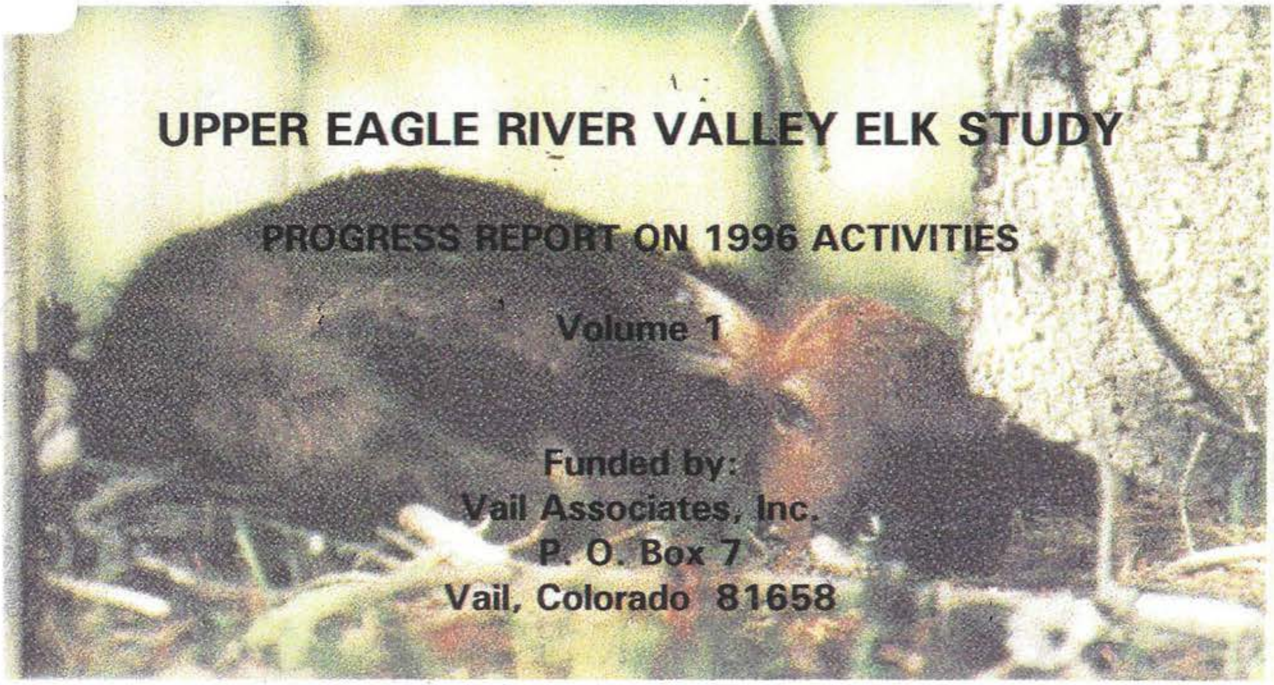

UPPER EAGLE RIVER VALLEY ELK STUDY

PROGRESS REPORT ON 1996 ACTIVITIES

Volume 1

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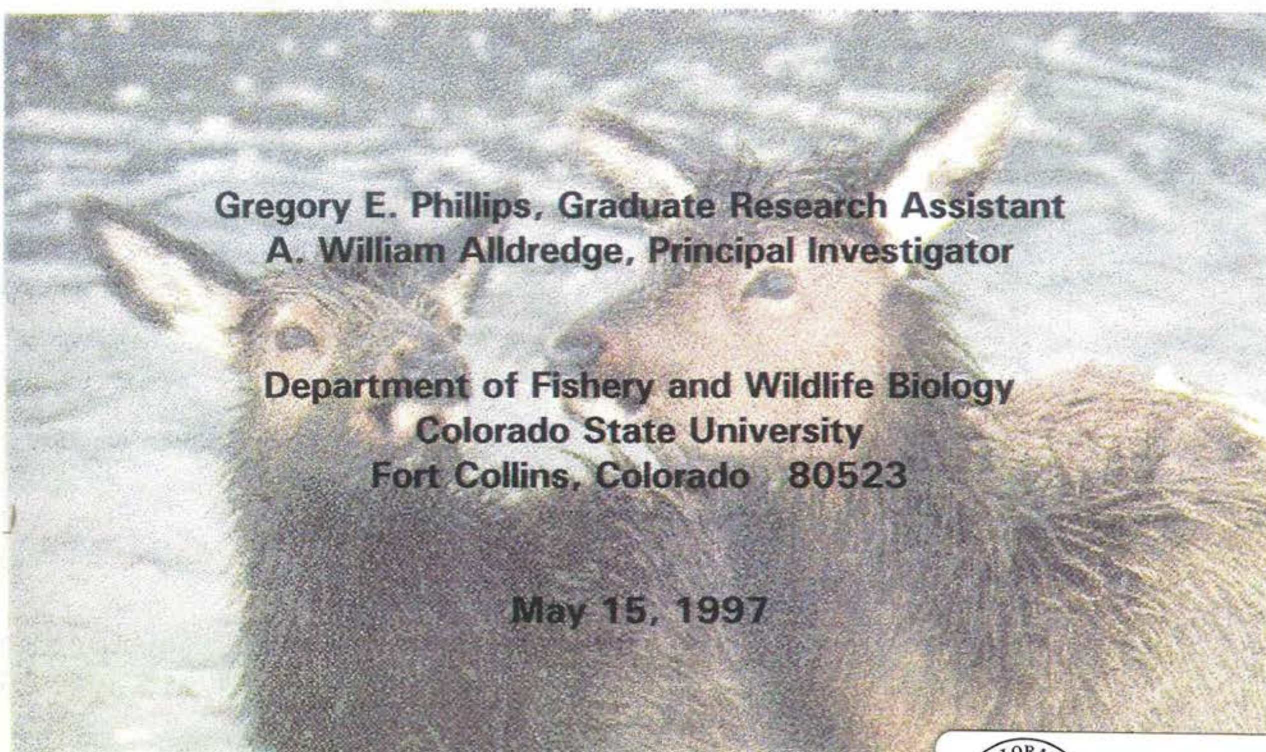

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May 15, 1997

ACKNOWLEDGMENTS

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Title page watermarks are from photographs by Keith A. Szafranski (top) and Mark Planck (bottom). These images are used by permission of the photographers.

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1. INTRODUCTION

The **goal** of the Upper Eagle River Valley Elk Study is to evaluate selected impacts on elk associated with land development and related human activities occurring in areas historically used by elk. Four primary **objectives** have been established for the study that will contribute to understanding human-induced impacts on elk populations:

1. Test the hypothesis that human-induced disturbance of elk in calving areas reduces the recruitment of calves into the population.
2. Document elk spatial use patterns on the study area with particular emphasis on calving areas, winter range and movement corridors.
3. Develop a population dynamics/ecological risk assessment model for elk on the study area.
4. Compare survival rates for adult cows among concurrent elk studies in Colorado.

