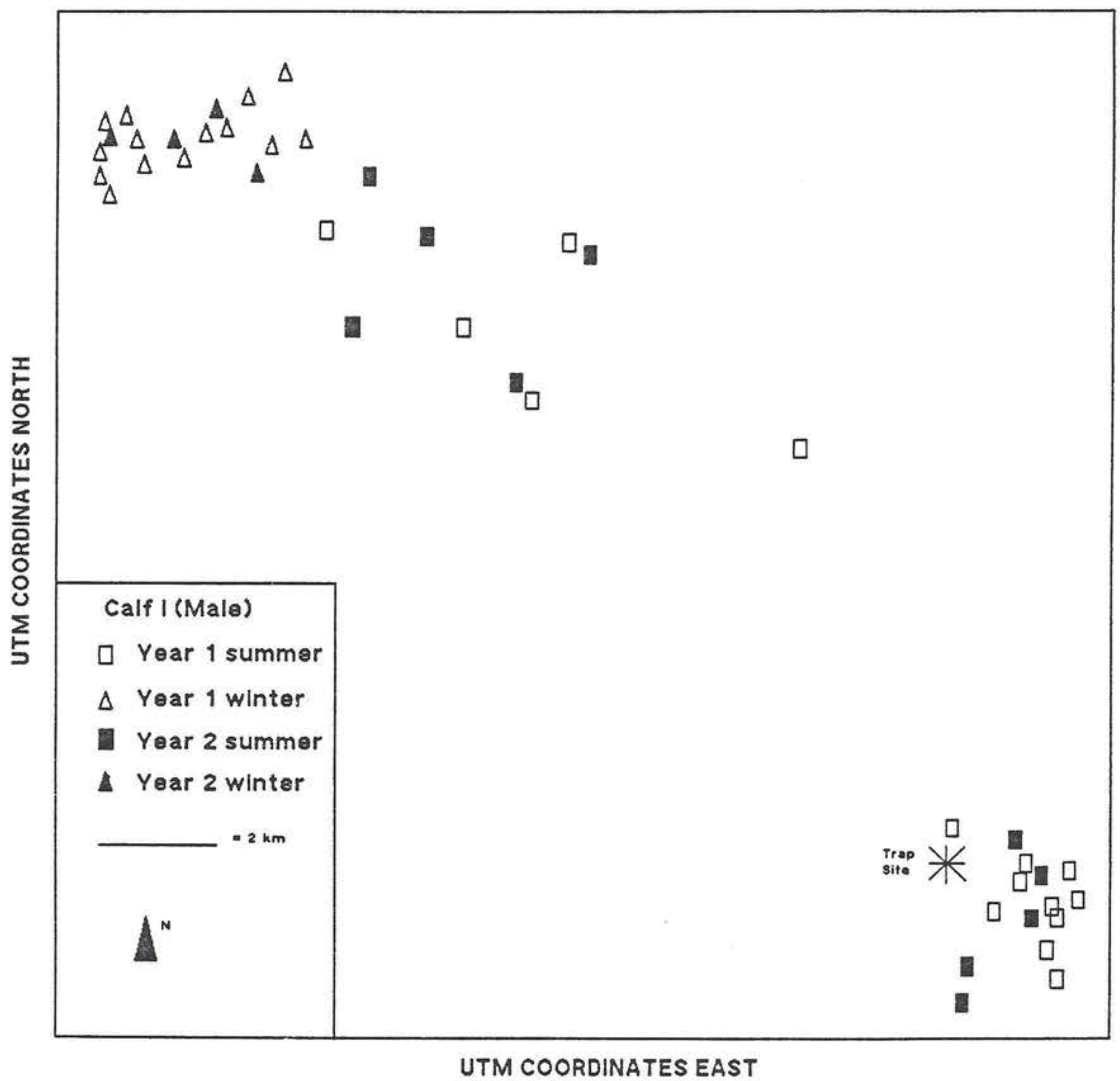

Fig. 3.11. Estimated locations for Calf I from June 1987 through December 1988, in the upper Eagle River Valley, Colorado.

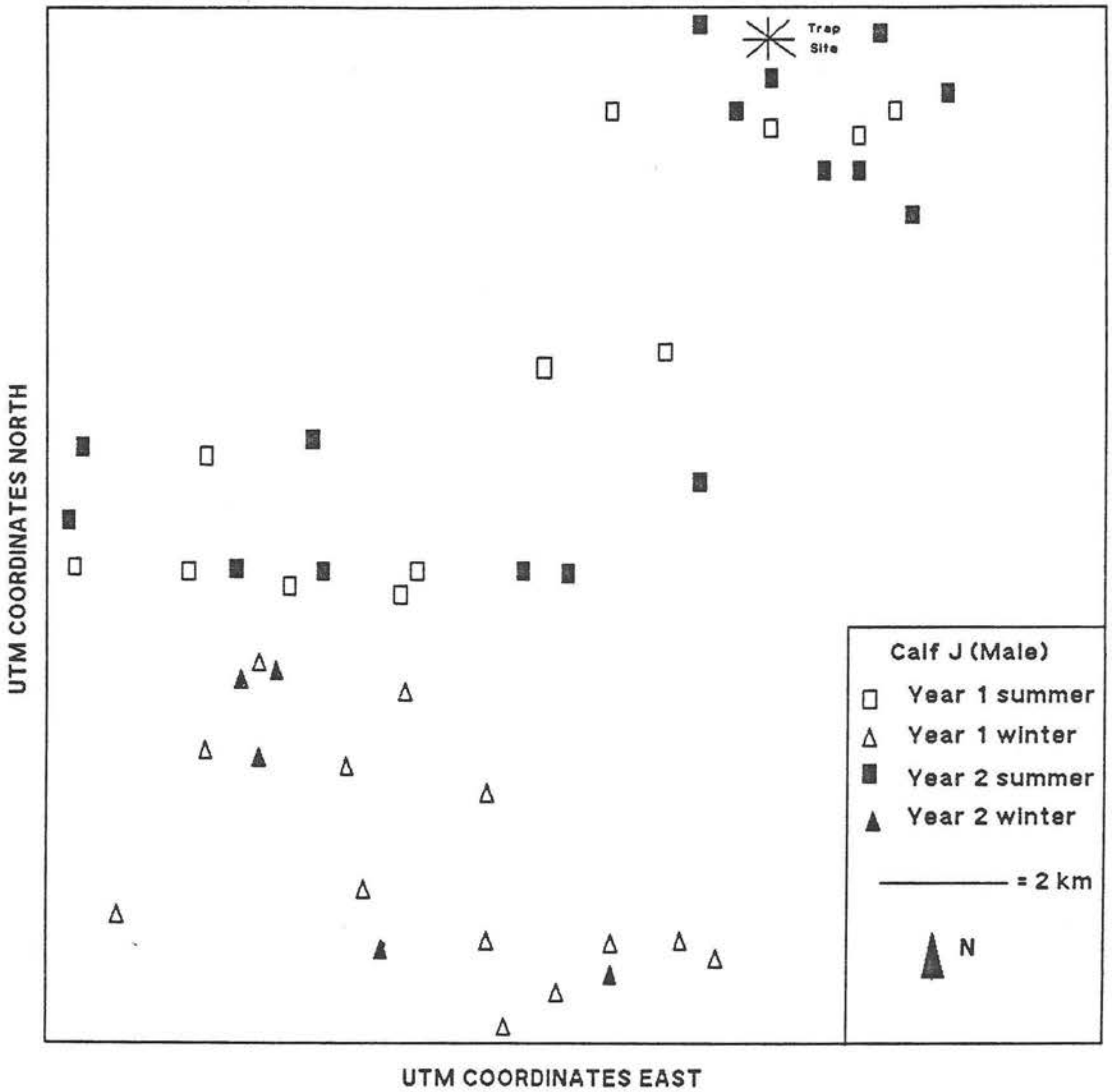

Fig. 3.12. Estimated locations for calf J from June 1987 through December 1988, in the upper Eagle River Valley, Colorado.

within summer ranges was 7.5 km. One adult cow, marked with a blue collar at Arrowhead in 1985, was observed in Stafford Gulch during summer 1987. No other marked elk were observed migrating between Stafford Gulch summer range and Arrowhead winter range and the extent of this movement pattern is unknown.

The 2 female calves, fitted with radio collars, also utilized a different summer range during year 2 but showed fidelity to the same winter range. Calf D (Figure 3.6), captured in China Bowl (Figure 3.2) on 9 June 1987, moved to Stafford Gulch by late June and utilized this area throughout summer. In year 2, this calf returned to its natal range but did not use the same summer range as in year 1. Instead she spent the summer approximately 3 km south of the back bowls of Vail near Battle Mountain. Straight line distance between mean locations of the 2 summer ranges was 12.3 km and maximum distance within summer range was 7.1 km. Calf G (Figure 3.9) was captured in and used Stafford Gulch (Figure 3.2) during the first summer but did not return in year 2. This calf also dispersed to Battle Mountain with a distance between mean locations of 12.8 km and maximum distance within summer range of 7.3 km. Both of these cow calves showed fidelity to the Dowd Junction winter range with distances between mean locations during consecutive years $\leq$ 2 km.

The other five telemetered male calves showed fidelity to summer and winter ranges. Straight line distance between the mean of seasonal range locations for individual elk calves during consecutive years was $\leq$ 3 km. Calves B, C, and E (Figures 3.4, 3.5, and 3.7) were captured in China Bowl (Figure 3.2), summered near Stafford Gulch, and wintered at

Dowd Junction. Calf I (Figure 3.10) was marked in and summered near Stafford Gulch (Figure 3.2) and also wintered at Dowd Junction. Calf J (Figure 3.11) was captured at, and summered on, Chicago Ridge (Figure 3.2) and wintered near Highway 91 north of Leadville.

Discussion

In ungulate species, it has been suggested that adult females exhibit fidelity to home ranges and that males disperse in search of mates (Bunnell and Harestad 1983). Numerous studies have confirmed fidelity to seasonal ranges in females (i.e., elk: Craighead et al. 1972, Wright 1983, deer: Carpenter 1979, Garrott et al. 1987, and moose: Markgren 1972), but little is known about the movement patterns of males.

Although elk migrate over vast areas, they appear to demonstrate strong fidelity to individual summer and winter ranges. Several observations have been reported that female elk repeatedly return to the same seasonal range (Brazda 1953, Knight 1970, and Hershey and Leege 1982). However, few studies to date have addressed movement patterns of bull elk and none have studied movements of bull calves.

Although exact timing of dispersal is unknown, the literature suggests that bull elk which disperse do so before they reach sexual maturity (Geist 1982). Bunnell and Harestad (1983) suggested that the majority of dispersal movements by black-tailed deer was made by "male virgins about the time they attain puberty". Elk are a polygynous species (Geist 1982) and this leads to greater competition for mates among males than females. Competition for mates is thought to be one cause of dispersal by males from their natal range. Dispersal is reported to occur during the summer-autumn period when forage requirements and competition for mates are high (Geist 1982). Squibb (1985) reported that yearling bulls are capable of breeding but success rates are very low due to displacement of the mounting bull by a dominant bull. Hunting pressure on males may influence male dispersal.

The telemetered elk calves we monitored do not disperse from their natal home ranges as yearlings. Even if some telemetered calves utilized different summer ranges in year 2, the distance was small relative to their home range size. Short dispersal distances were expected during the period when cows displace their offspring as yearlings prior to giving birth to another calf (Geist 1982). Also, displacing males from a cow's home range is a way to avoid inbreeding. Dobson (1979) indicated that natural selection favors dispersal by juvenile males if they gain some advantage in achieving outcrossing. Cederlund et al. (1987) suggested that there was a tendency for male moose calves to leave their dams earlier than female calves, as was found among other cervids (Stranggaard 1972, and Clutton-Brock et al. 1982). Although our study provides no evidence for differences in natal dispersal between sexes among yearling offspring, it does provide a starting point from which this question should be further addressed.

Of the seven bull elk telemetered as calves, only one exhibited dispersal from both its natal summer and winter range. We do not know what caused this shift in home ranges between years, but speculate that the increased human activity on the Arrowhead ski site influenced dispersal. About the time this bull migrated to its new winter range during mid winter of year 1, development activities at Arrowhead were continuing to increase in preparation for opening of the ski area the following year. This calf was able to migrate to an area that appeared to be well below carrying capacity and did not return to ranges it had previously used. Five of the six additional telemetered males exhibited fidelity to the same seasonal ranges both years, and the remaining bull showed fidelity to its winter range but shifted summer range. Eight of nine telemetered calves showed fidelity to home ranges.

Dispersal rates could be underestimated because only a small number of bull calves were monitored. Cow elk in our study exhibited fidelity to home ranges and disproportionate numbers of females have been tagged and studied. Also, dispersal in GMU 45 may be prevented or deterred by physical barriers surrounding this study area (i.e., Interstate 70, ski areas, towns).

Ideally, there are ways to improve this study including, increasing the number of radio-collared calves, collaring equal numbers of bulls and cows, marking calves of telemetered cows with known movement patterns, and monitoring calves for three or more years. These and other improvements could strengthen this study.

Evaluation of Historical Calving Range

SB & AH Ditch Study

We also surveyed an historical calving ground to evaluate the efficacy of mitigation from ski area development at Beaver Creek. The SB &AH Ditch was surveyed prior to much development and was reported to be an area used for calving. This segment of our report describes evaluation of that calving area.

The SB & AH ditch runs approximately 14.5 km in length north from the Beaver Creek ski area, following the contour along the hillside west of the creek to Bachelor Gulch. In 1974, an elk calving search was conducted by CDOW personnel (Moser, Colorado Division of Wildlife) in the proposed Beaver Creek and Arrowhead ski areas to delineate calving beds. Mitigation recommendations were made, based on the results of that survey, addressing potential impacts of future development on elk calving grounds. These mitigations are listed in the U.S. Forest Service Environmental Assessment (EA) and generally state: (1) maintain a flow of water in the SB & AH ditch to provide suitable habitat for elk calving, (2) minimize human activities on the hillside west of Beaver Creek during calving season, (3) roads above 2562 m be closed to public vehicle access, and (4) only the gondola (mid mountain lift) would be open to summer operation. We conducted a second survey in 1988 for the purpose of evaluating the success of mitigation by documenting the use of the area by elk for calving.

From 3 through 5 June, 1974, the SB & AH ditch was surveyed by 8 CDOW conservation officers and 1 BLM biologist to determine elk calving areas and locate birthing beds. This survey used 9 men on horseback for 16 hours and covered the ditch, McCoy Park and Bachelor Gulch. Twenty-four fresh birthing beds were located along the hillside west of Beaver Creek and 2 were located in Bachelor Gulch. All locations were within 150 m of the ditch, (which contained water at that time), and each bed was closely associated with Aspen groves. Bed sites were plotted on USGS topographic maps.

On 6 June 1988 a second survey was conducted by members of the CDOW and CSU, with efforts concentrated in areas surrounding the SB & AH ditch. Eight people, including 2 (Byrne and Green) who participated in the previous survey, searched for 7 hours. No fresh calving beds were located during this survey and there was no water in the ditch. Twenty-two day beds were found but only 2 were identified as recent. Elk tracks along the Beaver Creek portion of the ditch were lacking. Three additional surveys were conducted between 1980 and 1988, by the CDOW and 10 students from Colorado Mountain College, and those surveys found no fresh calving beds and a decrease in elk activity near Beaver Creek (Andree, pers. comm.). However, the portion of ditch on Arrowhead was heavily used and some water was in the ditch.

Findings from 1988 supported previous conclusions that elk have stopped using the Beaver Creek portion of the SB & AH ditch for calving. Results from this survey also concurred with a study conducted by Torbit (1985) on the Arrowhead ski area. Torbit reported a 12 fold increase in elk track densities on the Arrowhead property as compared to elk tracks counted on Beaver Creek. The 1988 survey also verified a lack of overall elk use near Beaver Creek.

The abandonment of this area for a calving ground may be because of a breech in mitigation. In 1984, the Beaver Creek portion of the SB & AH ditch was destroyed and filled with soil, greatly limiting water availability. Runoff from snowmelt and underground springs were now channeled down the mountain instead of into the ditch. This action is in direct contradiction with mitigation for wildlife stated in the Beaver Creek EA. Lack of water in the ditch may have caused elk to leave the Beaver Creek portion of the area because sign increased 10-15 fold where free flowing water was present on the Arrowhead side of the ditch. Reduction in solitude, because of increased human activity, could have also contributed to the reduced elk use in this area.

Based on the 1988 survey and results from Torbit (1985), mitigation has not been successful. Three of 4 mitigation actions have been ignored. Thus it is impossible to state if mitigation was incorrect or if failure to follow mitigation caused reduction of elk use. We recommend that mitigation for wildlife be reinstated and enforced. Mitigation should include; restoration of the SB & AH ditch to a condition where it will maintain flowing water during spring and summer, and closure of this area to human activity during the calving season, 15 May through 20 June.

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Chapter IV

CARRYING CAPACITY ESTIMATES FOR DOWD JUNCTION WINTER RANGE

Introduction

Winter is generally a time of poor nutrition for elk populations (Nelson and Leege 1982), when elk that ranged over thousands of hectares in summer are forced onto restricted winter ranges. Deep snow renders large portions of forage supplies unavailable and plants become dormant and are less digestible (Hobbs 1979). Population objectives for management of big game animals are often based on winter range carrying capacity estimates.

Carrying capacity is the number of animals of a specified quality that a habitat can support while sustaining habitat productivity (Bailey 1984). Management of big game populations requires an understanding of limiting resources, which in Colorado and much of the west, winter range (Lyon and Ward 1982). Because of the intensity of human development in valley bottoms, traditional ranges are being lost. Identifying the quantity and quality of winter range is essential for wildlife biologists to manage elk populations effectively.

The Dowd Junction range is a parcel of land, approximately 130 ha, located along the Eagle River in Eagle County Colorado that has been identified as winter range for a portion of the elk population in Game Management Unit (GMU) 45 (Figure 4.1). This range lies between two destination ski areas, Vail and Beaver Creek. Because of the continued construction of recreational ski facilities and associated offsite development, wintering areas are in jeopardy.

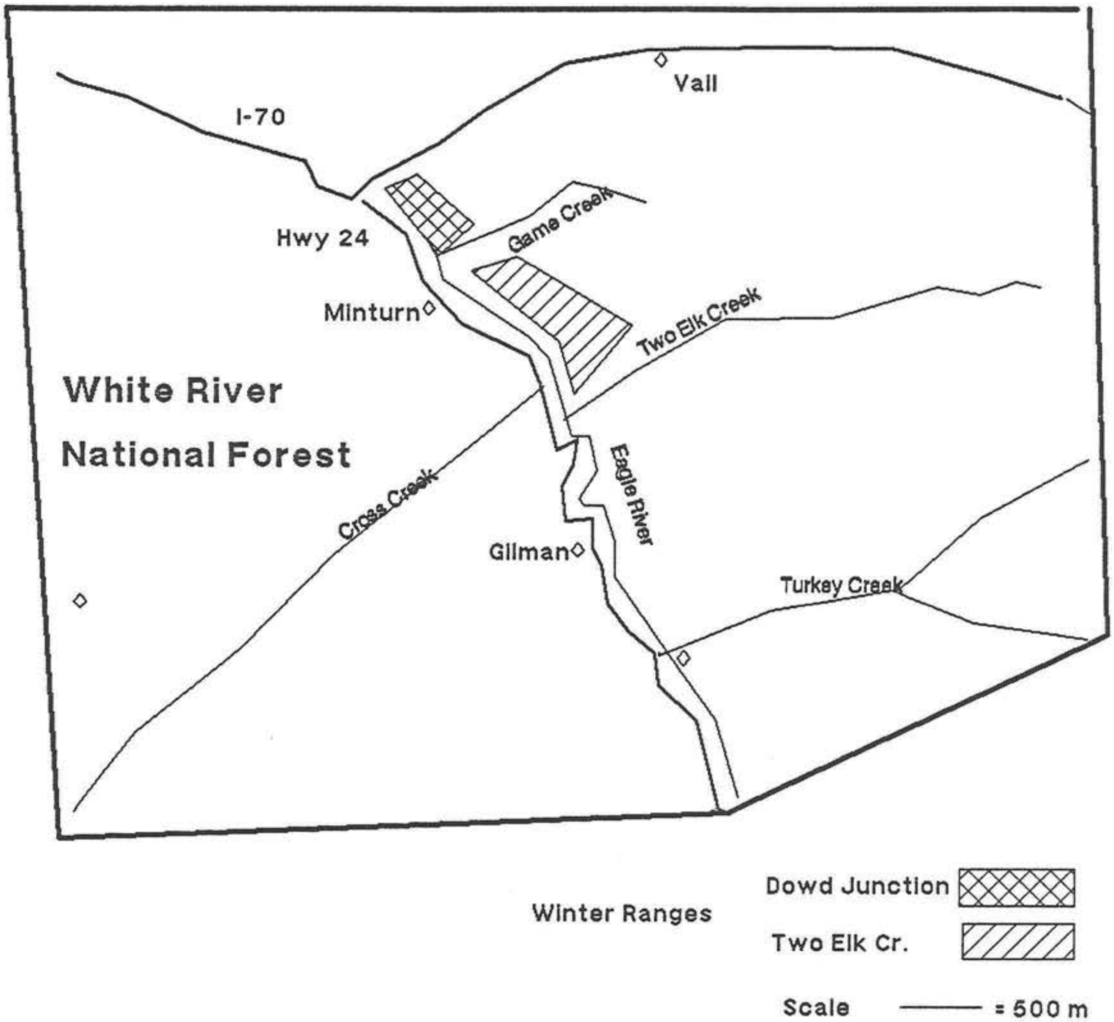

Fig. 4.1. Map of Dowd Junction elk winter range in Eagle County, Colorado.

The objective of this portion of our study was to provide an estimate of the carrying capacity of the Dowd Junction winter range. These estimates were made during 1987 and 1988 and were based on range forage supply and daily energy requirements of elk. Results of this study can provide wildlife biologists with carrying capacity estimates that are useful in making objective management decisions concerning the local elk population.

Methods

Habitat Technique

Boundaries for the Dowd Junction winter range were identified on a topographic map based on 2 years of radio telemetry data for elk use and historical information from the Colorado Division of Wildlife (Andree pers. comm.). Forage biomass was estimated at the end of the growing season (Sept 1-7) 1987 and (Aug 15-22) 1988.

The range was divided into 216 equal units, each 0.59 hectares (1.47 acres), using a Modified Acreage Grid (Bryan 1942), and were successively numbered. In 1987, a random numbers table was used to select 21 units across the winter range. Within each unit, 5 plots, each 2.9 m^2, were sampled for grasses, forbs and shrubs. One plot was estimated ocularly and clipped, and an additional 4 plots were ocularly estimated 15 meters from the clipped plot in each direction (north, south, east, west). Current annual growth was clipped at ground level for grasses and forbs, and annual growth for shrubs was collected from ground level to 2.0 m high. Clipped samples were placed in paper sacks and weighed with Homs hand-held scales ranging between 0-100 g, 0-500 g, and 0-1000 g depending on sensitivity required. Each ocular estimate was calibrated to the clipped weight.

In 1988, 175 units were randomly selected across the study area. Within each selected unit. 1 plot was sampled. Every fifth plot was estimated ocularly and clipped, and 4 additional plots were estimated ocularly. Ocular plots were calibrated to the clipped plots. All clipped samples were air dried at approximately 21^0 C for two weeks and reweighed. Each ocular estimate was calibrated to the new dry weight and recorded.

Comparisons between years and sampling methods were estimated using the double sampling technique described in Cochran (1960). Variances and confidence limits were calculated to determine similarities or differences between the two years. Variances were calculated using the formula for estimating variances in double sampling for regression.

$$V_{(Y_R)} = \frac{S_y^2}{n'} + \frac{1}{n} - \frac{1}{n'} \quad \frac{x'}{x}^2 \quad (S_y^2 - 2\ R\ S_{xy} + R^2\ S_x^2)$$

Confidence intervals were calculated using the following formula and are estimated for forage biomass only.

$$Y_R \pm 1.96 \ \ \text{Var}_{(Y_R)} \ + \%\ \text{of}\ Y_R$$

For convenience in calculation, variation among individual animals and forage intake levels were assumed constant. A t-test was calculated to statistically compare the two years of habitat data.

Methods of Habitat Analysis

Carrying capacity for the Dowd Junction winter range was calculated using two methods. First, carrying capacity was calculated using a modified version of the formula reported by Hobbs (1979):

$$\text{Carrying Capacity} = \frac{\text{Total forage Biomass} \quad (\text{kg})}{\text{Elk Forage Intake} \quad \text{kg}\cdot\text{day}^{-1}} = \text{elk}\cdot\text{day}\,.$$

Total forage biomass was calculated as total biomass available on the winter range based on habitat data collected in 1987-88. Total biomass was calculated using combinations of 25, 50, 75, and 100 percent of grass, and 50, 75, and 100 percent of shrubs available (Table 4.1). Forbs were excluded from analysis because they contributed less than 2% of total biomass. Contributions of each class (grass and shrubs) were calculated using percentages derived from field observations of forage availability which is restricted by snow cover and topography. As snow depth increases percent forage available decreases on this winter range.

Elk forage intake levels were estimated from the literature (Table 4.2) as 5.0 kg/day. Energy requirements for maintenance were based on elk body weight derived from the literature (Dean et al. 1976, Hobbs et al. 1982, and Nelson and Leege 1982) and carrying capacity estimates are reported in units of 200 kg animals. Winter was calculated as 135 days from 25 November to 10 April based on movement data obtained from monitoring telemetered animals in our study.

Table 4.1. Percent forage and elk days available because of snow and topography on the Dowd Junction winter range 1987-88.

Year	(%) Biomass Available			[a]Elk·Days	[b]Elk
	Forbs	Grass	Shrubs		
1987	100	100	100	29,155	216
	0	100	100	25,509	189
	0	75	100	22,270	165
	0	50	75	15,894	118
	0	25	50	9,516	70
	0	50	50	12,755	95
1988	100	100	100	32,684	242
	0	100	100	28,028	208
	0	75	100	24,620	182
	0	50	75	17,613	130
	0	25	50	10,606	79
	0	50	50	14,014	104

[a] Elk days calculated as 200kg elk using 5kg/day.
[b] Winter based on 135 days on the winter range.

Table 4.2. Forage requirements of elk collected from the literature.

Forage requirements	200kg elk	References
22 g/kg body wt.	4.38 kg/day	Baker and Hansen 1985
20 g/kg body wt.	4 kg/day	Geis 1954
25 g/kg body wt.	5 kg/day	Helwig 1957
25 g/kg body wt.	5 kg/day	Hobbs et al. 1982
23 g/kg body wt.	4.6 kg/day	Nelson and Leege 1982

Carrying capacity was also calculated according to a modification of the formula of Mautz (1978):

$$k = \frac{\sum_{i=1}^{n} (Bi \times Fi)}{(Rq \times Days) - En}$$

where k = number of elk the range can support for the winter period,

n = number of principal forages,

Bi = consumable biomass of principal forage species i,

Fi = nutrient content of principal forage species i,

Rq = individual elk requirements; metabolic requirements for daily maintenance,

Days = number of days elk occupy the winter range, and

En = endogenous reserves of nutrient.

Estimates of forage quality and animal requirements were gathered from the literature (Geis 1954, Helwig 1957, Hobbs et al 1982, Nelson and Leege 1982, Milchunus 1977, and Baker and Hansen 1985). We assumed that requirements were constant between years. This assumption is reasonable for forage quality because variability in these estimates was small (Hobbs et al. 1981). Principal forage was identified as species contributing 2% or more of the total forage biomass. Metabolizable energy (ME) and nitrogen content of forage species were estimated using the same methods as Hobbs et al. (1982). Range supply of ME and nitrogen were calculated as the sum of products of forage biomass values multiplied by their content value. Content values of ME and nitrogen for each species were gathered from the literature. Estimations of carrying capacity were calculated as range supply divided by daily energy requirements 9,185 kcal (Table 4.3) and nitrogen requirements of 0.036 kg/day.

Table 4.3. Calculations of daily energy requirements for 200 kg elk (from Hobbs et al. 1982).

Activity	Time spent in activity (hours/day)	Energy cost (kcal/kg/hour)	Daily cost (kcal)
Feeding[a]	11.38	2.37	5,394
Bedding	9.77	1.03	2,013
Traveling[b]	2.85	3.12	1,778
Total			9,185

[a] Assuming 2 km/hour walk.
[b] Assuming 4 km/hour walk.

Results

No significant difference (P = 0.8) between ocular estimates and clipped plots was detected. Ratios of ocular to clipped plots were 1.01 in year 1 and 0.97 in year two (Figures 4.2 and 4.3). Because these ratios were close to 1, we did not adjust my ocular estimate values.

On the Dowd Junction winter range we identified 21 plant species consisting of 9 forbs, 5 grasses, and 7 shrubs listed in Appendix 2. Principal forage species included 4 grasses and 5 shrubs. One grass and 2 shrub species were removed from analysis because they contributed less than 2% of total forage biomass.

Principal forages contributed 1.46×10^5 kg of biomass in the winter of 1987-88 and 1.63×10^5 kg the following year (Table 4.4). Grasses and shrubs contributed approximately 87% of total range supply

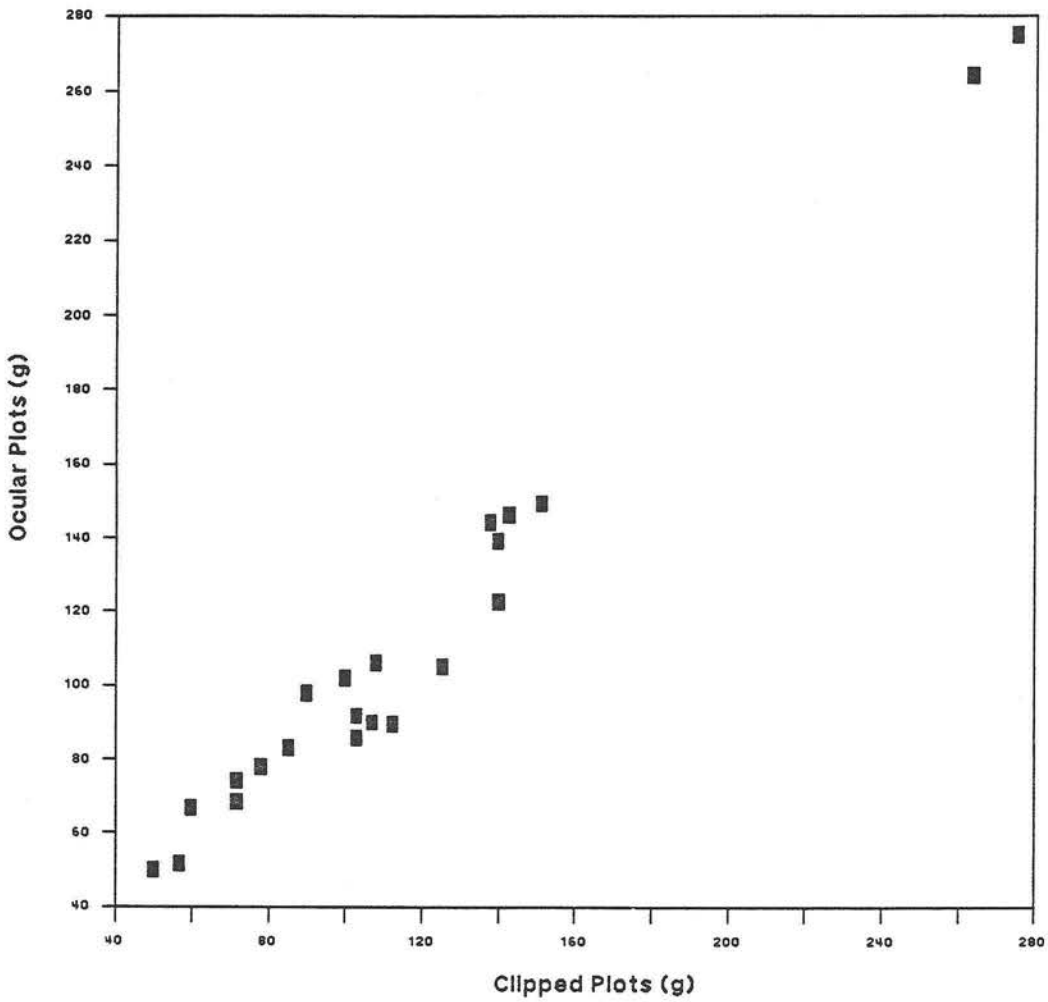

Fig. 4.2. Ratio (1.01) of clipped and ocular estimated plots from the Dowd Junction winter range in Colorado during 1987.

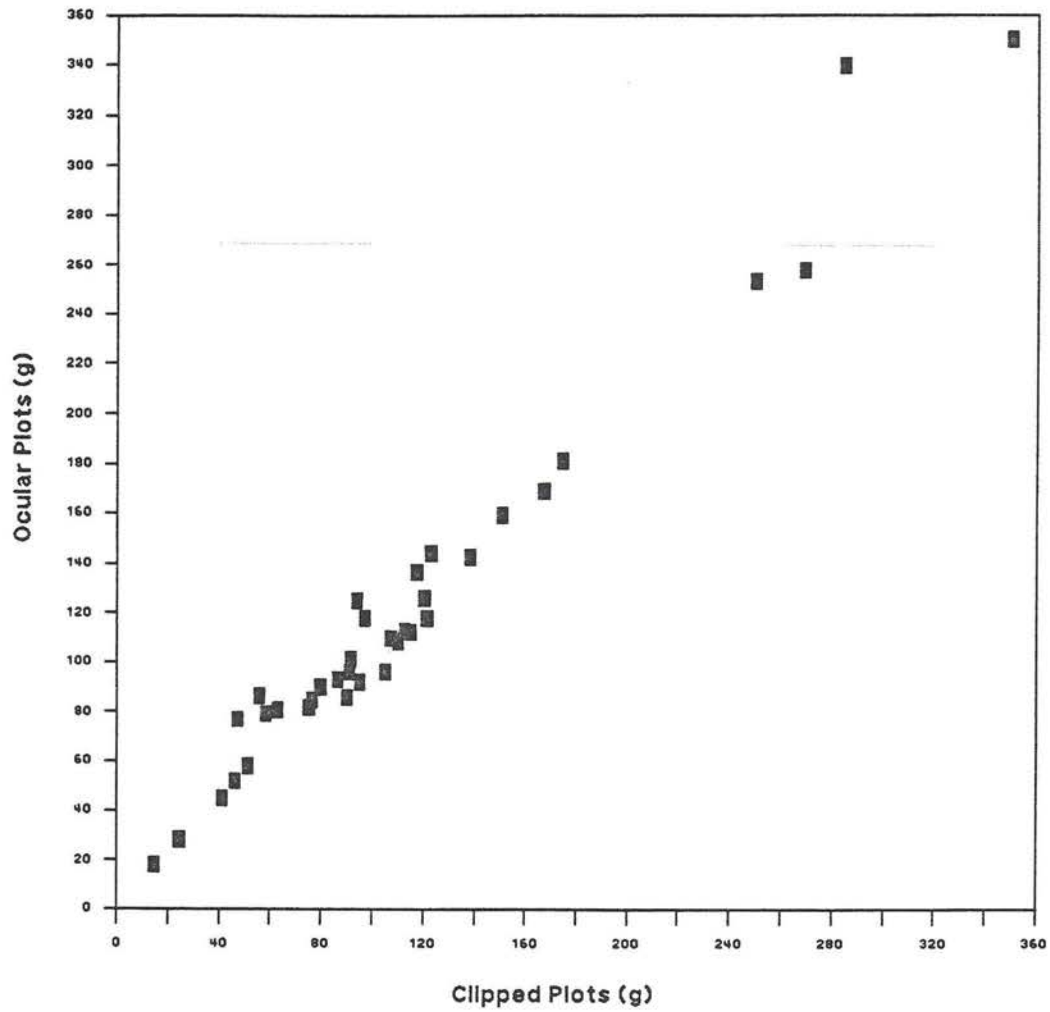

Fig. 4.3. Ratio (0.97) of clipped to ocular estimated plots for the Dowd Junction winter range in Colorado during 1988.

Table 4.4. Total forage weight on the Dowd Junction winter range from 1987-88.

Forage Type	Year	Total (kg) on Winter Range	Percent of Total Forage
Forbs	1987	18,230	12.5
	1988	23,282	14.2
Grass	1987	64,767	44.4
	1988	68,159	41.7
Shrubs	1987	62,778	43.1
	1988	71,979	44.1
Total	1987	145,775	100.0
	1988	163,420	100.0

and made up approximately 98% of elk forage. Range supply consisted of 44.4% and 41.7% grass and 43.1% and 44.1% shrubs in 1987 and 1988, respectively (Table 4.4).

Principal forage species contributed 1.8×10^8 kcal of ME and 933 kg nitrogen to total range supply in the winter of 1987-88, and 2.0×10^8 kcal ME and 1.0×10^3 kg nitrogen the following year (Table 4.5). Shrubs contributed 45% and 48% of total metabolizable energy, and 61% and 64% total nitrogen to elk forage during the two years. Carrying capacity calculated from forage energy supply was 152 ± 17 in year 1 and 168 ± 18 elk during year 2 (Table 4.6). Carrying capacity estimates, based on nitrogen supply with 90% CI, were 190 ± 21 during year 1 and 212 ± 23 in year 2 (Table 4.6).Carrying capacity calculated from total range forage biomass was 189 ± 20 (90% CI) during year 1 and 208 ± 22 elk (10% more) in year 2 (Table 4.6). At 50% utilization of total forage biomass, carrying capacity was 95 ± 10 and 104 ± 11 elk in 1987 and 1988 respectively. Additional carrying capacity calculations based

Table 4.5. Contribution of principle elk forage to winter-range metabolizable energy and nitrogen supply in the upper Eagle River Valley, Colorado, during 1987-88.

			Forage concentration		Range supply	
Forage[a]	Year[b]	Biomass[c] (kgx10^3)	ME[d] (kcal/g)	Nitrogen[e] (g/kg)	ME (kcalx10^6)	Nitrogen (kg)
Grasses						
Agropyron smithii	1987	4.0	1.7	5.5	6.8	22.0
	1988	9.5	1.7	5.5	16.2	52.3
Bromus tectorum	1987	10.0	1.6	6.0	16.0	60.0
	1988	4.5	1.6	6.0	7.2	27.0
Carex spp.	1987	1.5	1.6	6.2	2.4	9.3
	1988	1.5	1.6	6.2	2.4	9.3
Poa spp.	1987	42.0	1.8	6.6	75.6	275.1
	1988	44.0	1.8	6.6	79.2	288.2
Shrubs						
Amelanchier alnifolia	1987	17.0	1.4	8.5	23.8	144.5
	1988	14.0	1.4	8.5	19.6	119.0
Artemisia tridentata	1987	10.0	1.8	13.0	18.0	129.6
	1988	9.0	1.8	13.0	16.2	116.6
Prunus virginiana	1987	18.5	1.4	10.9	25.9	201.7
	1988	27.5	1.4	10.9	38.5	299.8
Purshia tridentata	1987	4.0	1.5	12.0	6.0	48.0
	1988	2.0	1.5	12.0	3.0	24.0
Symphoricarpos oreophilus	1987	6.0	1.3	7.2	7.8	43.2
	1988	14.5	1.3	7.2	18.9	104.4
Total supply	1987				182.3	933.4
	1988				201.2	1040.5

[a] Species contributing 2% or more to winter range.
[b] 1987 = winter 1987-88; 1988 = winter 1988-89.
[c] Total biomass on winter range.
[d] ME = gross energy x in vitro dry-matter digestibility (IVDMD) x 0.85.
[e] Nitrogen = crude protein/6.25 x 10.
ME and nitrogen values were gathered from the literature.

Table 4.6. Comparison of two methods for estimating the Dowd Junction winter range carrying-capacity in 1987-88.[1]

Method	Year	Estimated Elk (200kg)		90% CI
Total biomass available (Grasses + Shrubs)	1987	189	±	20
	1988	208	±	22
Energy base (ME)	1987	152	±	17
	1988	168	±	18
Nitrogen base	1987	190	±	21
	1988	212	±	23

[1] These estimates can vary depending upon constants such as forage intake rates used in calculations.

on variations in range forage availability due to snow cover are presented in Table 4.1.

Estimations of winter range carrying capacity using total forage biomass and total nitrogen were within 1% of each other during both years. ME estimates were 20% lower than total forage biomass and total nitrogen. Using literature values for concentration of nitrogen (g/kg), shrubs were approximately 40% higher compared to grasses while ME concentrations were 12% higher for grasses compared to shrubs (Table 4.5). Since grasses and shrubs contribute like amounts to total biomass, and using concentration values from the literature nitrogen estimates were larger than ME. Consequently, shrubs contain concentrations of nitrogen adequate for maintenance, but are often deficient in ME, and grasses offer adequate ME, but contain insufficient levels of nitrogen (Hobbs et al. 1982).

Confidence intervals indicate these estimates are repeatable, but do not identify sources of variation because confidence intervals were calculated for total forage biomass only. Annual variations between carrying capacity estimates were similar for all three methods, total forage biomass, metabolizable energy, and nitrogen. Carrying capacity estimates for year 1 were 10% lower than year 2 using all three methods (Table 4.6). We also emphasize that carrying capacity estimates can be changed considerably by altering parameters such as daily forage intake rates. Thus estimates and associated confidence intervals are suggestive rather than accurate measurements.

Discussion

Total forage biomass varied slightly between years on the Dowd Junction winter range, with an increase of 10% from year 1 to year 2. The source of increase is uncertain, but we speculate that forage production on this range has increased slightly over the past three years because of favorable weather conditions and reduced use by elk. Growing seasons have been long with average precipitation (National Oceanic and Atmospheric Administration 1986 and 1987). Winters have been normal with the majority of snow accumulating from December through mid-March. Warm weather in late March and early April facilitated snow melt and allowed elk to move to areas higher in elevation. Spring migration reduces total winter range utilization and thus may have prevented heavy forage use. Also, warm weather early in the year provided optimal growing conditions.

Forage variability between years does not appear to be caused by difference in sample sizes. Results of the t-test indicate no noticeable difference between sample sizes. Percent composition of each forage class, forbs, grasses, and shrubs, remained relatively constant, varying only 3% among years for any one class, indicating equal increases in total production in year 2. Thus, variation was not influenced by changes in sample sizes.

Concentration values of ME and nitrogen for each plant species were not measured in this study, instead they were collected from the literature. These literature values were calculated with total forage production values measured to produce results presented herein.

Carrying capacity calculated using ME was approximately 20% lower than nitrogen and total biomass estimates. All three methods produced estimates that compare favorably to present CDOW population information. However, discrepancies among methods were expected because nitrogen concentration levels varied between classes while ME concentrations were relatively similar. Consequently, forage on the Dowd range contributed more nitrogen since shrubs are more available and provide the most forage for elk during periods of deep snow.

Although shrubs contribute more to an elk's diet, a mixture of grass and browse appears to be important for maintaining energy and protein. Hobbs et al. (1981) concluded that elk winter diets in a variety of upper montane habitats contained levels of digestible dry matter that were substantially submaintenance in protein. Grass is an important source of digestible dry matter and energy, and browse is generally a better source of protein.

Throughout winter, diet quality for elk declines, and loss of nutrients is attributed to leaching of cell solubles from plant tissue (Tukey 1970). Elk mitigate loss of forage quality through alterations of diet mix (Hobbs et al. 1979). Grasses and shrubs contribute the most to an elk's winter diet. These 2 forage classes are complimentary foods with grasses providing a more completely digestible source of energy and browse containing more protein (Hobbs et al. 1981). Differences allow elk to vary their dietary chemical composition by shifting the proportion of forage class they consume. This compensation allows elk to maintain diet quality at a relatively stable level despite variation among habitat quality. Carrying capacity estimates based strictly on forage supply at the beginning of winter may be somewhat inflated because forage biomass may be lost during winter by trampling, wind loss and shattering (Hobbs et al. 1982).

Based on total forage biomass and total range nitrogen supply, the Dowd Junction winter range can support approximately 200 elk, however, these estimates are based on 100% utilization of total grasses and shrubs available. Estimates based on 100% utilization are unrealistic, but were presented as indicators of total range production. It is impractical to manage a range for 100% utilization. In order to perpetuate forage production, wildlife populations need to be managed at minimal impact densities based on approximately 50% biomass utilization levels to avoid forage damage (Mautz 1978). Maintaining an elk population below maximum density minimizes impacts on vegetation.

Competition with other big game species or livestock does not occur on the Dowd Junction range. Because this range is west facing and receives considerable amounts of snow, deer are unable to winter here, and livestock grazing is prohibited.

Carrying capacity depends on environmental factors that vary in space and time. These factors, especially weather, constantly alter the supplies of habitat resources and the requirements of animals for those resources (Bailey 1984). Based on field observations, during a normal winter, small groups of elk move back and forth between the Dowd Junction and Two Elk Creek winter ranges. Thus, population densities fluctuate throughout winter. During heavy winters, such as the winter of 1983-84 when snow depths were above normal, small herds of elk were forced to join other groups and all were restricted to the Dowd Junction range resulting in densities above our carrying capacity estimates. If excessive snow accumulation occurs on consecutive years, causing elk to congregate and herd numbers to exceed carrying capacity for extended periods of time, over-utilization will damage habitat resources resulting in a reduction of range carrying capacity. Also, length of winter influences the ability of a range to support a population (Wallmo et al. 1977).

Variation in total forage production has important implications for management of elk populations. Plant biomass appears to be influenced by environmental factors which can fluctuate from year-to-year depending on changes in precipitation, snow cover or animal densities. All of these factors must be considered when managing elk.

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CHAPTER V

SUMMARY AND RECOMMENDATIONS

Movement Patterns and Seasonal Range Use

Forty telemetered elk in Gore-Eagle Valley were monitored from January 1985 through December 1988 to identify movement patterns and seasonally important ranges. At least 3 separate herds were identified by winter range segregation; Arrowhead, Dowd Junction-Two Elk Creek, and Homestake. During winters of our study average snowfall occurred and we found a few small groups of elk were able to winter on the hillside adjacent to Beaver Creek and above the town of Red Cliff. During winters with heavy snowfall however, elk were restricted to the 3 primary winter ranges (Andree pers. comm.). Based on our telemetry data, these 3 critical winter ranges appear to be the only available ranges available for elk use in severe winters. Perpetuation of this elk herd depends upon maintaining these winter ranges.

Calving areas were scattered across the study area and individual telemetered cow elk showed strong fidelity to specific calving areas. Areas where we monitored elk calving include, Copper Mountain, Stafford Creek, Fall Creek, Wearyman Creek, Whitney Lake, Spruce Saddle, McCoy Park, and the Back Bowls of Vail. Thirteen elk captured and telemetered at Dowd Junction used Tea Cup and China Bowls during calving season. These bowls are the site for future expansion of the Vail Ski Area. Impacts of this development will be measured in a future study conducted by Master's Candidate James R. Morrison and Dr. William Alldredge of CSU. Presently the Back Bowls are closed to human activities between 15 May and 30 June to minimize impacts to this calving area. Future mitigation in this area should be based on the findings of that research.