We began work in 1994 and focused primarily on developing a study plan, preparing radio telemetry equipment, and capturing and radio-collaring an appropriate sample of adult female elk (Alldredge and Phillips 1995). During 1995, we monitored elk locations and survival, obtained pretreatment data for determining calf:cow ratios and captured additional elk to offset mortality losses and increase our sample size (Phillips and Alldredge 1996). Project activities escalated in 1996 with the addition of our first calving-season treatment period. In this report, we discuss our accomplishments for 1996.

2. SUMMARY OF STUDY PLAN

Previous studies have described displacement or alteration of spatial use patterns by elk associated with human activities such as roads/vehicles, logging, mining, recreation and development (Lyon and Ward 1982, Edge et al. 1985, Kuck et al. 1985, Berwick et al. 1986, Czech 1991 and Cassirer et al. 1992). Restriction of human access to elk calving areas during calving season reflects concerns that elk may be particularly sensitive to disturbance during the parturition period (Towry 1984). An expectation of impacts on the rate of population change (through birth, death, immigration and/or emigration) are implicit in such concerns.

Our primary objective is to test the hypothesis that human-induced disturbance of elk during the calving season reduces elk recruitment rates. To test this hypothesis, we initiated a three-year control-treatment design (Phillips 1994) with 2 study areas located south of Interstate 70 near the Vail and Beaver Creek ski areas. The Vail (VA) and Beaver Creek (BC) study areas are shown in Fig. 1. Control and treatment groups of 75 adult female elk were radio-collared on these areas in 1994. Sample sizes were increased to 86 animals each in December, 1995.