Three ranges, Grouse Mountain, Stafford Creek, and Isolation-Lost Lakes, were recognized as areas where large numbers of elk congregated during summer. The majority of elk in our study utilized these 3 ranges from approximately 1 June through 30 September in all years. Group sizes of 100 elk were common in these summer areas. McCoy Park, Battle Mountain, and Raggey-Ass Mountain were also identified as areas where smaller groups of approximately 50 elk spent summer. Elk summer use in McCoy Park was reduced from 375 elk observed during 18 relocations in 1987 as compared to 76 elk observed during 15 relocations in 1988. We speculate this reduction was influenced by the construction of Trappers Cabin and ski area construction at Arrowhead Ski Area. We recommend these summer solitude areas be considered as important elk habitats and special considerations should be made to preserve these areas during any future development.

Dispersal of Elk Calves

Telemetered calves in our study dispersed very little from their natal ranges in the first 18 month of life. The one exception was a calf that shifted home ranges during year 2. We speculate that this dispersal was influenced by the construction activities associated with the development of the Arrowhead ski area in 1988. These findings can provide baseline information from which future studies can address dispersal patterns exhibited by elk. For future studies we recommend increasing sample sizes, telemetering bull calves of cows with known movement patterns, and monitoring telemetered elk calves for 2 or more years if possible.

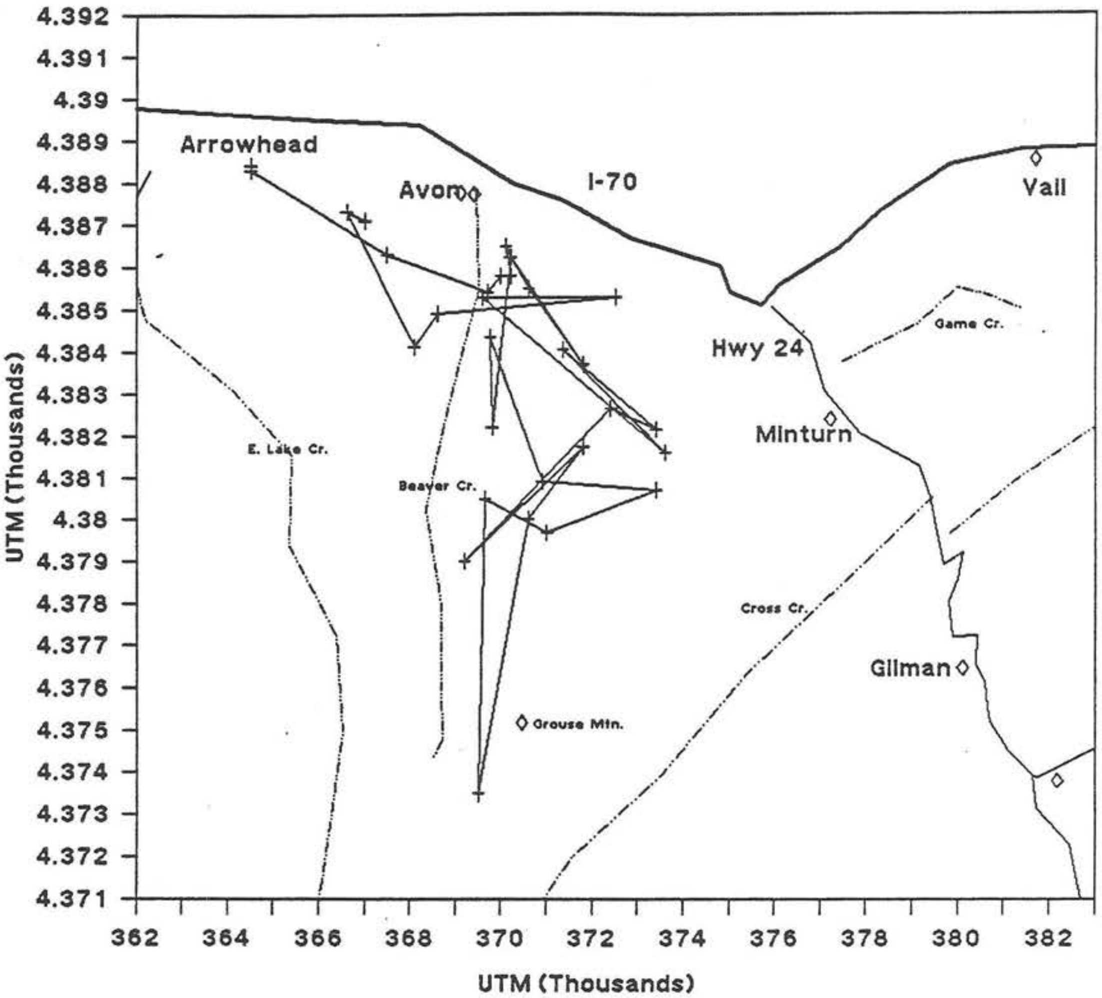
Carrying Capacity Estimates for the Dowd Junction Winter Range

The Dowd Junction range was identified as critical winter range by the CDOW. For this reason, carrying capacity estimates for the Dowd Junction winter range were calculated based on total forage production to provide wildlife personnel with information needed to better manage the local elk herd.

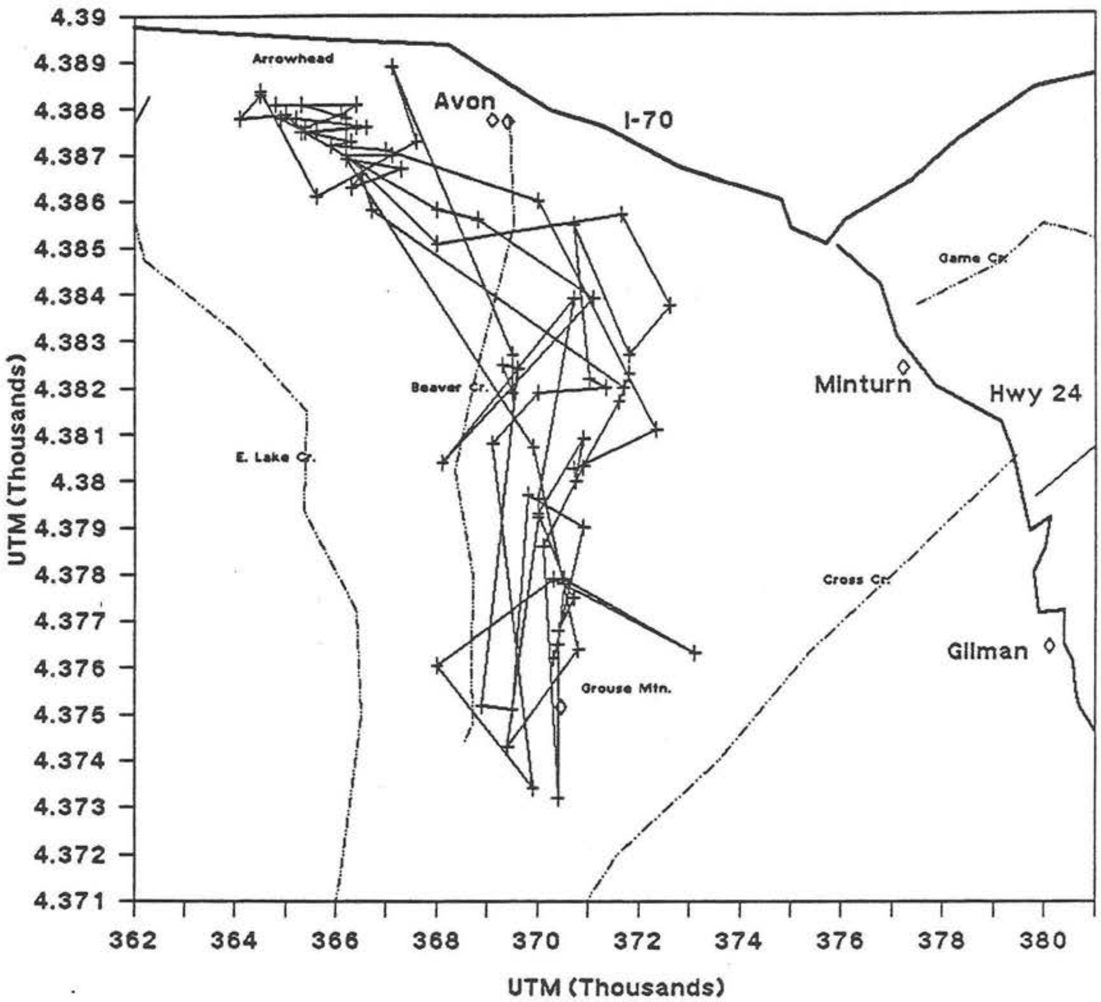
Estimates on the Dowd Junction winter range based on 50% utilization were approximately 100 elk and estimates increased by 10% between 1988 and 1987. This increase could have resulted from more favorable growing conditions in 1988 as compared to 1987, reduced elk use in the winter of 1987-88 allowing increase forage production or a combination of these 2 factors. Winter elk numbers should be maintained at levels similar to those presented in this study for 50 % utilization.

APPENDICES

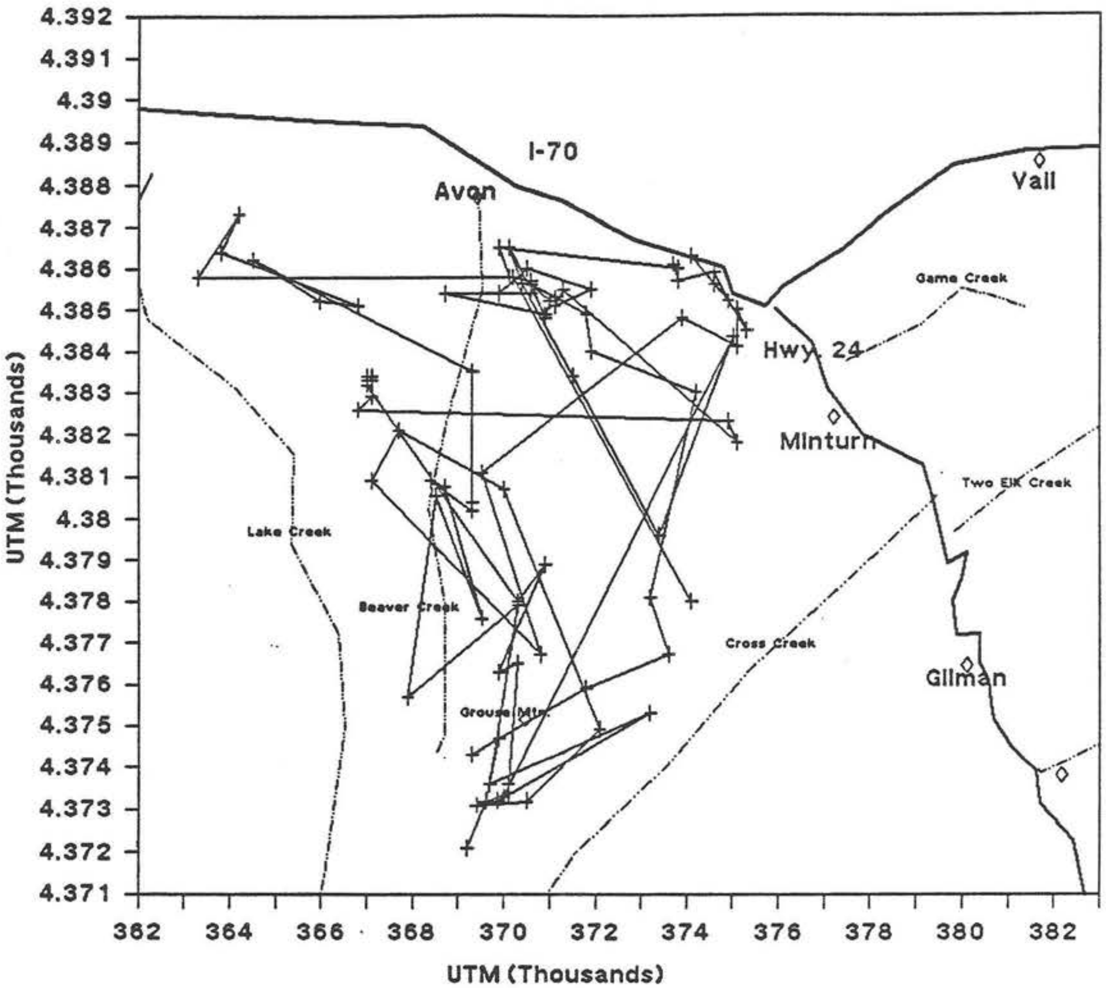
Appendix 1. Maps depicting movements for individual elk monitored from 1986 through 1988.



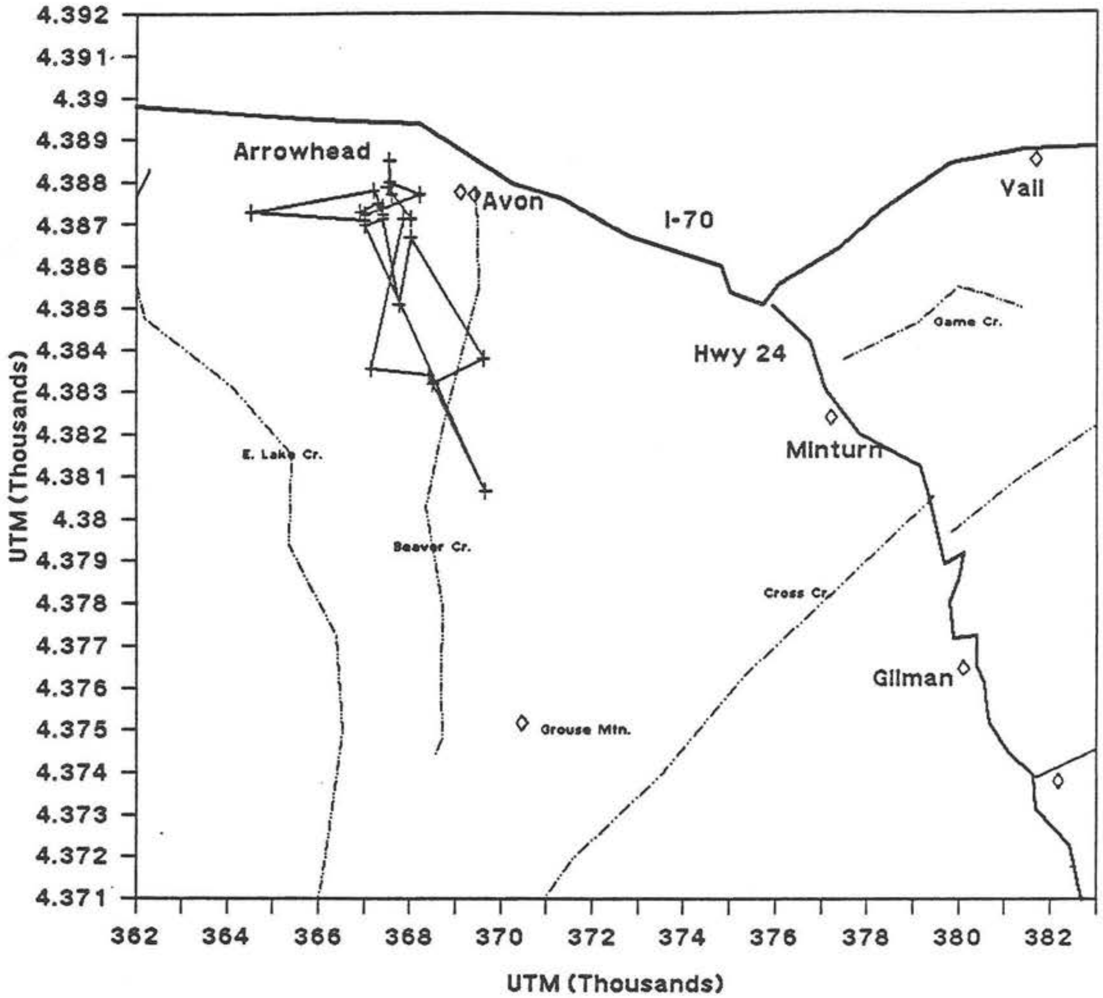
Appendix Fig. 1A. Movement patterns exhibited by cow A across the study area from February 1986 through March 1987.



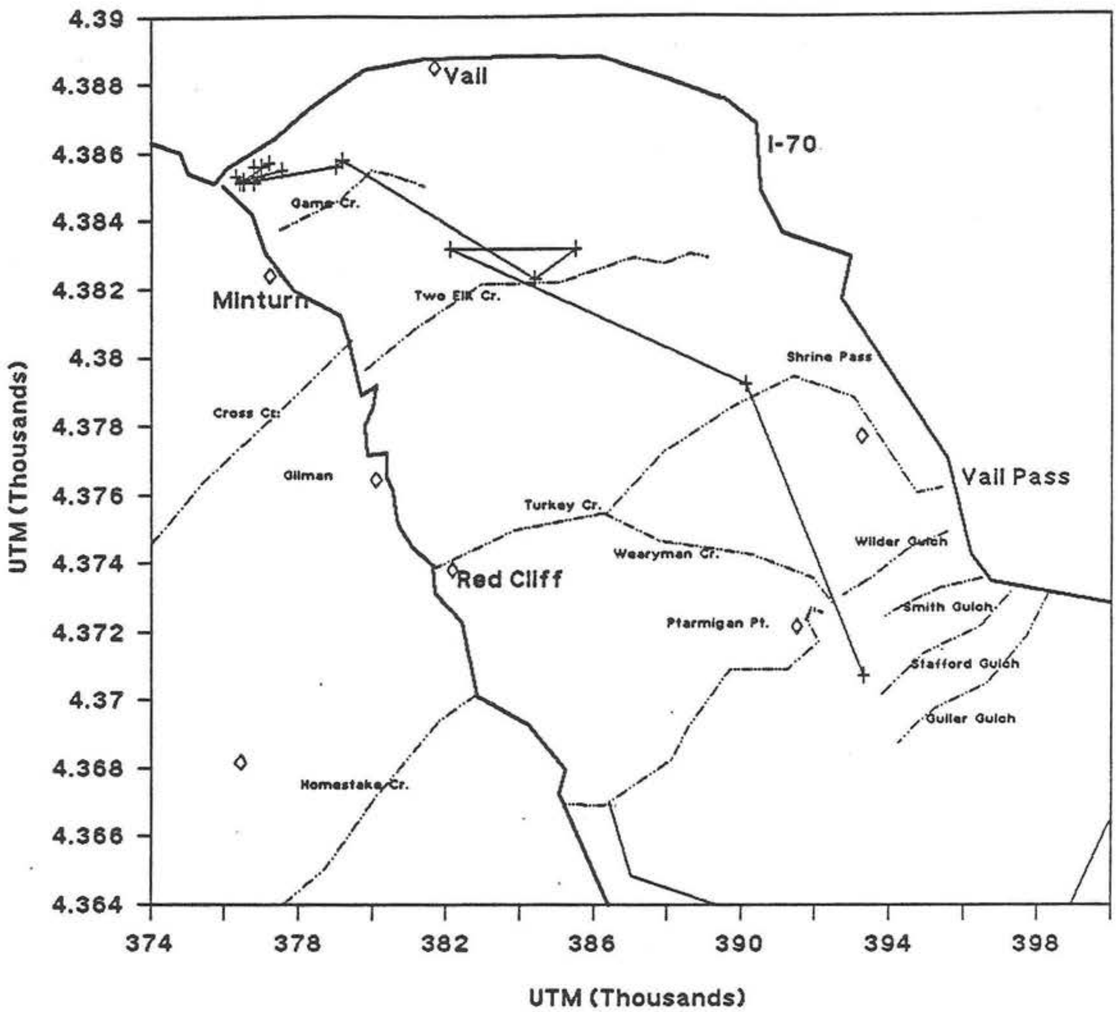
Appendix Fig. 1B. Movement patterns exhibited by cow B across the study area from January 1986 through December 1988.



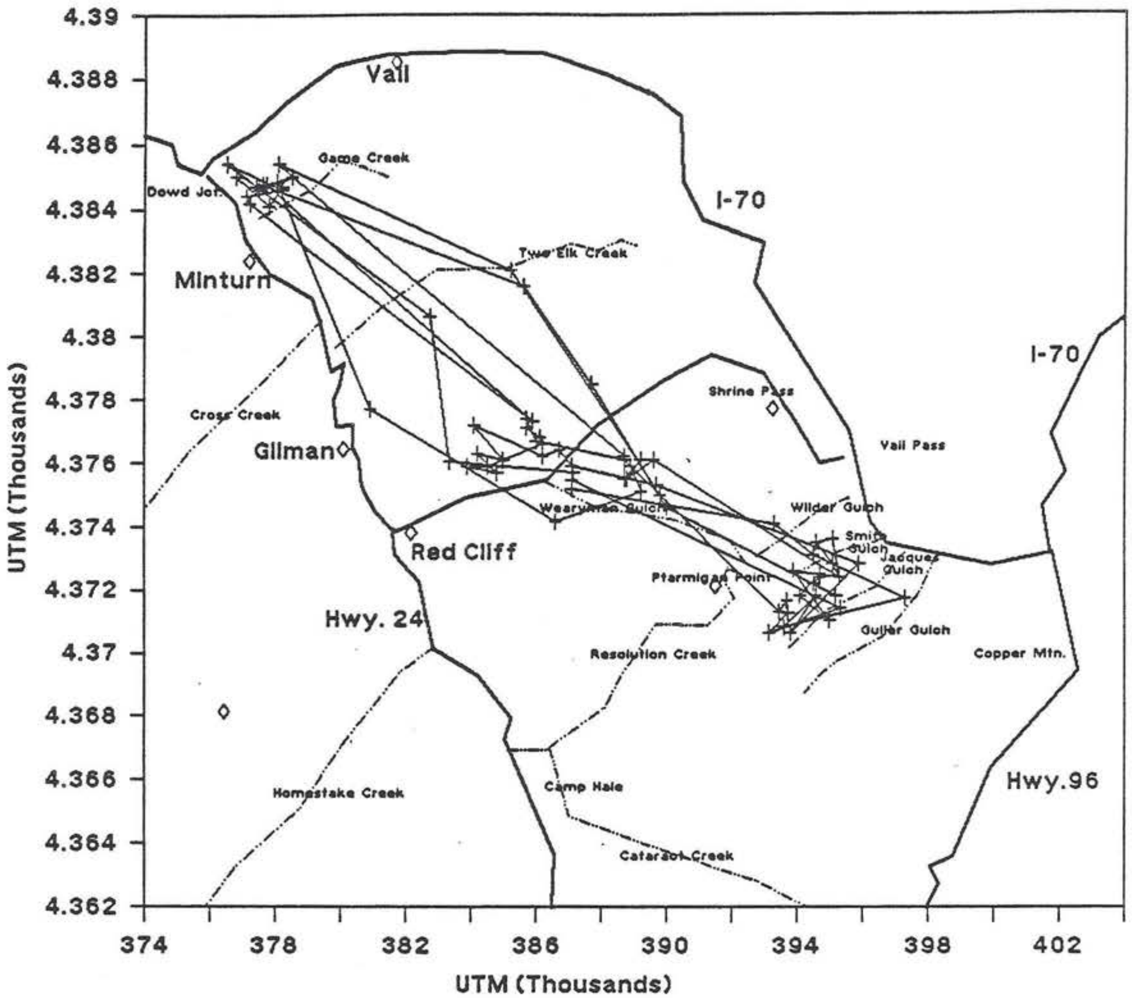
Appendix Fig. 1C. Movement patterns exhibited by cow C across the study area from January 1986 through December 1988.



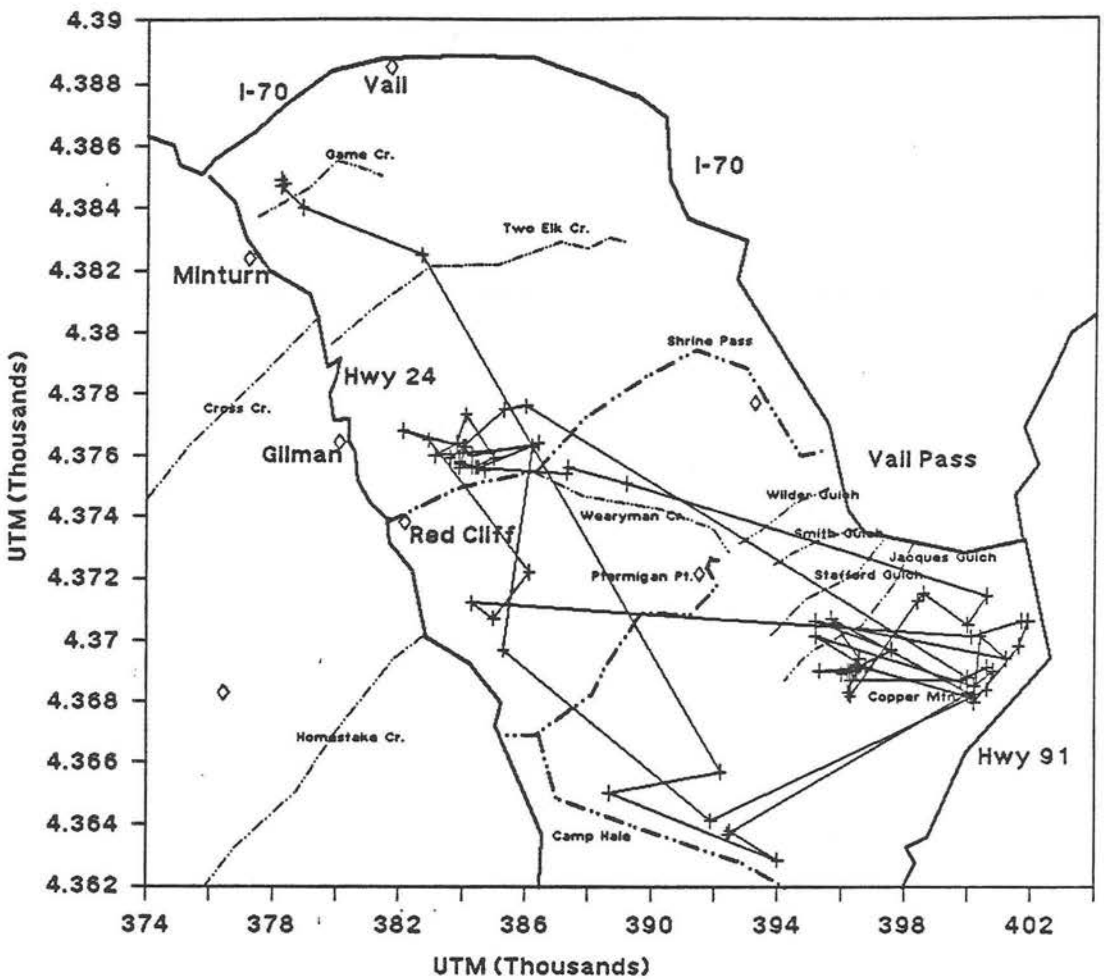
Appendix Fig. 1D. Movement patterns exhibited by cow D across the study area from February 1986 through October 1987.



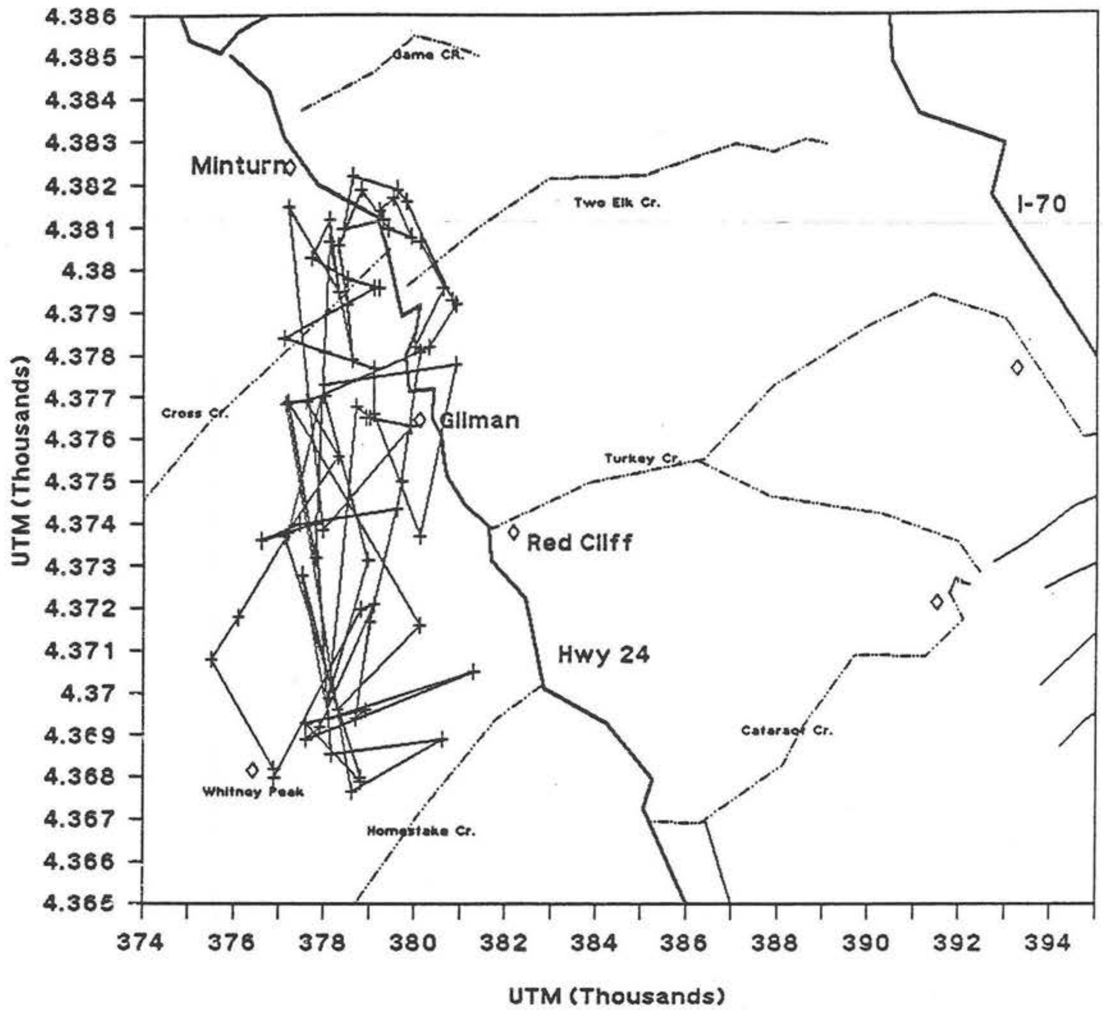
Appendix Fig. 1E. Movement patterns exhibited by cow E across the study area from January 1986 through November 1986.



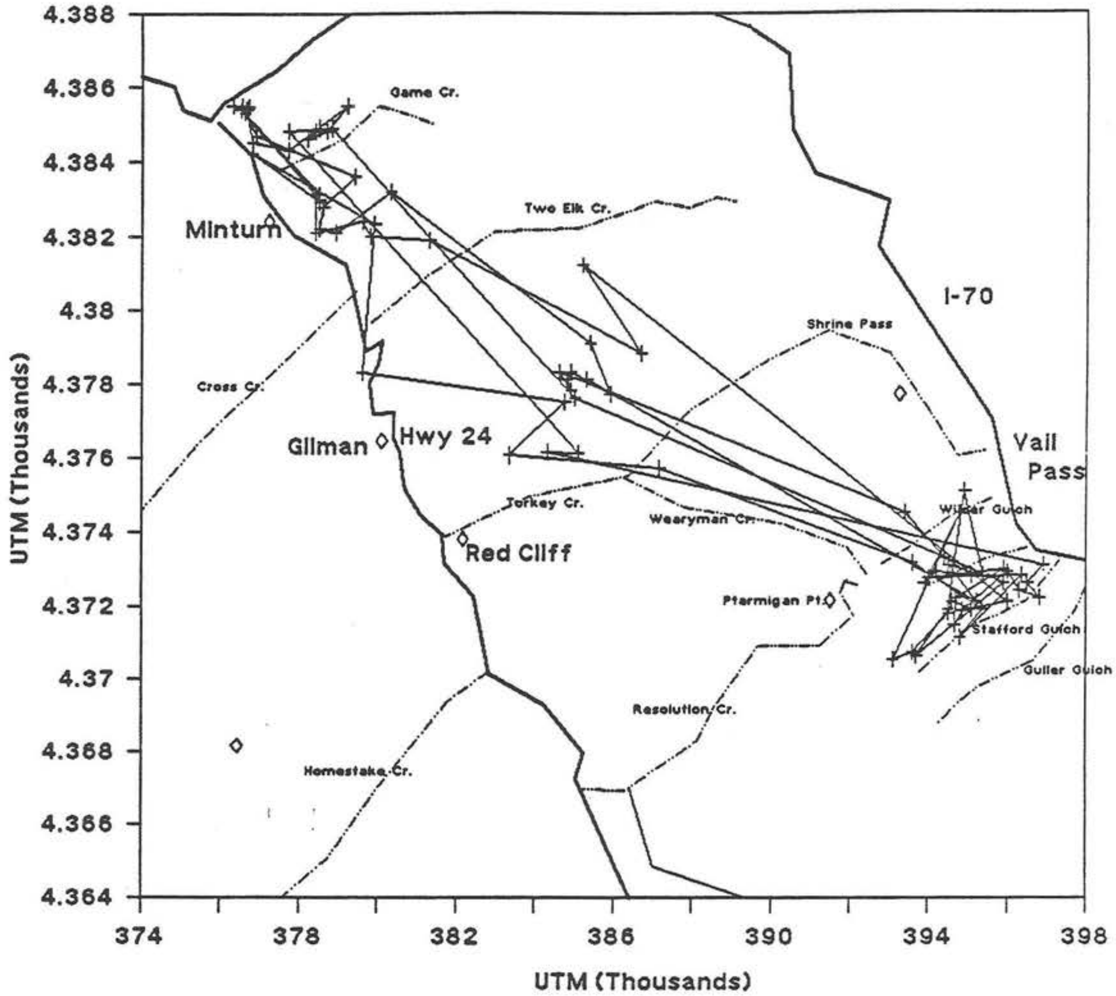
Appendix Fig. 1F. Movement patterns exhibited by cow F across the study area from January 1986 through December 1988.



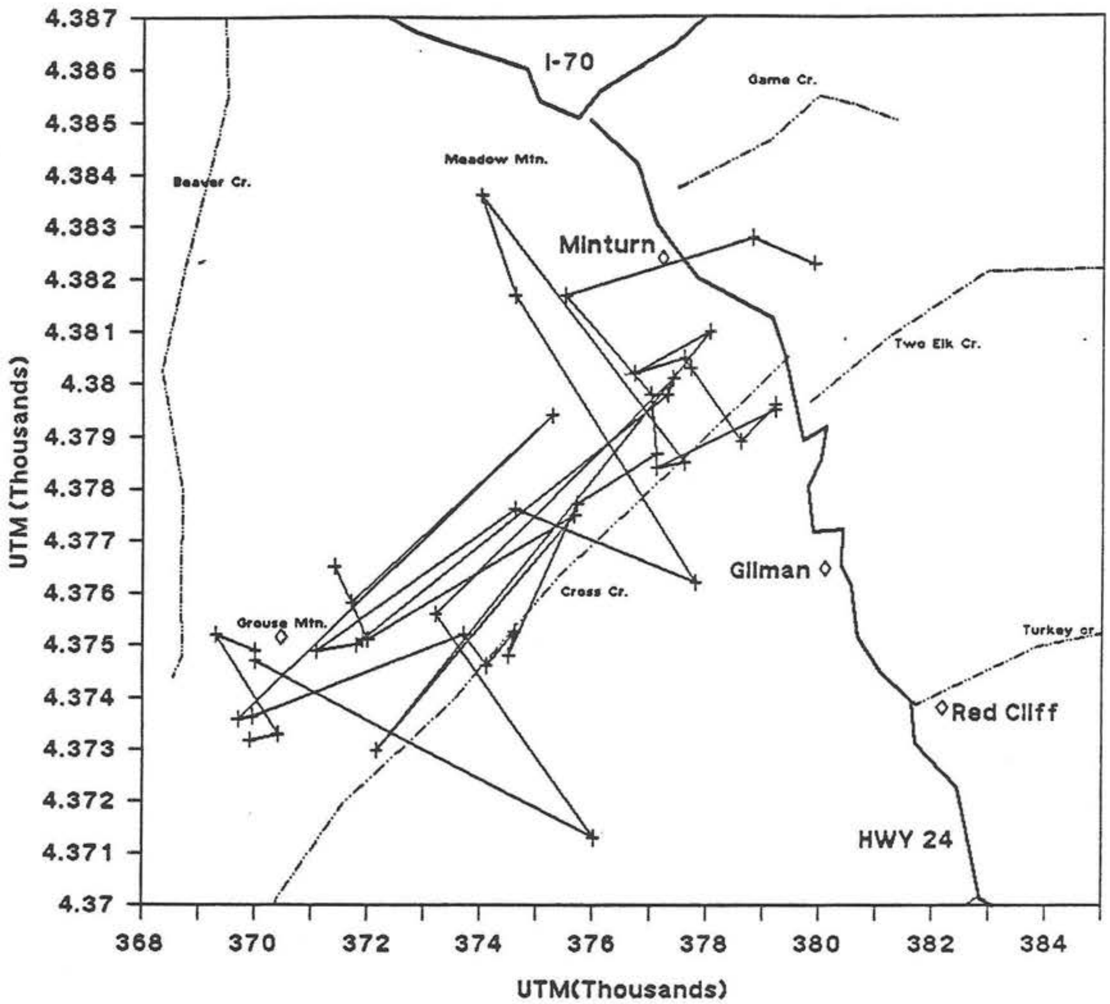
Appendix Fig. 1G. Movement patterns exhibited by cow G across the study area from January 1986 through December 1988.



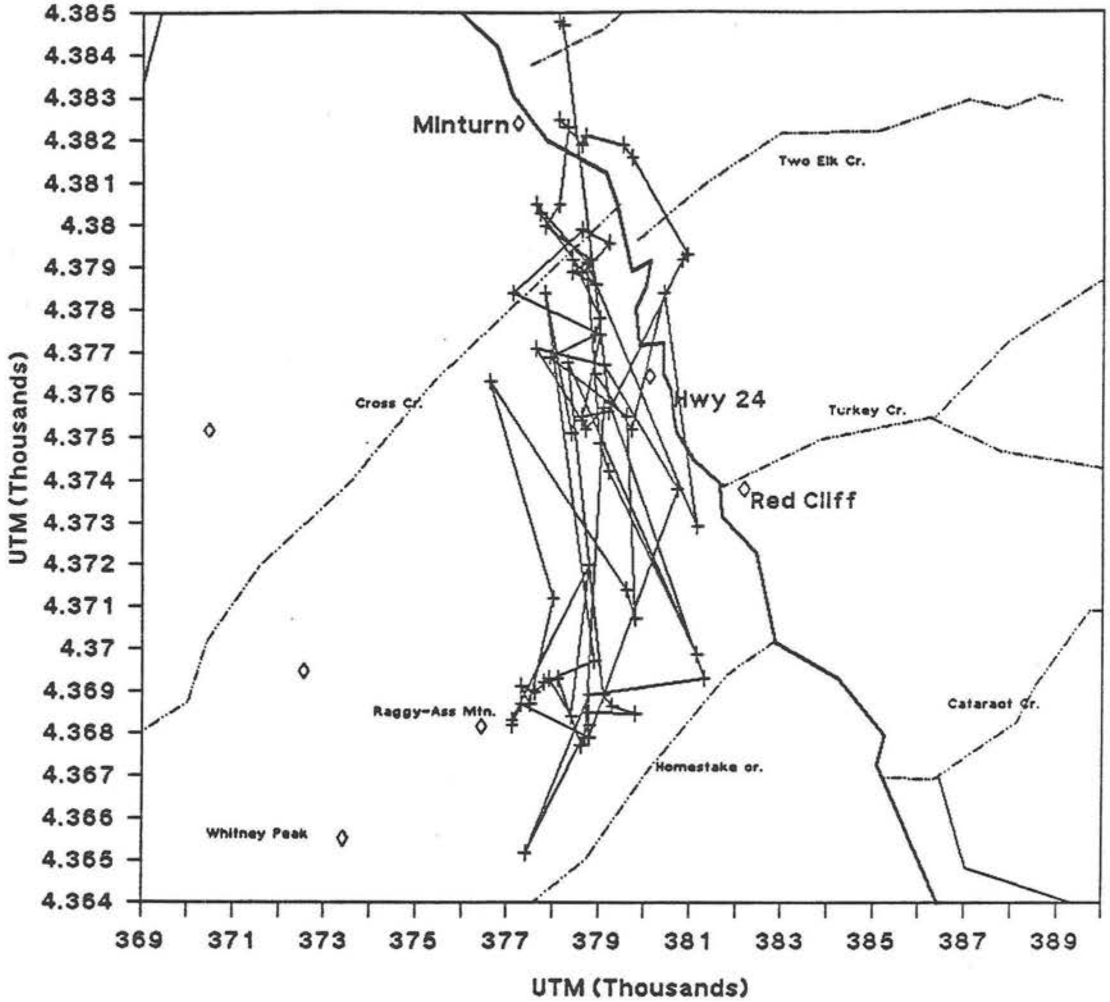
Appendix Fig. 1H. Movement patterns exhibited by cow H across the study area from February 1986 through December 1988.



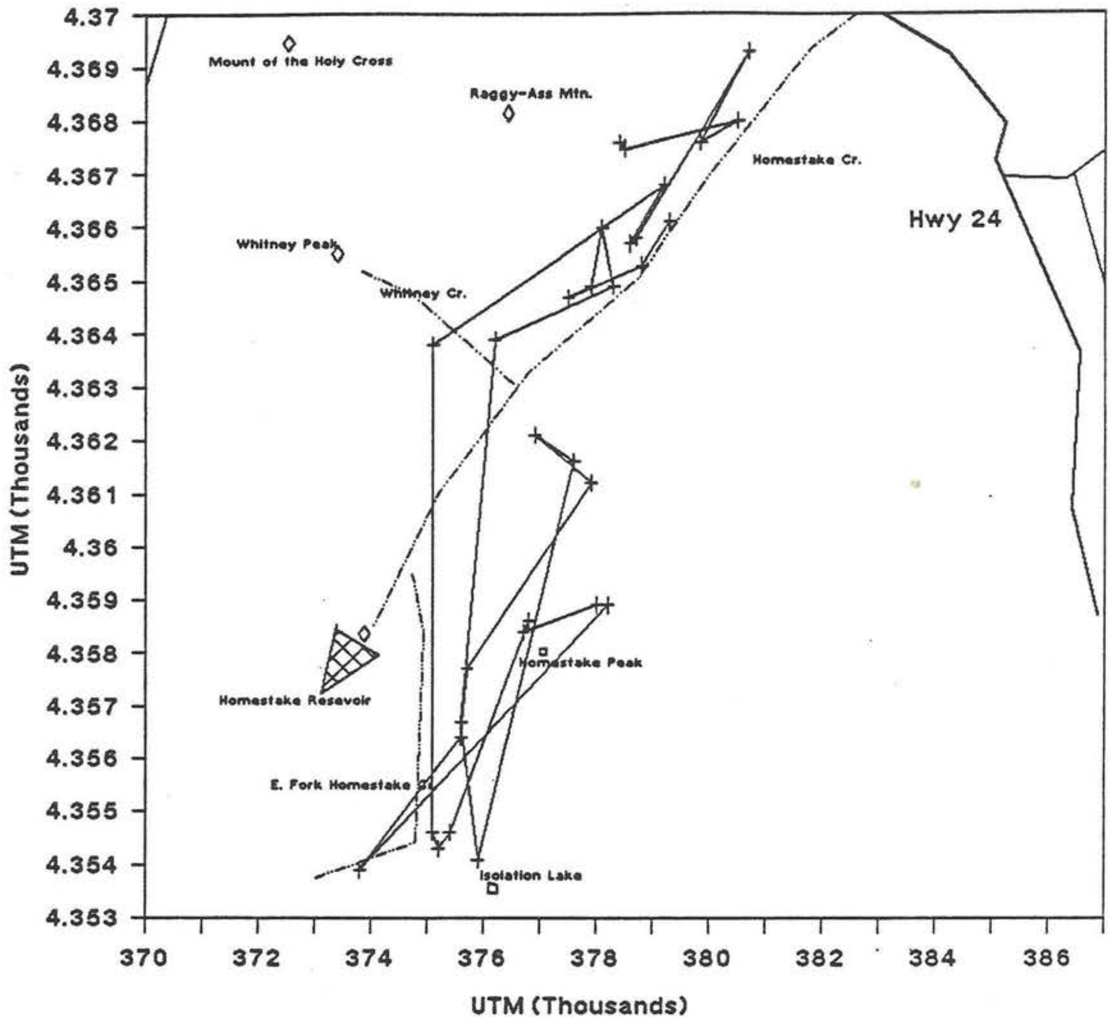
Appendix Fig. 1I. Movement patterns exhibited by cow I across the study area from February 1986 through December 1988.



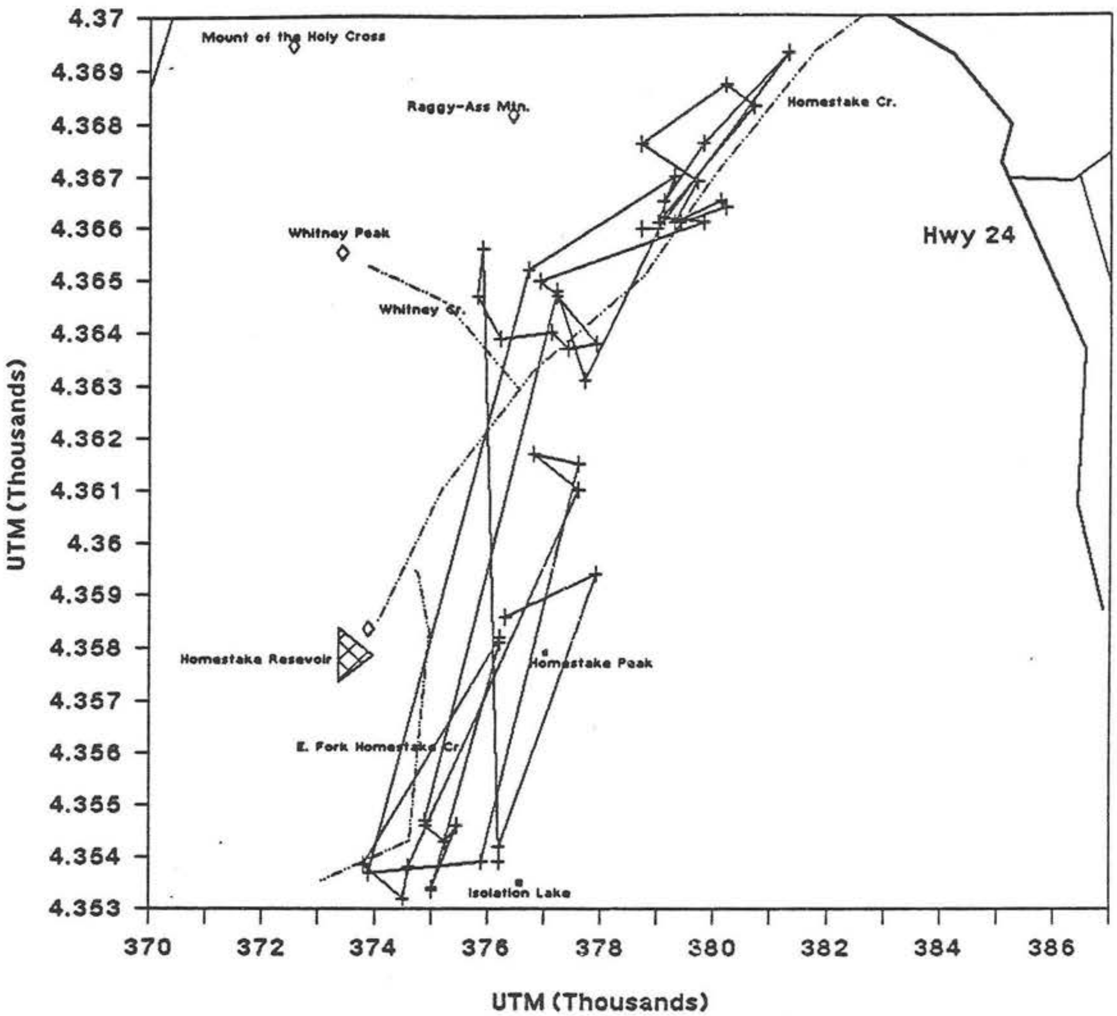
Appendix Fig. 1J. Movement patterns exhibited by cow J across the study area from February 1986 through December 1988.