Radio-collared elk on the BC study area will experience treatment consisting of simulated recreational activity during peak calving periods in 1996 and 1997. Post-calving season calf:cow ratios will be measured for marked elk on each study area between the end of calving season and the beginning of archery season to provide estimates of elk calf recruitment rates. One year of pre-treatment data and two years of post-treatment data will be collected to allow for tests of treatment effect. Results will provide quantitative evidence for use in assessing the potential effect of human-induced disturbance on elk.

In response to management needs within the upper Eagle River Valley, we will document existing spatial use patterns of elk with particular emphasis on calving areas, winter range and spring/fall transition ranges. Documentation of spatial use patterns will be accomplished using aerial telemetry. Supplemental information on spatial distribution of elk will be obtained from ground telemetry and direct observation. Information on calving area locations and habitat characteristics will be obtained during the treatment phase of our field work. These data will help define the extent of areas which are currently used by elk during critical seasons and can be used to minimize and/or mitigate impacts to elk populations from future development in the upper Eagle River Valley.

We will experimentally evaluate the effect of disturbance on elk reproductive success, and we will use computer modeling to predict effects on elk population dynamics due to human-induced disturbance and reductions in winter range and calving areas. Modeling represents a method for exploring the potential effects of interactions between these factors. We will cooperate with the Colorado Division of Wildlife (CDOW) in a study modeling impacts on wildlife populations resulting from development.

Although our primary purpose for radio-collaring adult cows is to evaluate spatial use and disturbance effects on recruitment, availability of telemetered animals also presents the opportunity to compare survival rates we measure with results of other concurrent elk studies in Colorado. At least two CDOW studies involving year-around monitoring of radio-collared adult cow elk are in progress. One study is south of New Castle and Rifle and the other is in the upper Poudre River drainage. The National Park Service is also conducting a study involving radio telemetry of adult cow elk in Rocky Mountain National Park. We will incorporate these data into our final comparison of survival rates.

Results of our study will provide managers and decision makers with scientifically defensible and publicly credible information that can be used in reasoned

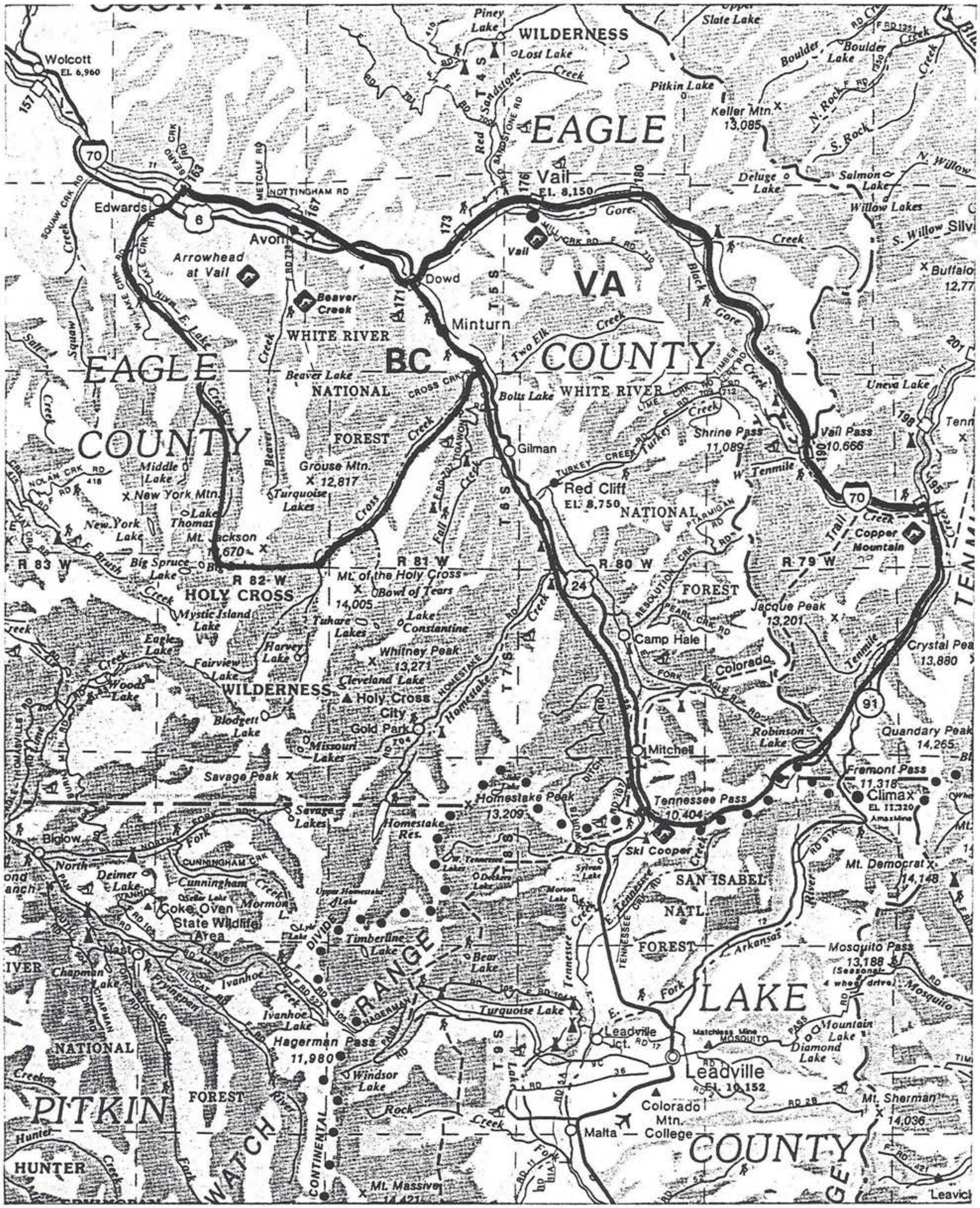

Figure 1. Locations of the Beaver Creek (BC) and Vail (VA) study areas.

decision making about the impacts of habitat alterations and human disturbance on elk. Our conclusions will have direct application in the upper Eagle River Valley and will also contribute to the body of scientific knowledge on elk in the western United States. Products from this research will include written reports, scientific publications and spatial-use maps.

3. ELK LOCATION AND SURVIVAL STATUS MONITORING

We monitored location and survival status of the BC and VA radio-collared elk throughout 1996 using ground and aerial telemetry, and visual observation. As of January 1, 1996, our sample consisted of 172 radio-collared adult cow elk, 86 each on the BC and VA study areas.

We conducted 27 flights in 1996 (Fig. 2), 24 of which were used to obtain spatial use patterns. From January to mid-May and September to December, we used ground telemetry to monitor survival status and general location of all radio-collared elk on an approximately twice-weekly schedule. For a discussion of telemetry methods and equipment used, see Phillips and Alldredge (1996).

3.1 Seasonal Distributions of Elk

Ground telemetry data, providing general locations of telemetered elk, are provided in Appendix 1 (Appendices 1-4 are bound separately as Volume 2 of this report and are available on request). The data are grouped in approximately 2-week intervals. Numbers of relocations for general areas within and around the BC and VA study areas are provided, along with a description of general location names.

Aerial-telemetry elk relocations are mapped for each 1996 flight in Appendices 2-4. Maps of the VA study area are provided in Appendix 2. Flights from 1995, as well as 1996, are included because they were not available for last year's report. Maps of the BC study area are provided in Appendix 3. Appendix 4 consists of a very simple map that includes both BC and VA study areas and enough of the surrounding area to show elk relocations well outside the study areas. Appendices 3 and 4 also include the last 2 flights from 1995 because these data are used in maps of 1995-96 winter elk locations in the next section. Although each individual flight map is not provided in Volume 1, all flight data are represented herein by seasonal combined maps or individual flight maps, where appropriate.

All maps show Universal Transverse Mercator (UTM) grids and coordinates (1927 North American Datum) for reference to topographic maps. These maps are based on United States Geological Survey (USGS) 30x60 min (1:100,000 scale) metric topographic maps ("Vail" and "Leadville").