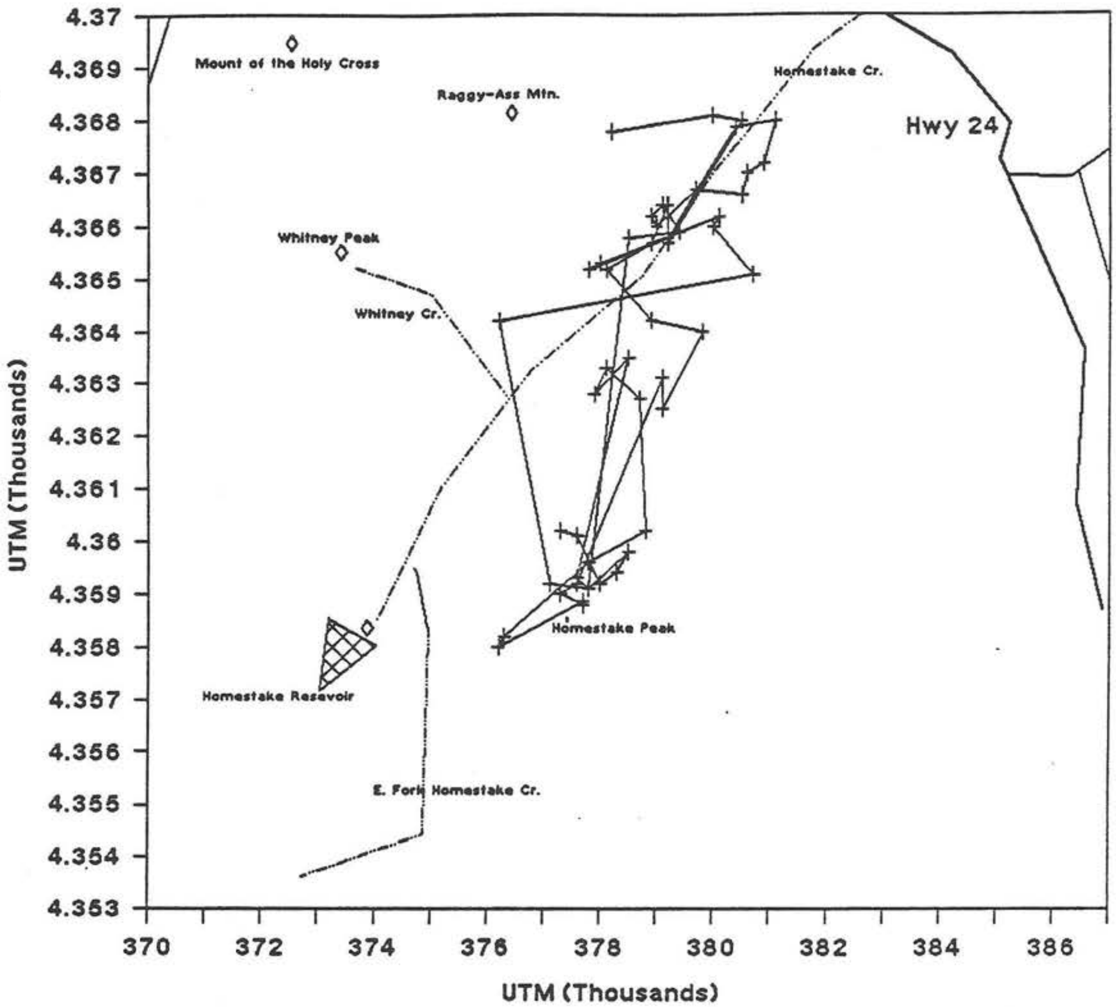
Appendix Fig. 1K. Movement patterns exhibited by cow K across the study area from February 1987 through December 1988.



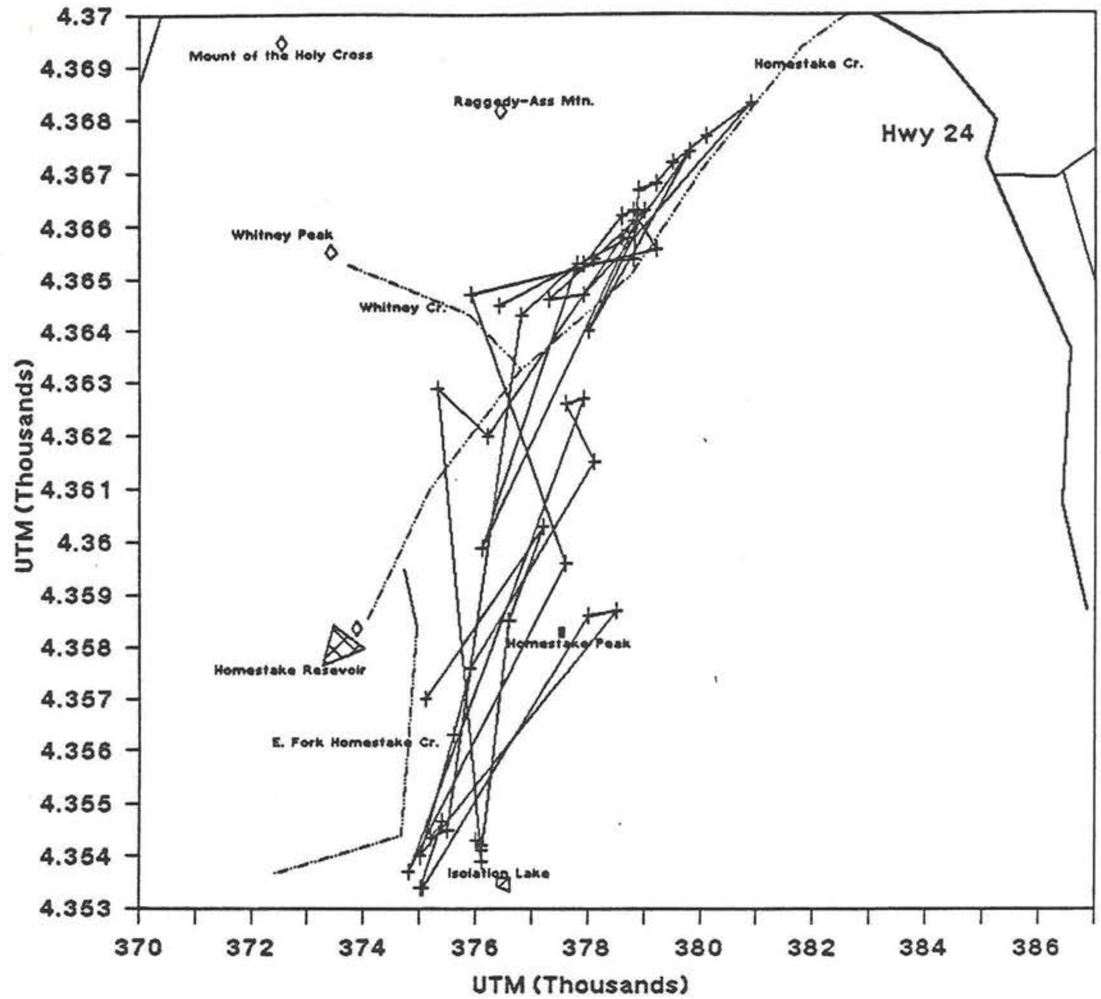
Appendix Fig. 1L. Movement patterns exhibited by cow L across the study area from December 1986 through February 1988.



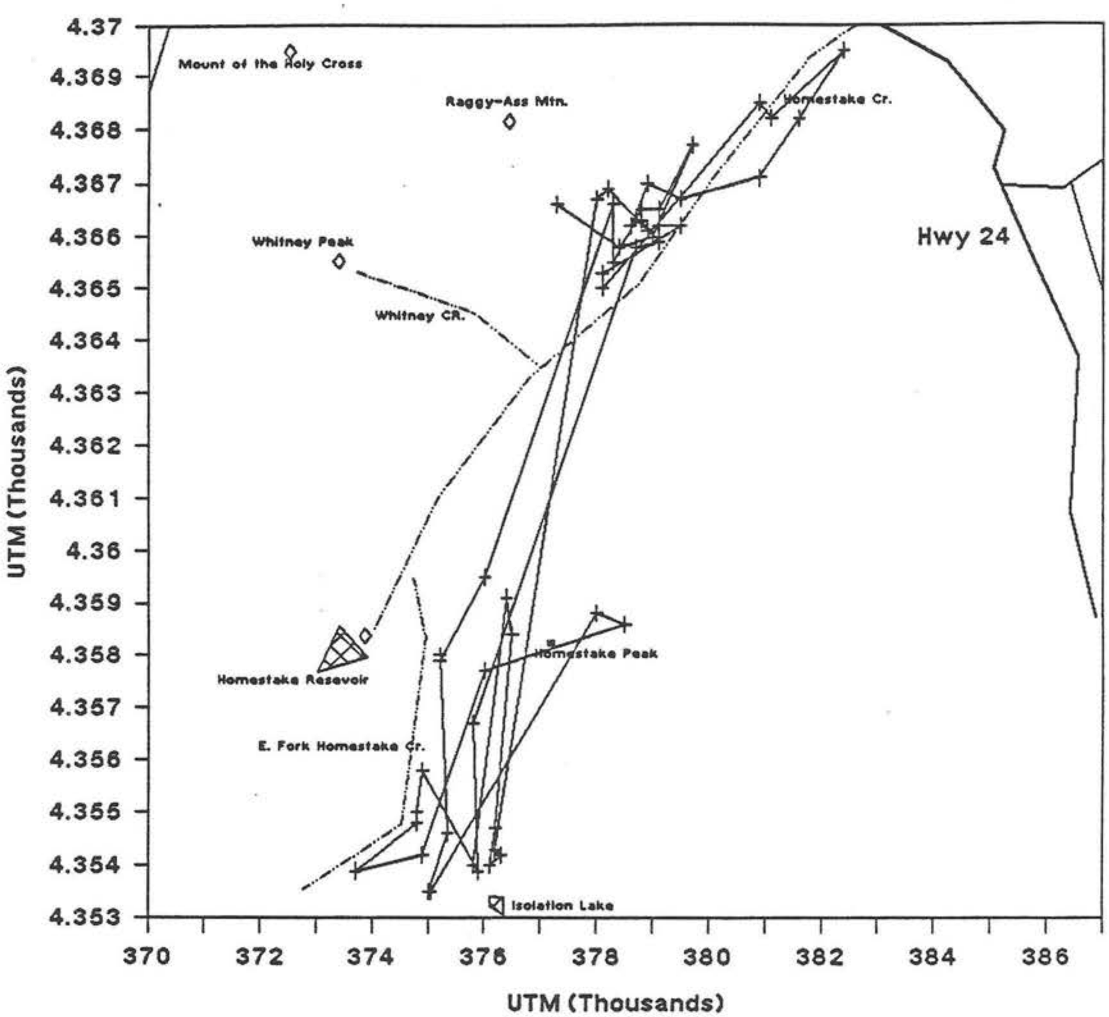
Appendix Fig. 1M. Movement patterns exhibited by cow M across the study area from December 1986 through December 1988.



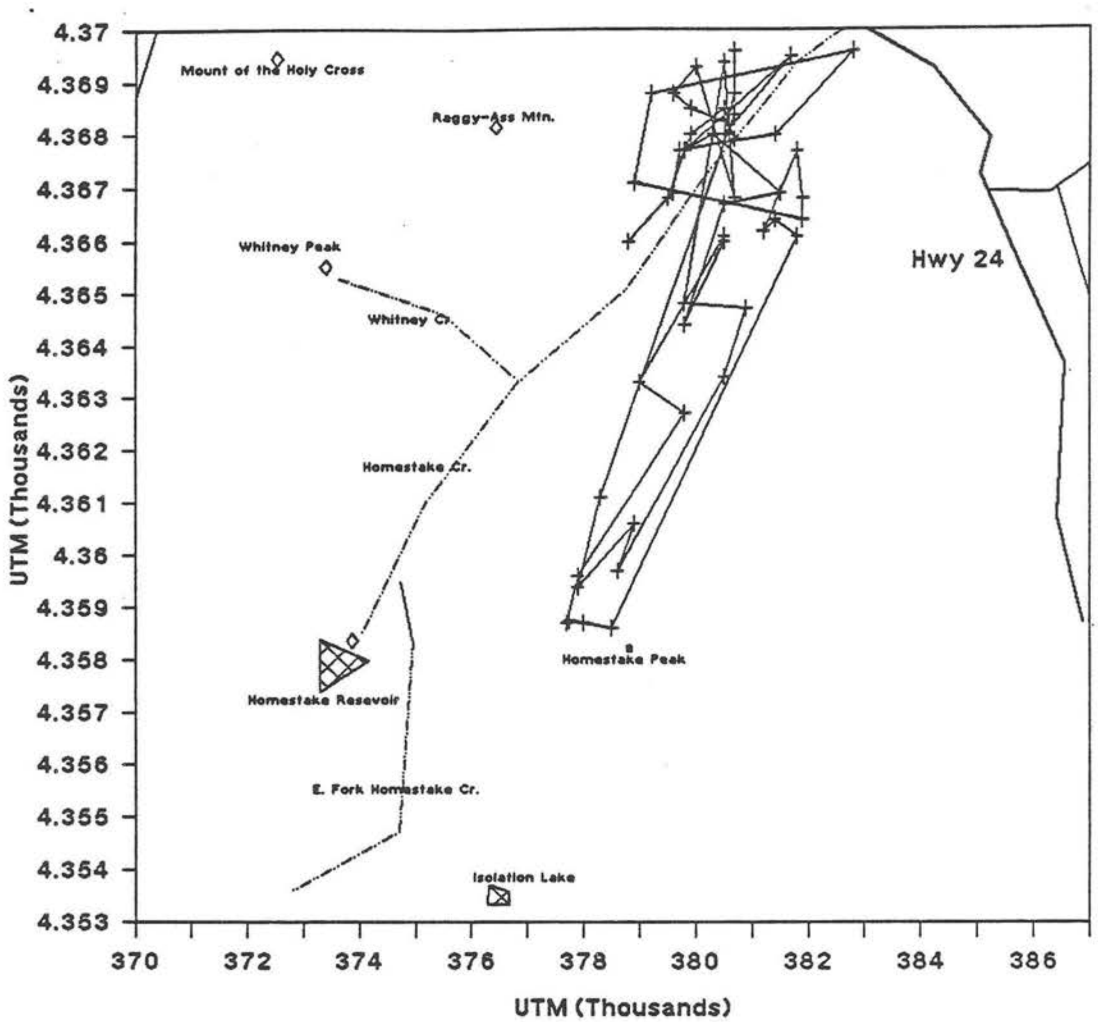
Appendix Fig. 1N. Movement patterns exhibited by cow N across the study area from December 1986 through December 1988.



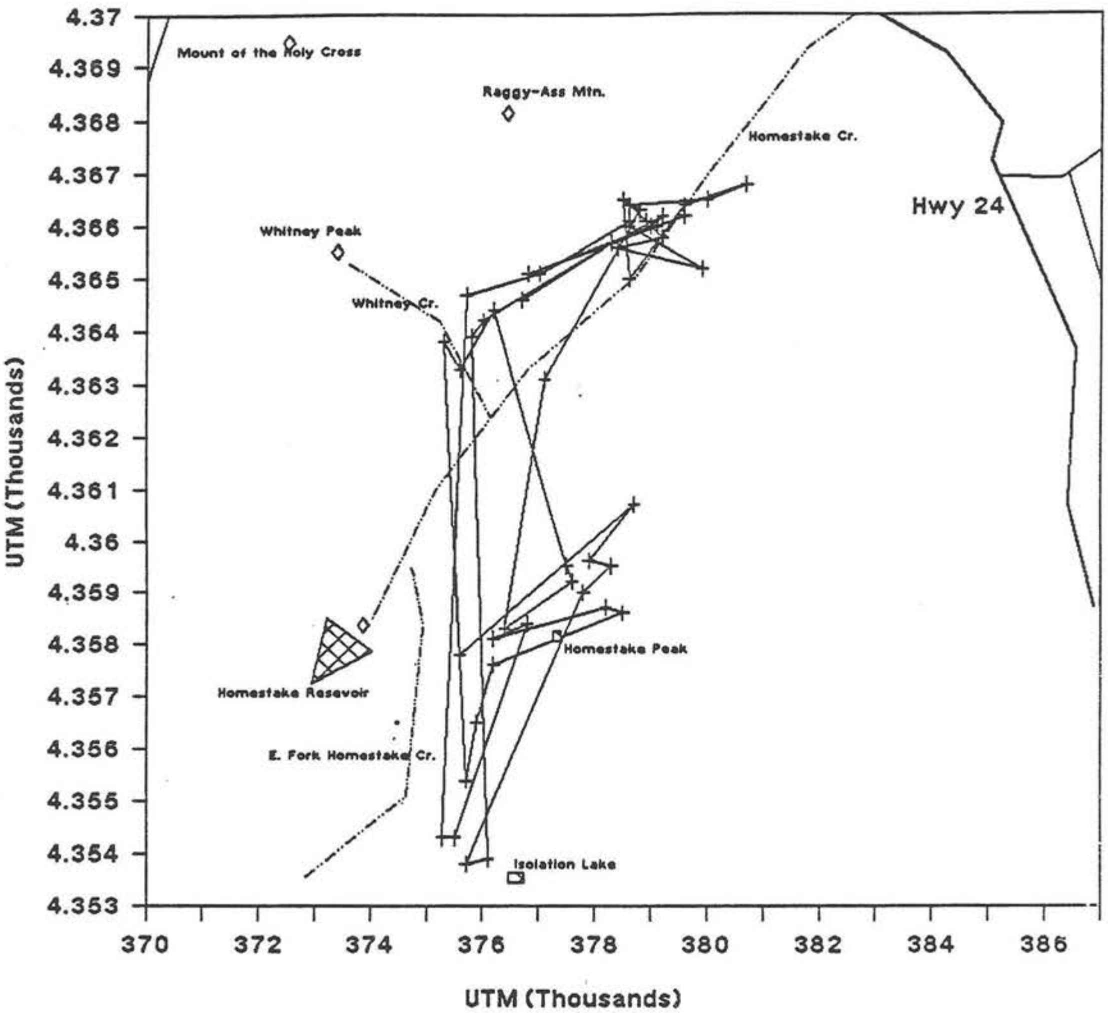
Appendix Fig. 10. Movement patterns exhibited by cow O across the study area from December 1986 through December 1988.



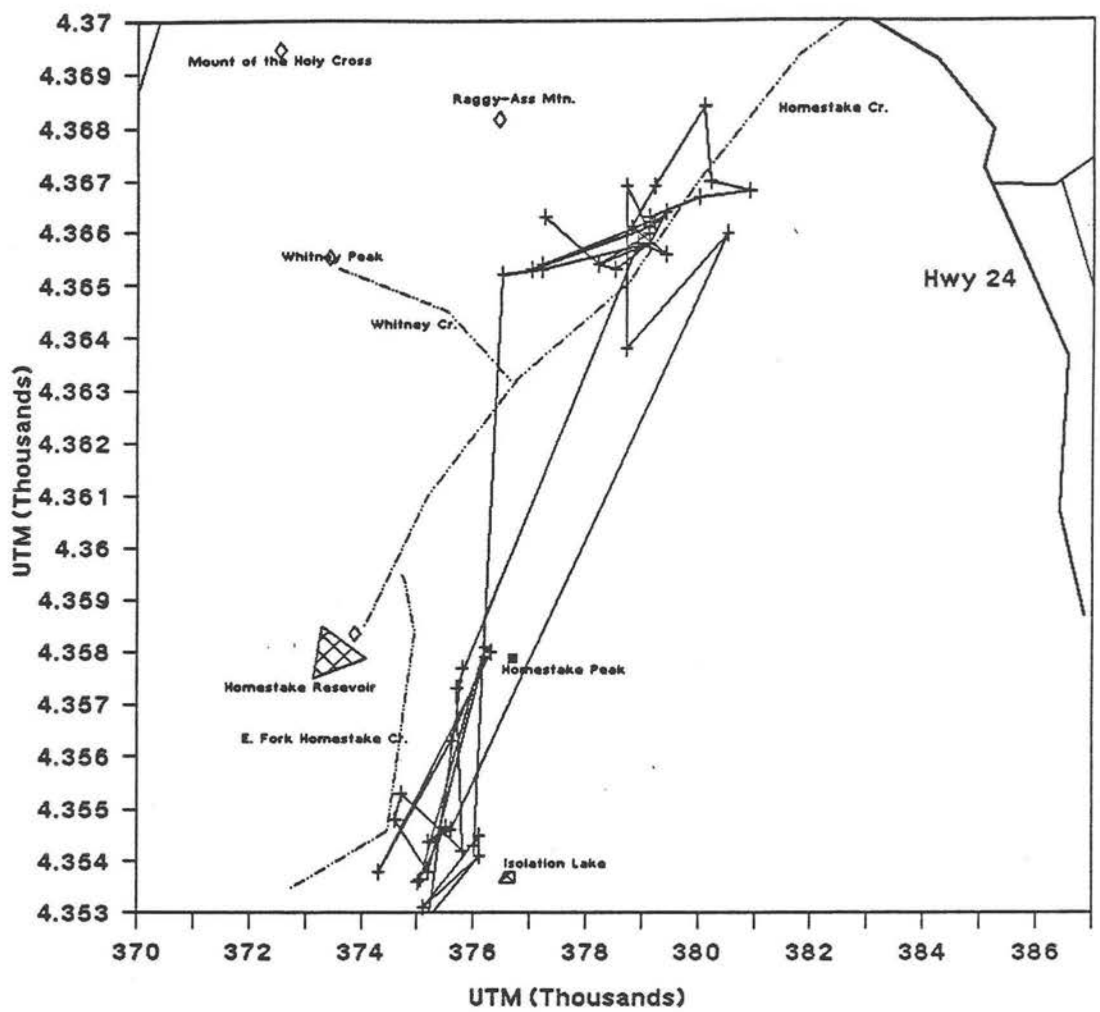
Appendix Fig. 1P. Movement patterns exhibited by cow P across the study area from December 1986 through December 1988.



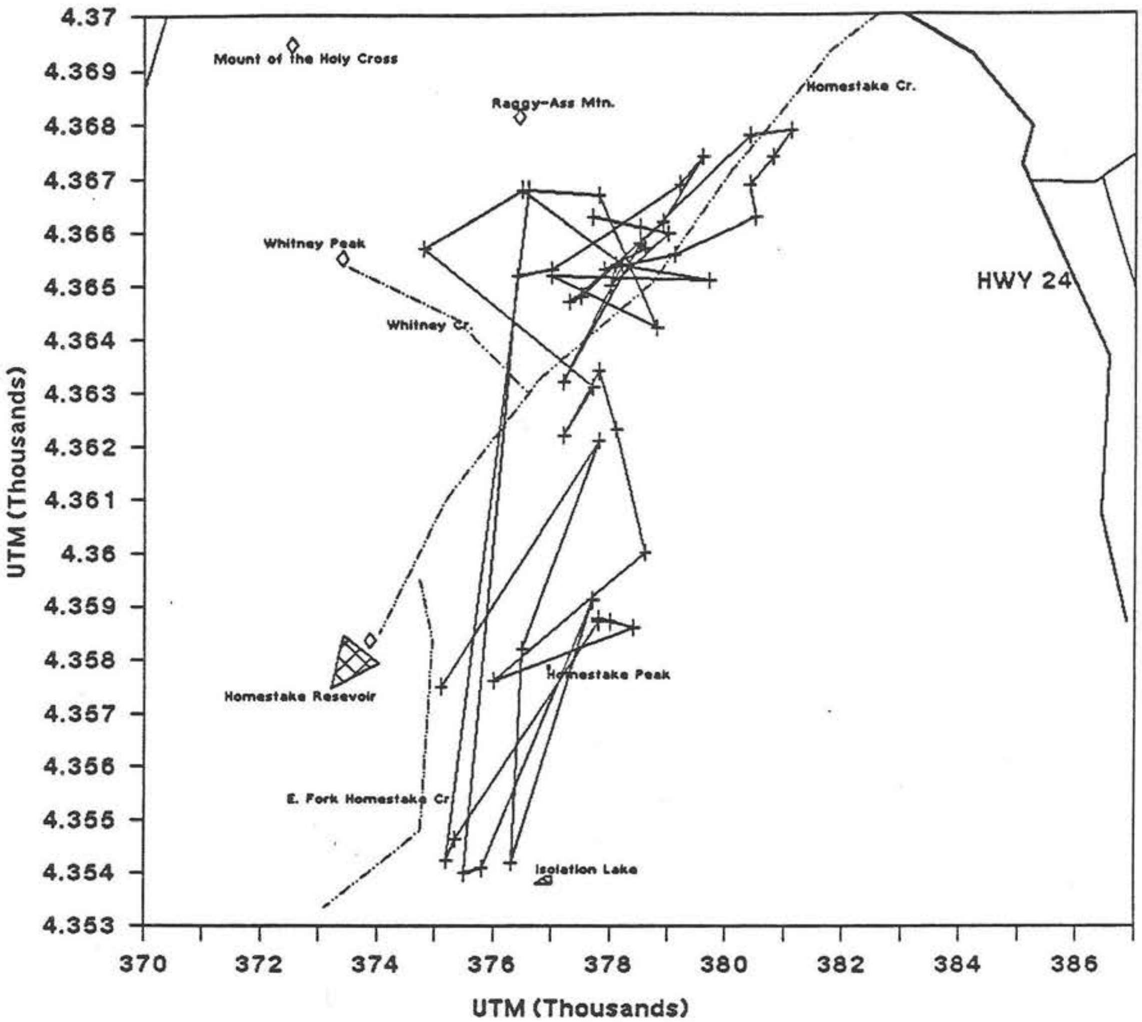
Appendix Fig. 1Q. Movement patterns exhibited by cow Q across the study area from December 1986 through December 1988.



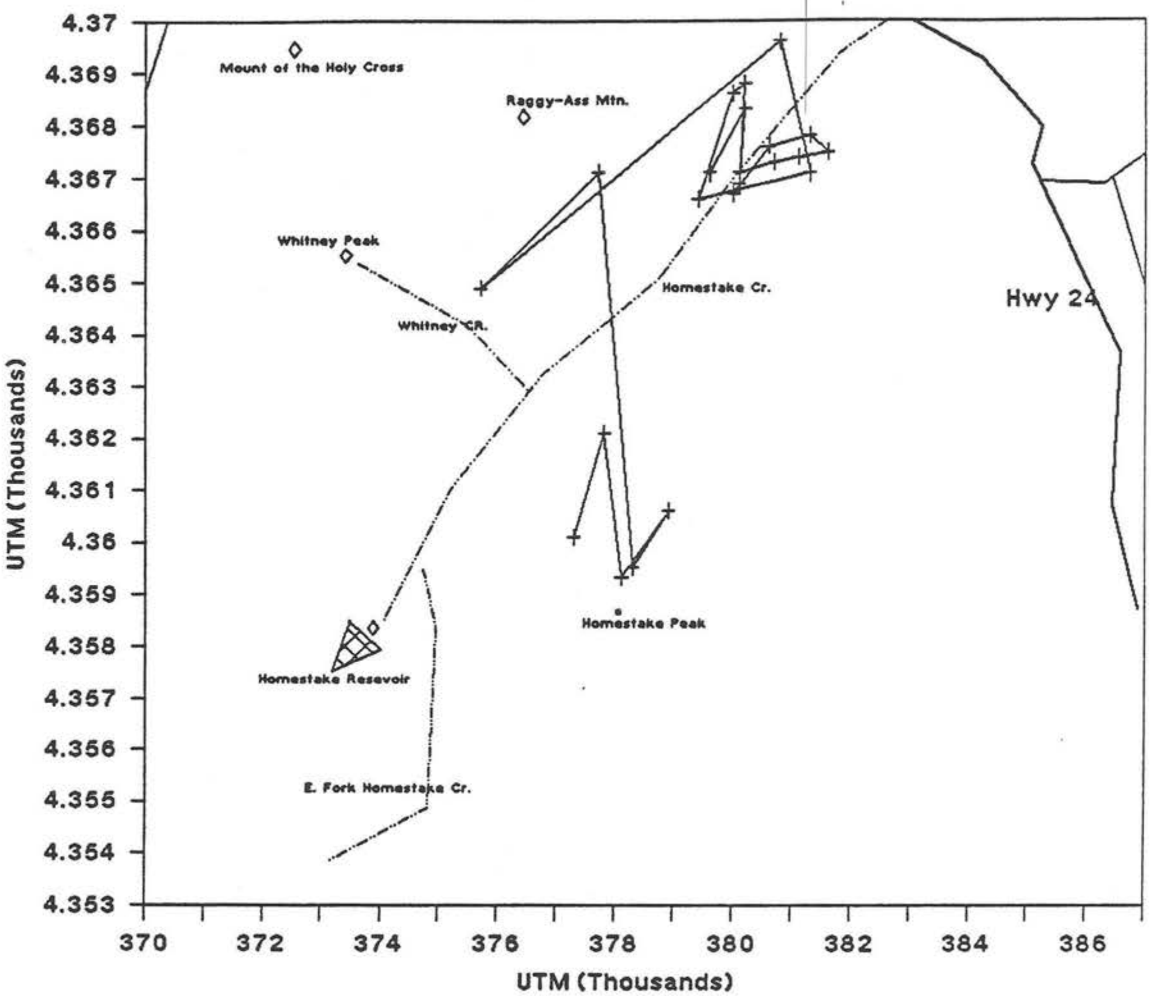
Appendix Fig. 1R. Movement patterns exhibited by cow R across the study area from December 1986 through December 1988.



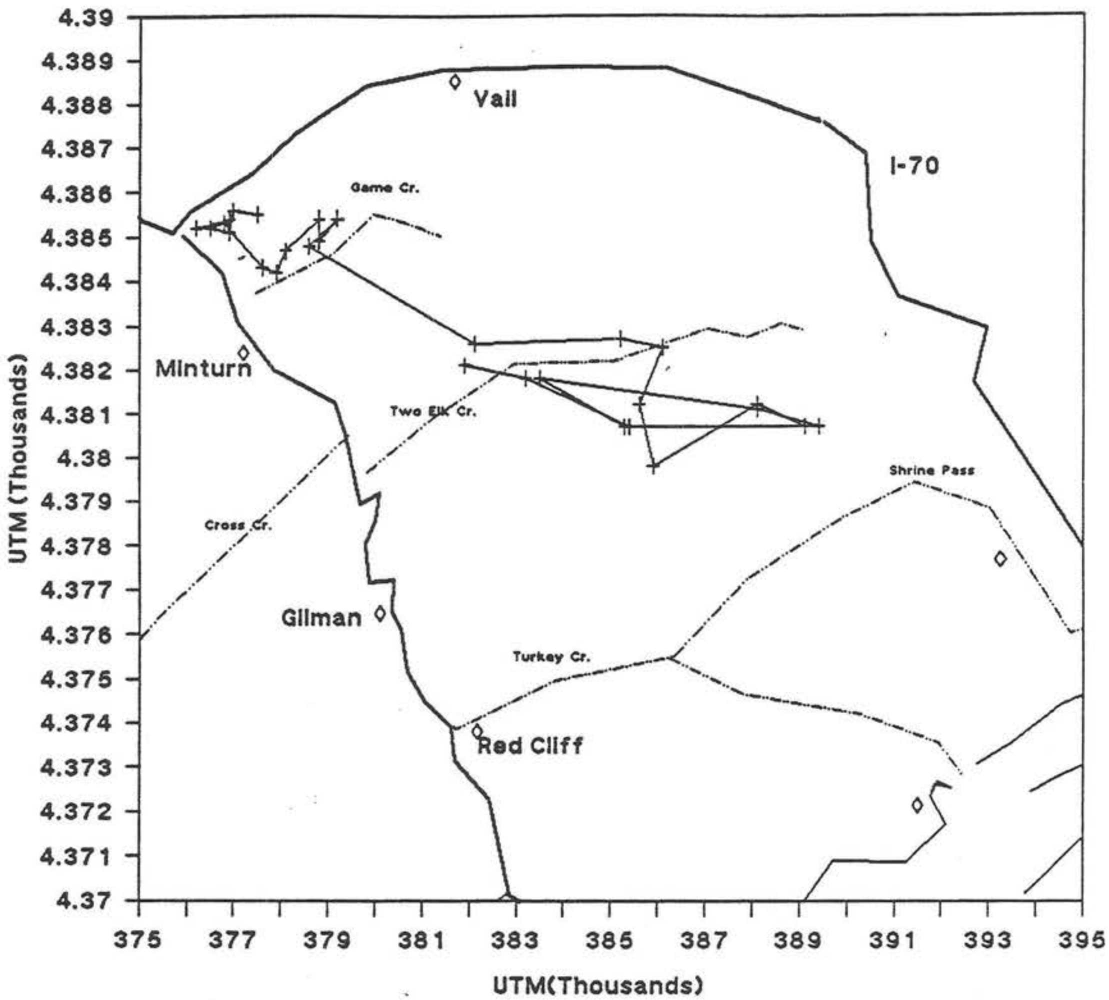
Appendix Fig. 1S. Movement patterns exhibited by cow S across the study area from December 1986 through December 1988.



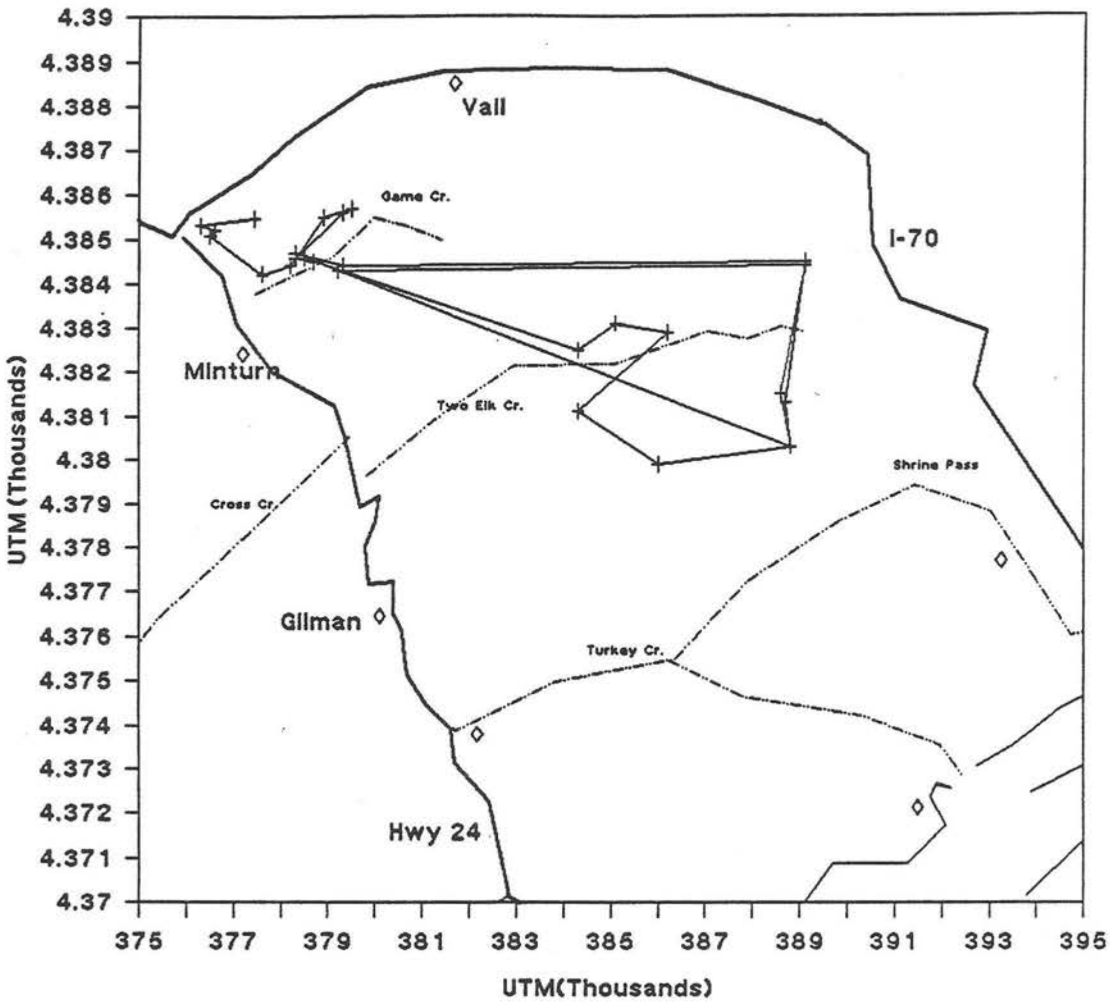
Appendix Fig. 1T. Movement patterns exhibited by cow T across the study area from December 1986 through December 1988.



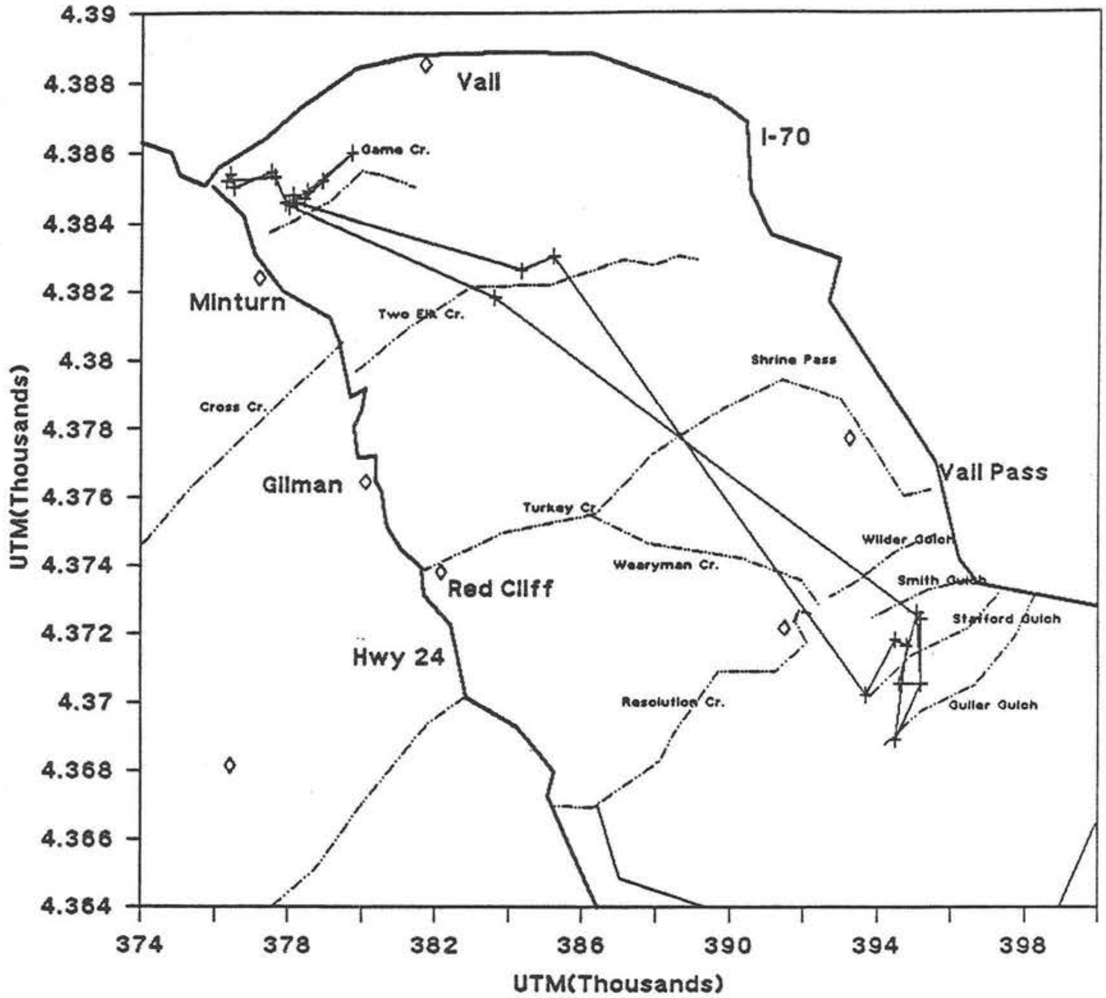
Appendix Fig. 1U. Movement patterns exhibited by cow U across the study area from December 1987 through December 1988.



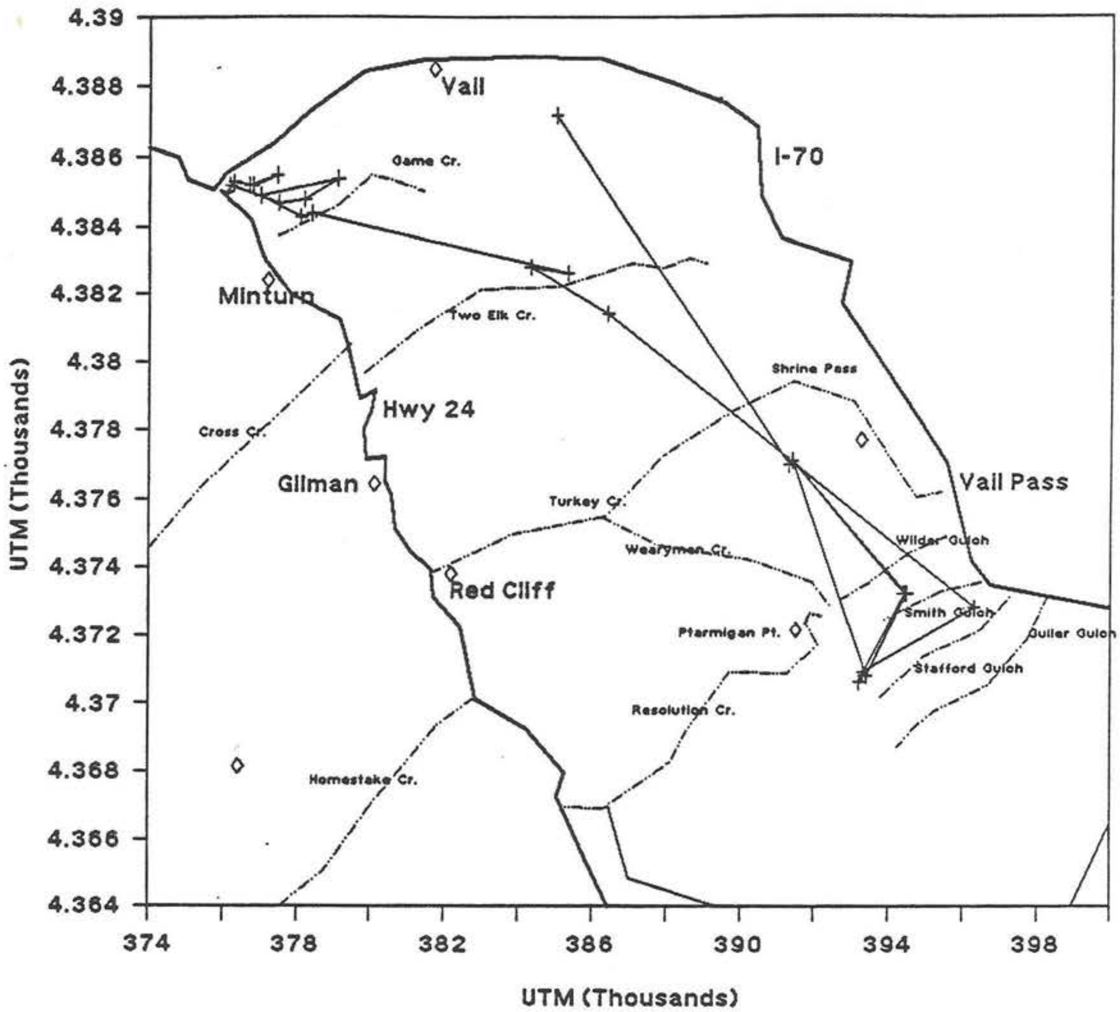
Appendix Fig. 1V. Movement patterns exhibited by cow V across the study area from January 1988 through December 1988.



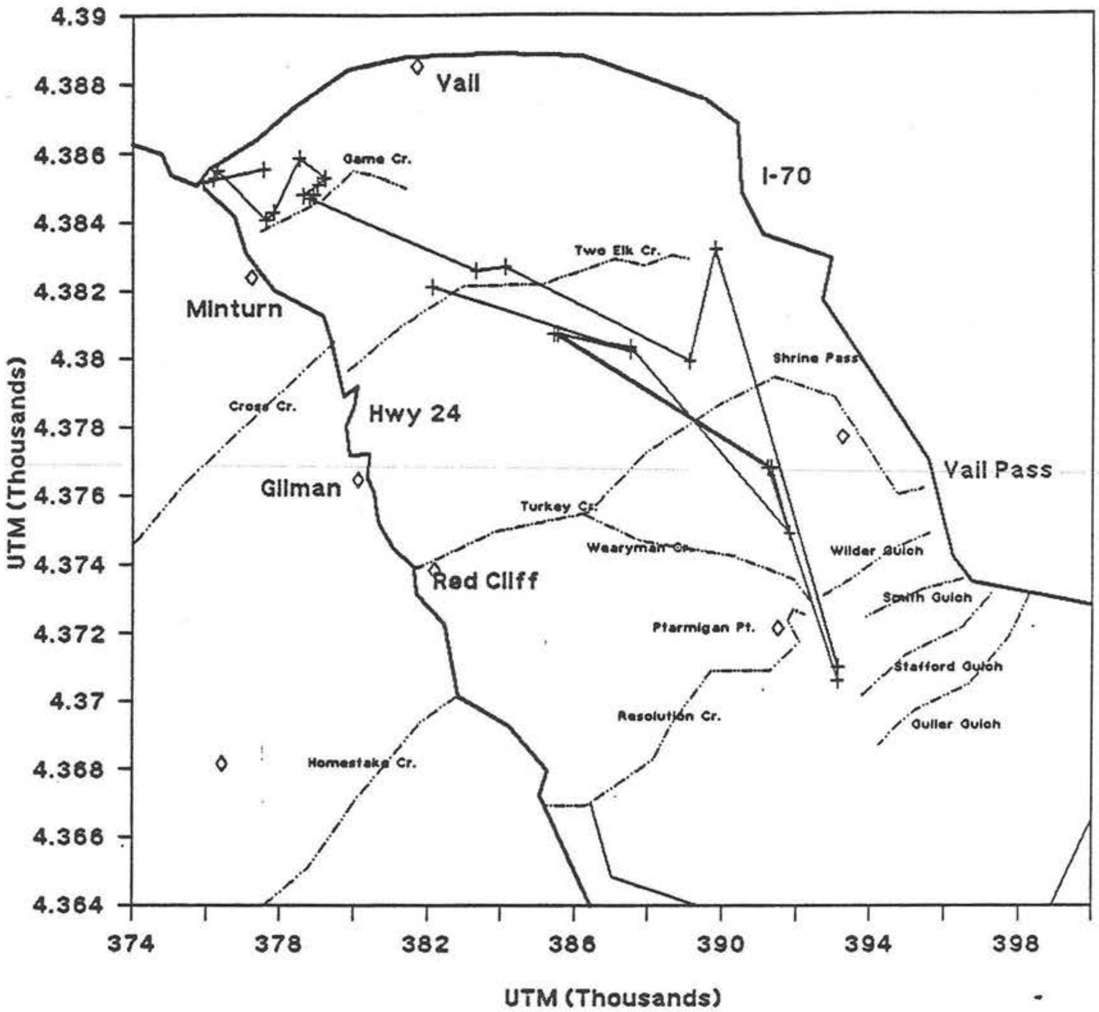
Appendix Fig. 1W. Movement patterns exhibited by cow W across the study area from January 1988 through December 1988.



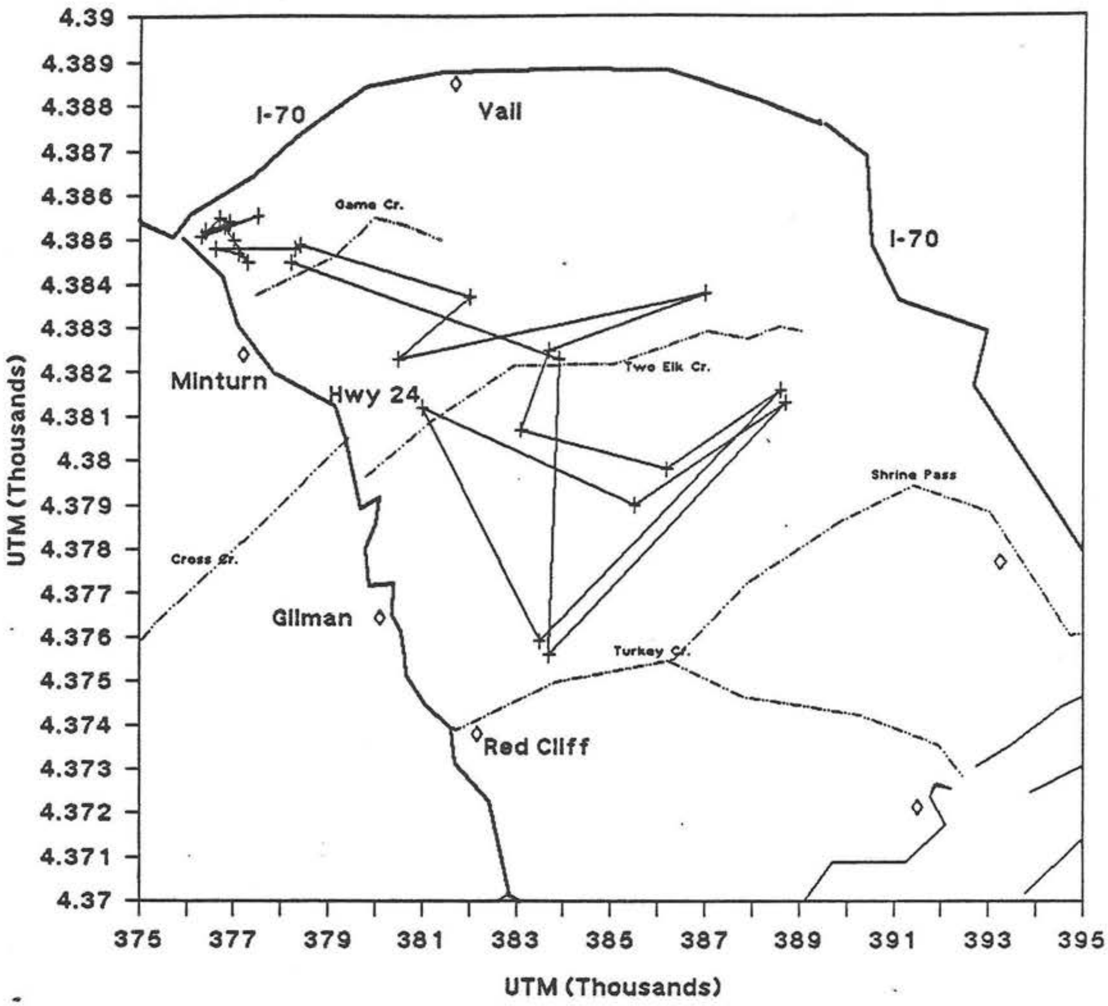
Appendix Fig. 1X. Movement patterns exhibited by cow X across the study area from January 1988 through December 1988.



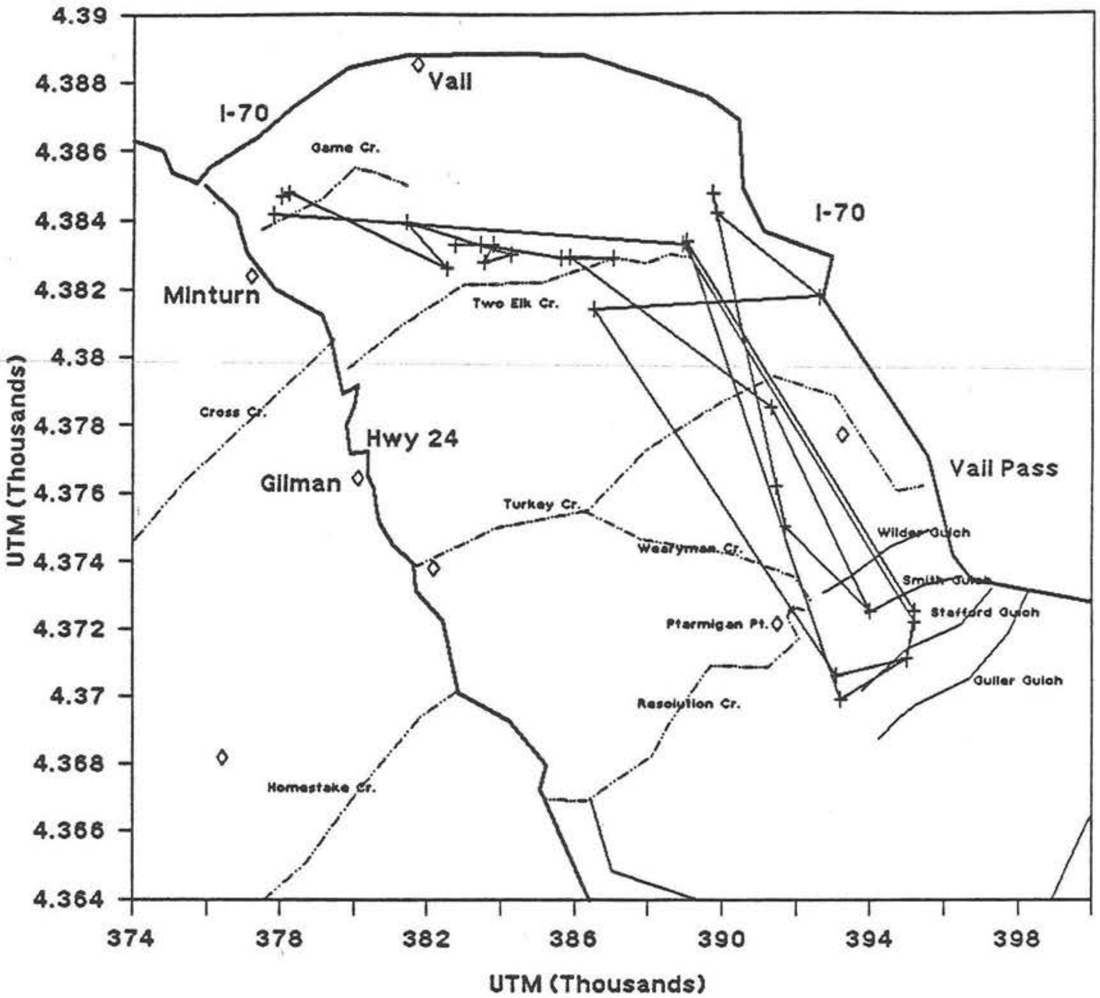
Appendix Fig. 1Y. Movement patterns exhibited by cow Y across the study area from January 1988 through December 1988.



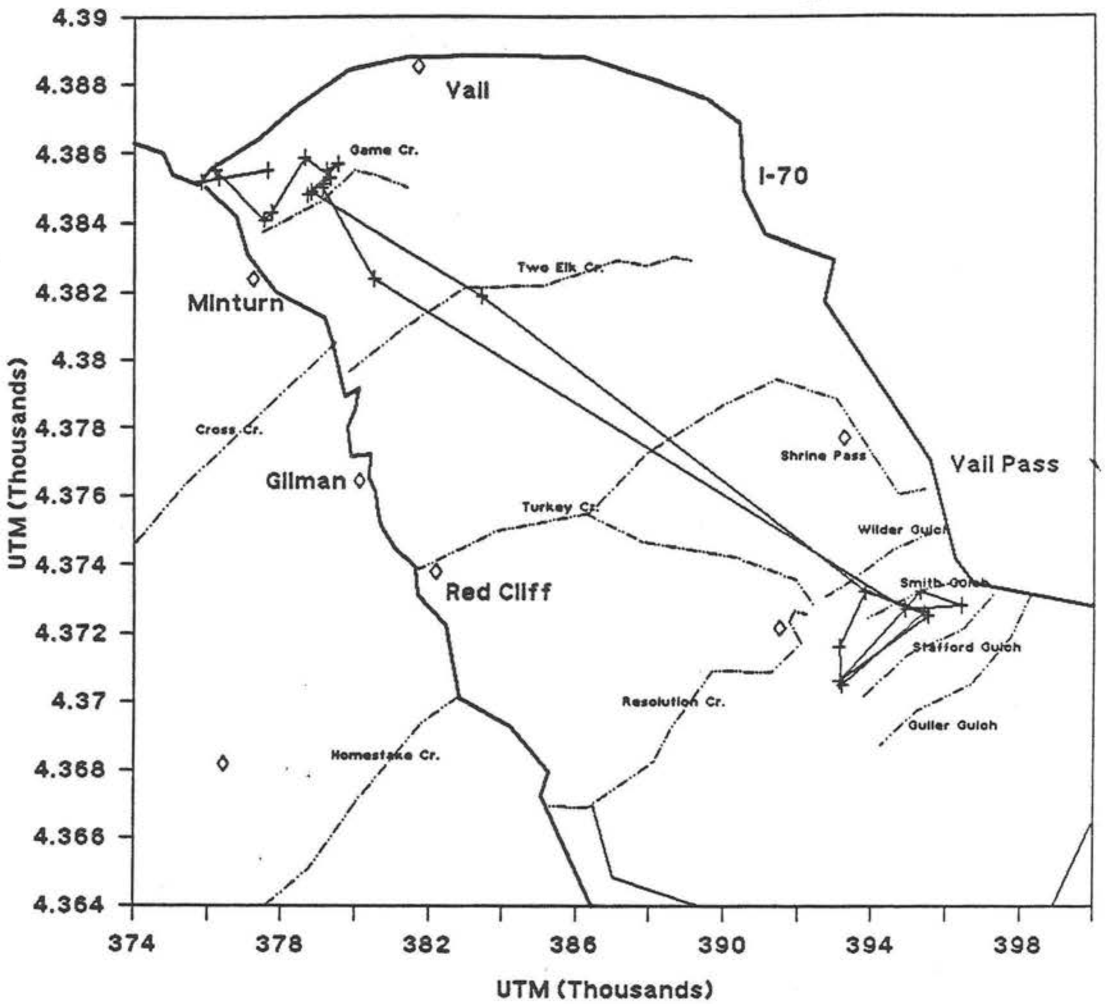
Appendix Fig. 1Z. Movement patterns exhibited by cow Z across the study area from January 1988 through December 1988.



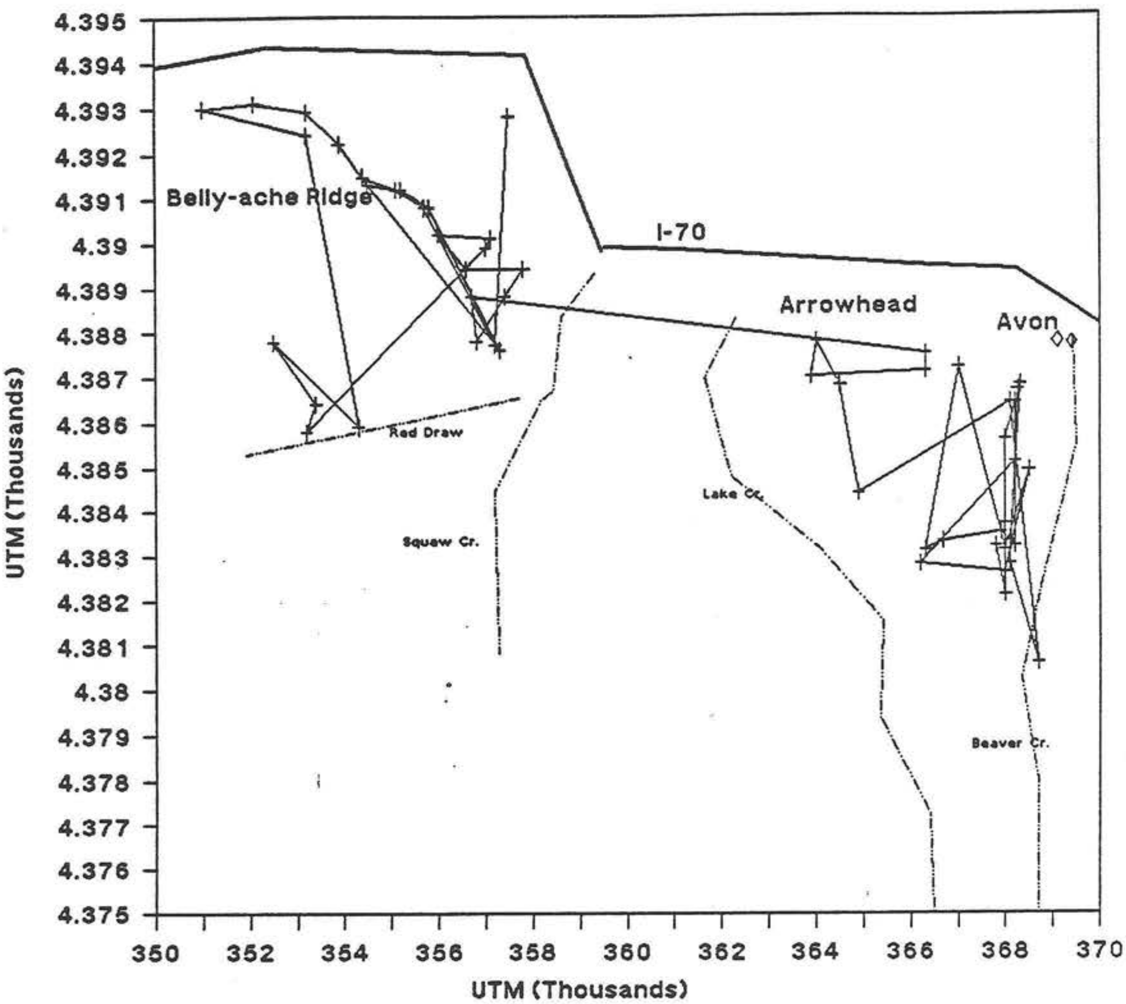
Appendix Fig. 1AA. Movement patterns exhibited by cow AA across the study area from January 1988 through December 1988.



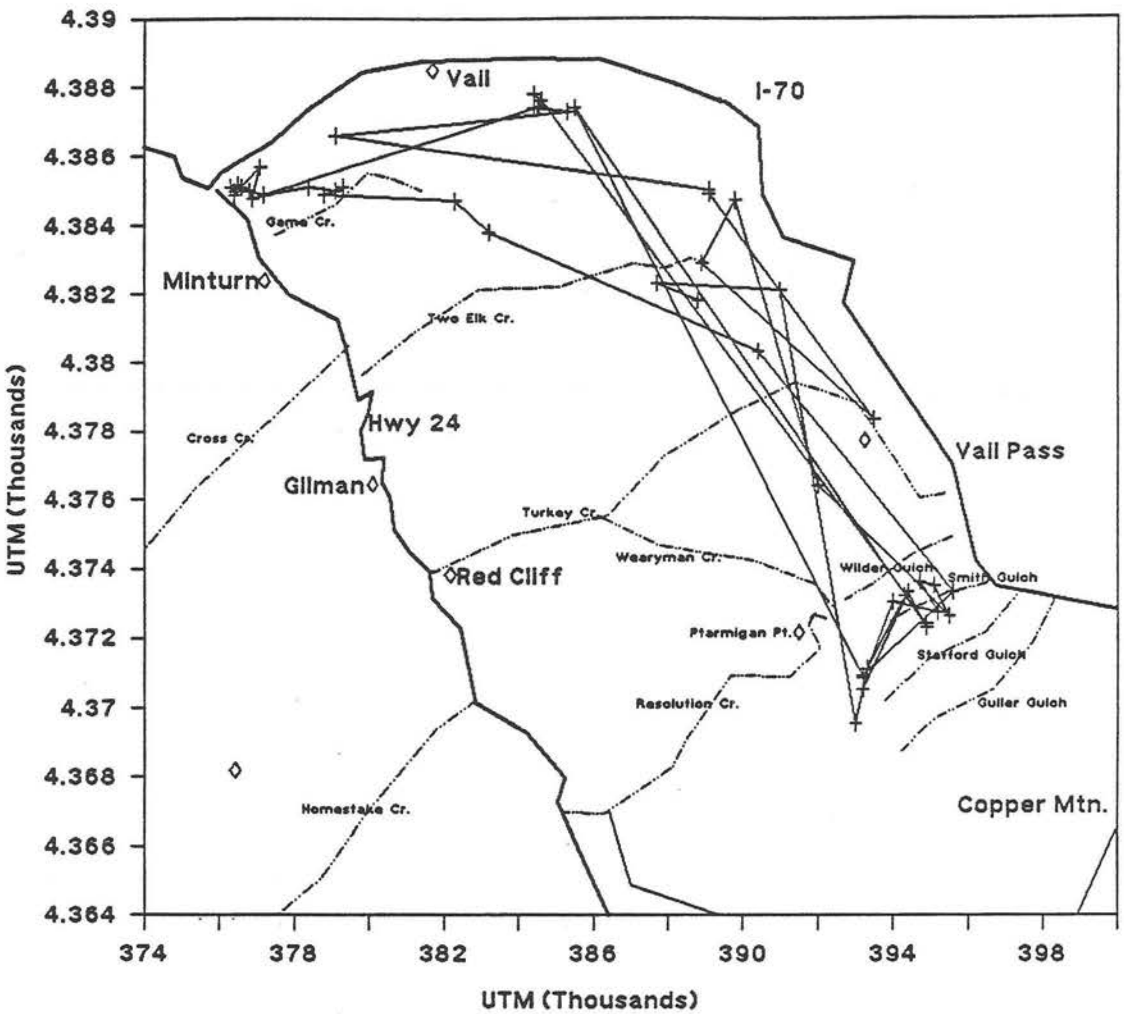
Appendix Fig. 1BB. Movement patterns exhibited by cow BB across the study area from January 1988 through December 1988.



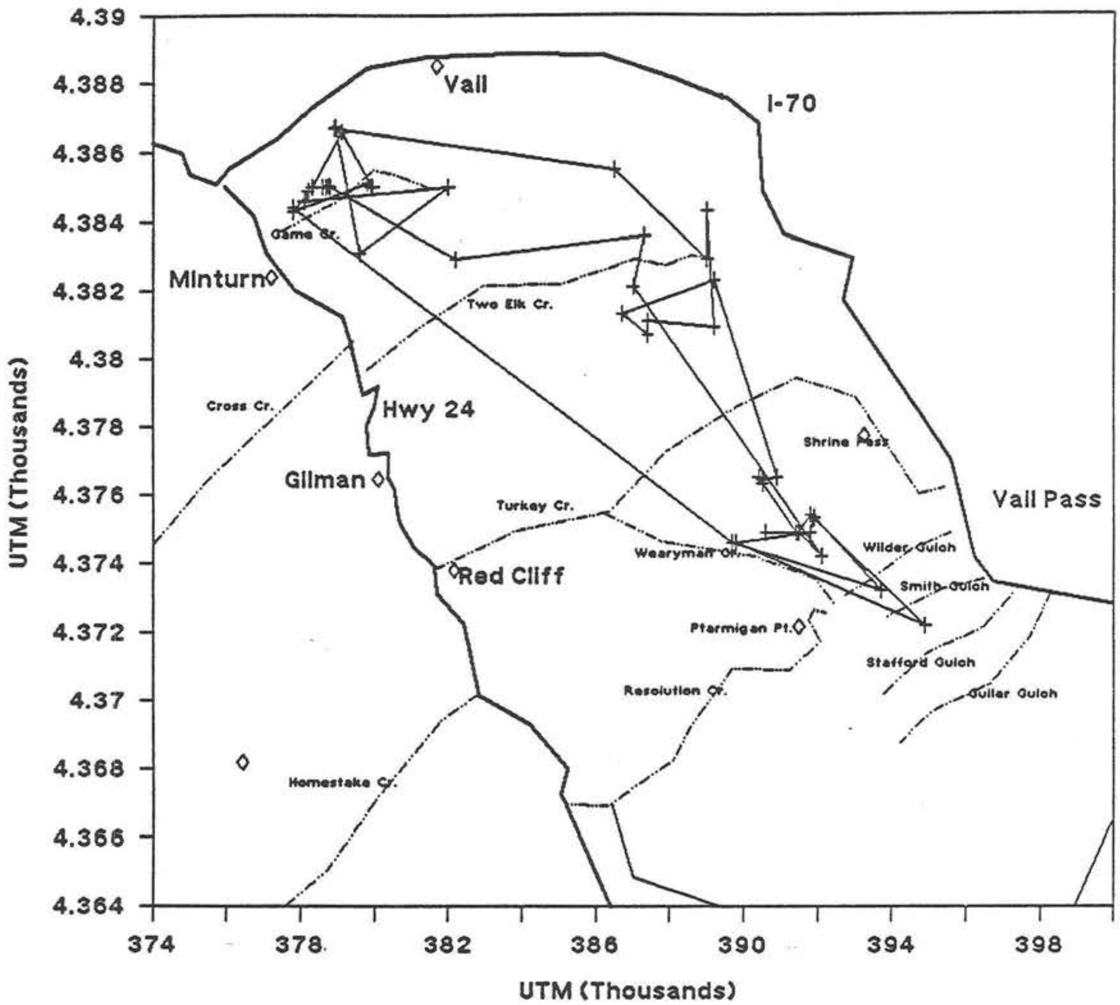
Appendix Fig. 1CC. Movement patterns exhibited by cow CC across the study area from January 1988 through December 1988.



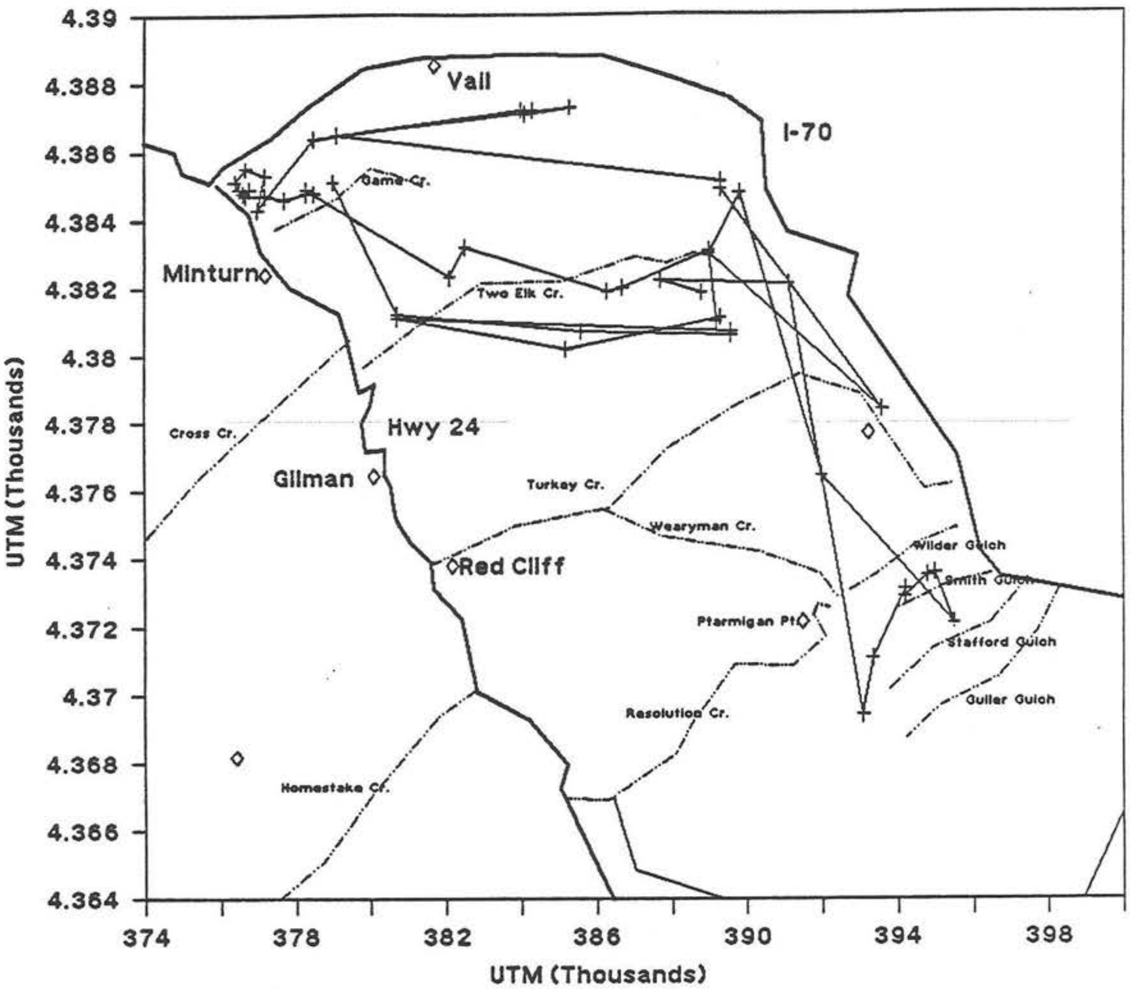
Appendix Fig. 1Ca. Movement patterns exhibited by calf A across the study area from June 1987 through December 1988.



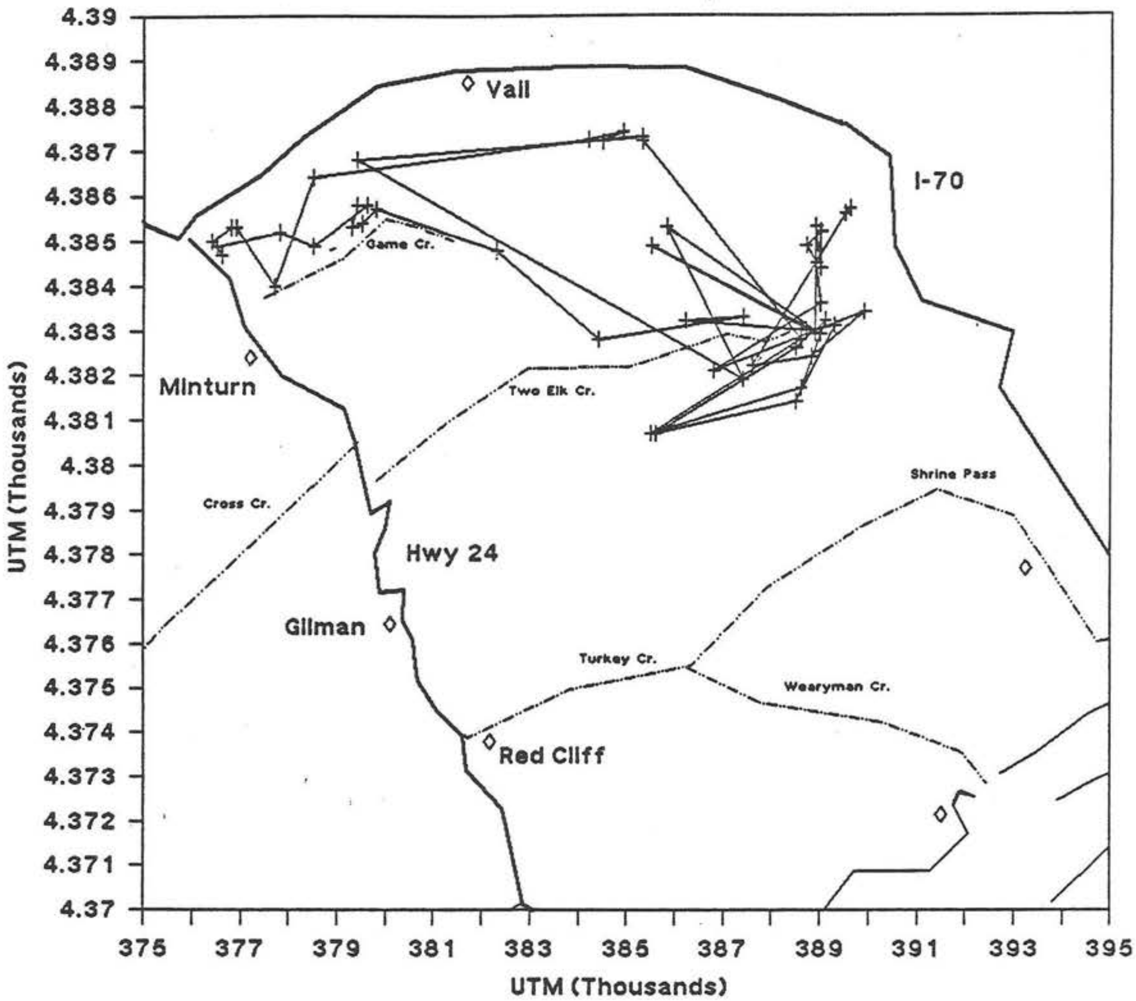
Appendix Fig. 1Cb. Movement patterns exhibited by calf B across the study area from June 1987 through December 1988.



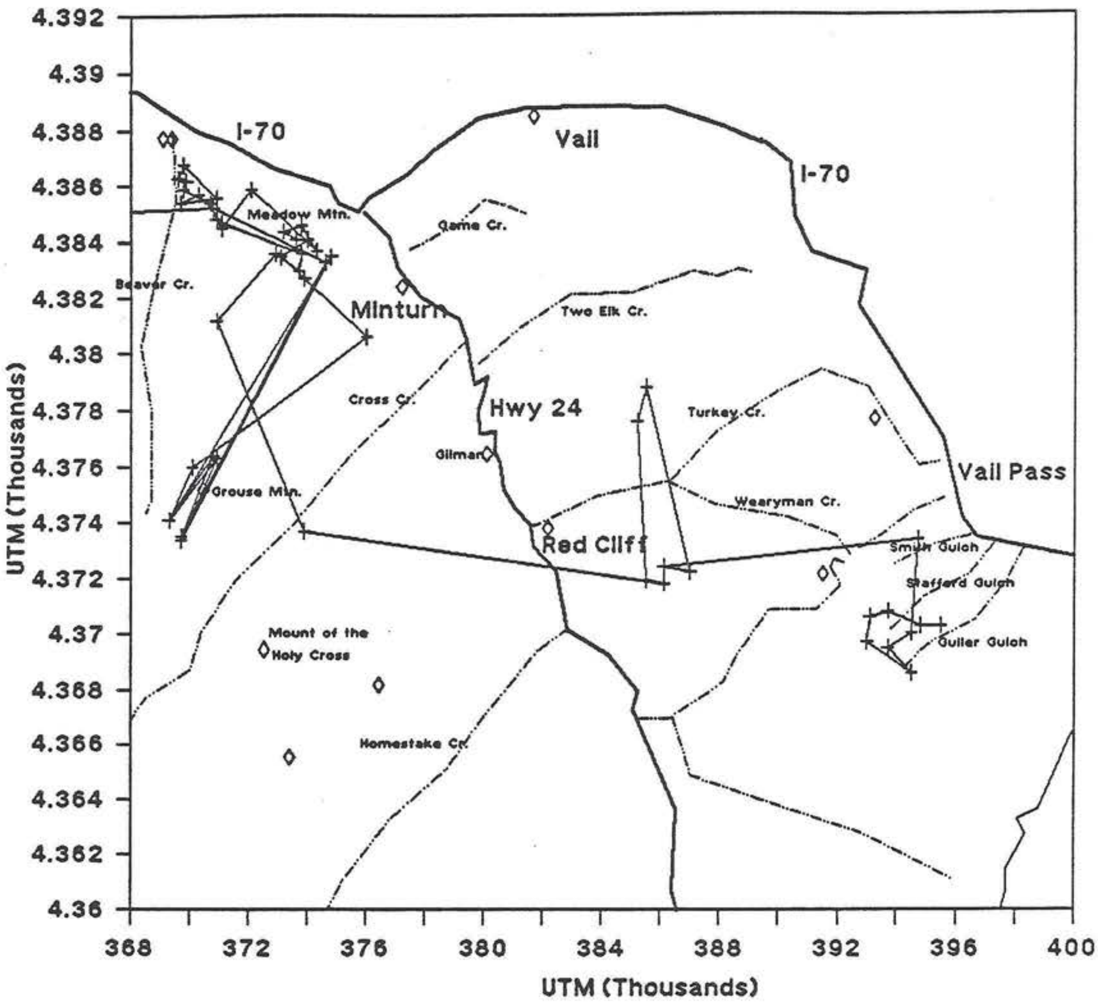
Appendix Fig. 1Cc. Movement patterns exhibited by calf C across the study area from June 1987 through December 1988.



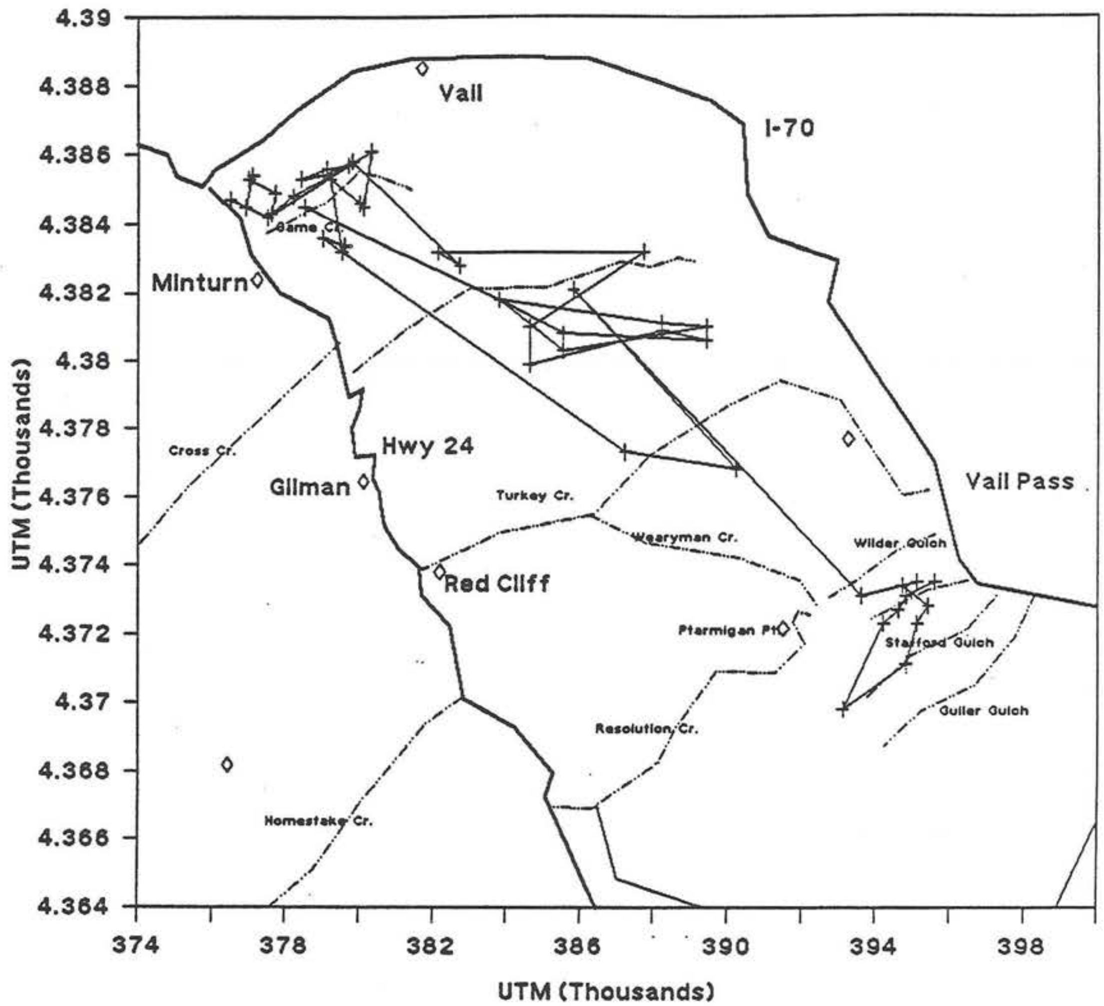
Appendix Fig. 1Cd. Movement patterns exhibited by calf D across the study area from June 1987 through December 1988.



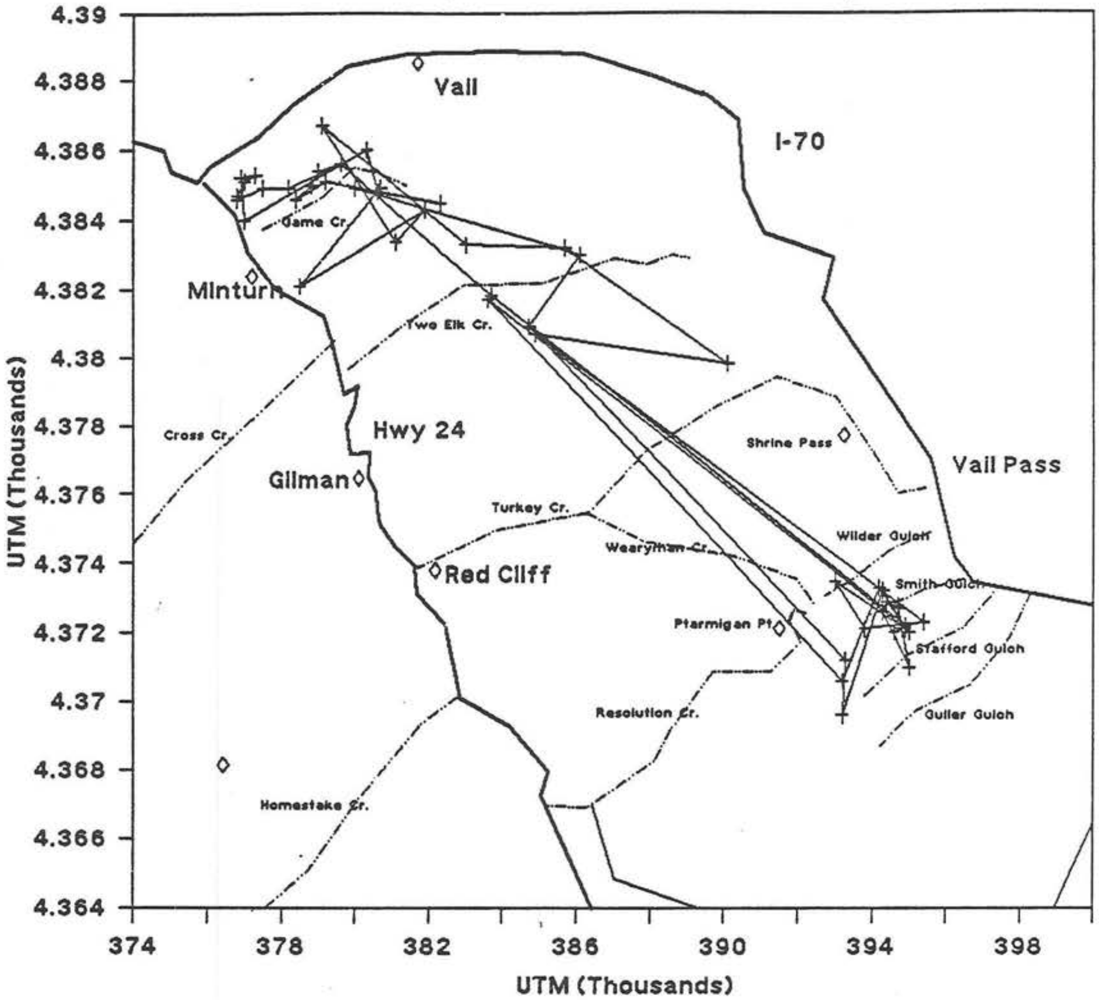
Appendix Fig. 1Ce. Movement patterns exhibited by calf E across the study area from June 1987 through December 1988.



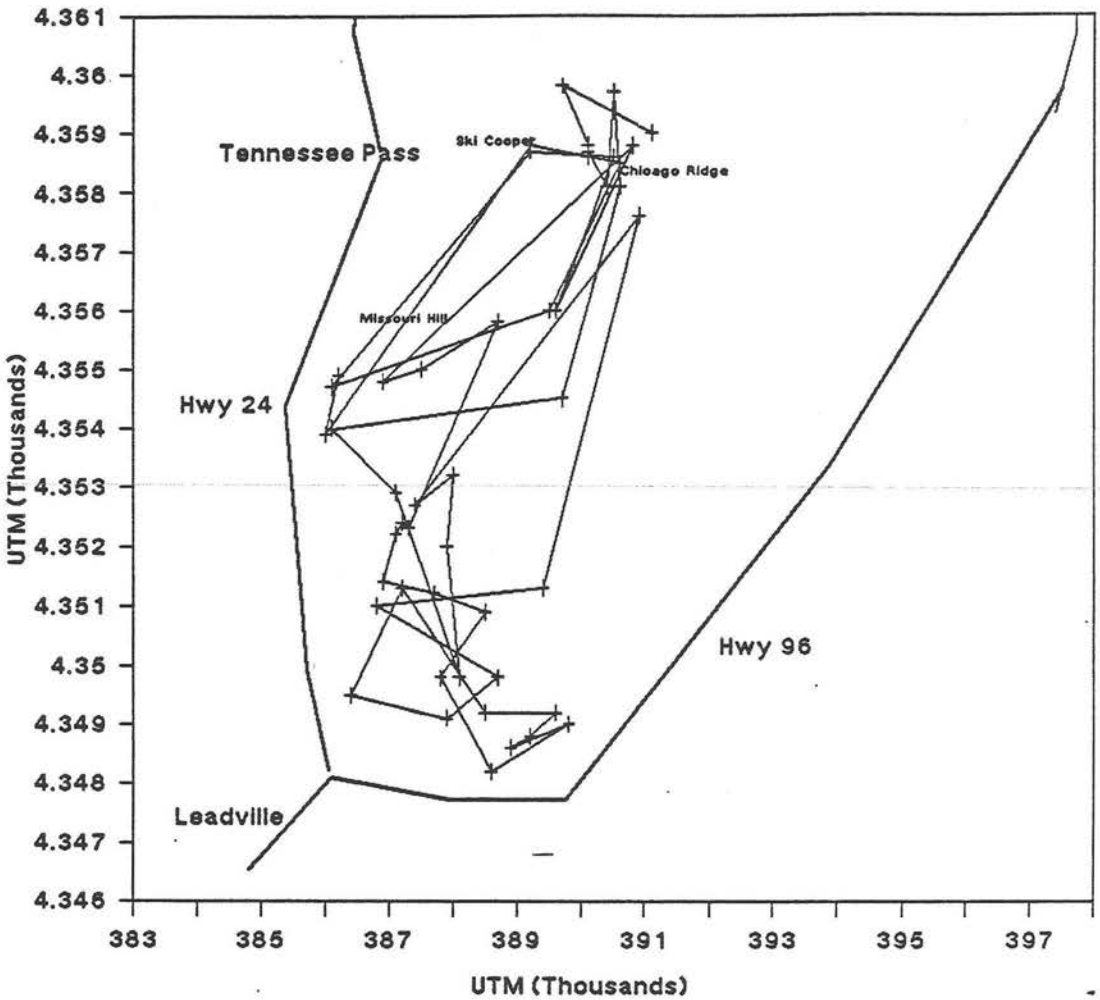
Appendix Fig. 1Cf. Movement patterns exhibited by calf F across the study area from June 1987 through December 1988.



Appendix Fig. 1Cg. Movement patterns exhibited by calf G across the study area from June 1987 through December 1988.



Appendix Fig. 1Ci. Movement patterns exhibited by calf I across the study area from June 1987 through December 1988.



Appendix Fig. 1Cj. Movement patterns exhibited by calf J across the study area from June 1987 through December 1988.

Appendix 2. List of all plant species identified on the Dowd Junction winter range in 1987-88.

Scientific name	Common name
Forbs	
Artemisia frigida	Sagebrush
Chrysopois heterotheca	Golden Aster
Cirsium spp.	Thistle
Galium boreala	Hara
Geranium spp.	Geranium
Linaria vulgaris	Butter & eggs
Oxytropus spp.	Loco weed
Penstemon spp.	Beard tongue
Phacelin heterophylla	Pursh
Grasses	
Agrpyron smithii	Wheat grass
Bromus tectorum	Cheat grass
Carex spp.	Sedge
Poa spp.	Blue grass
Stipa comata	Needle grass
Shrubs	
Amelanchier alnifolia	Serviceberry
Artemisia tridentata	Sagebrush
Chrysothamnus nauseous	Rabbit brush
Prunus virginiana	Chokecherry
Purshia tridentata	Bitter brush
Rosa woodsii	Rose
Symphoricarpos oreophilus	Snowberry