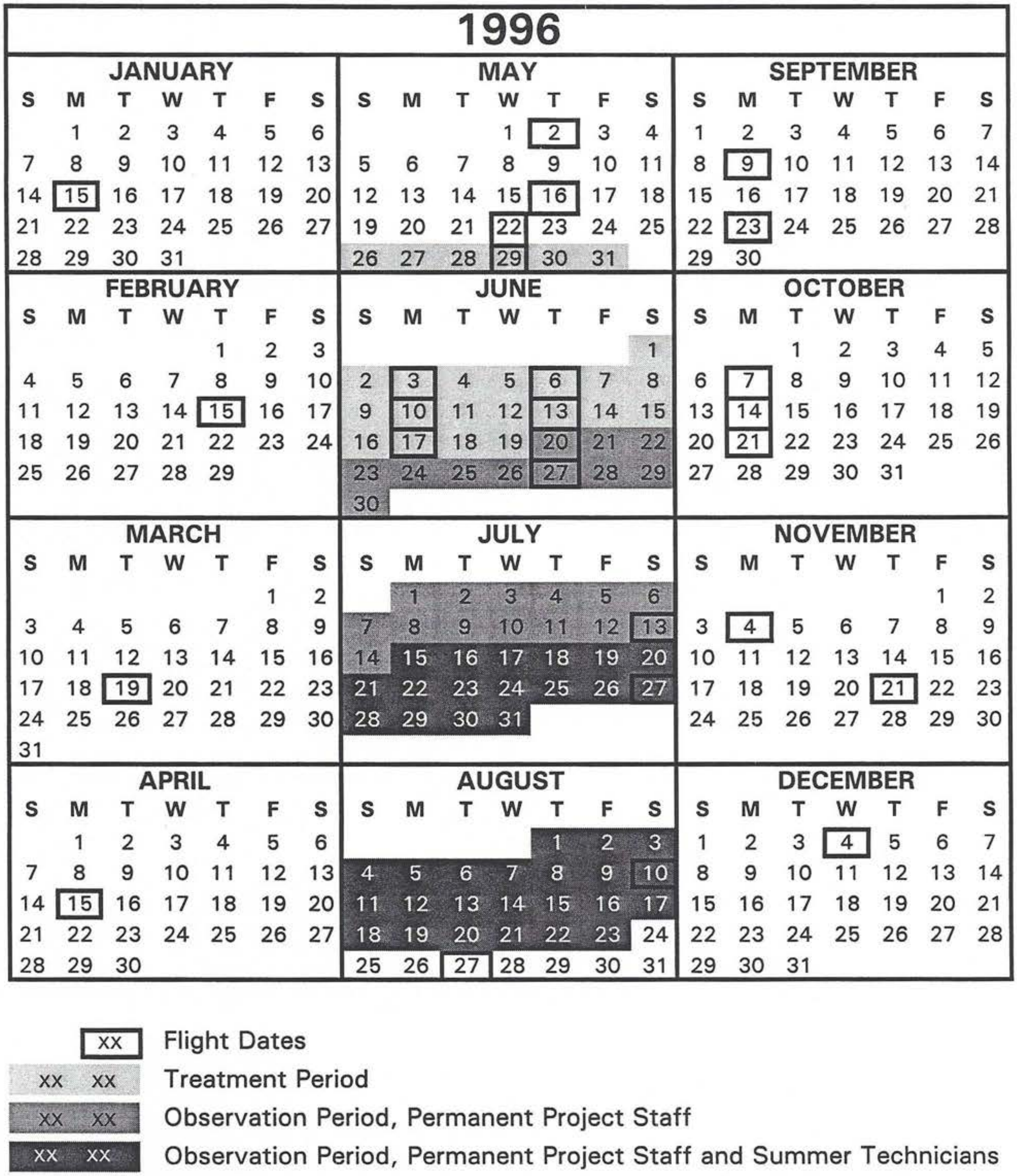

Figure 2. Flight schedule, and treatment and observation periods during 1996 for the Upper Eagle River Valley Elk Study.

3.1.1 Elk Distributions During Winter

Winter 1995-96 aerial telemetry relocations of randomly sampled elk are shown in Fig. 4 for the BC study area. These data resulted from 6 flights: November 20 and December 11, 1995, and the first 4 flights in 1996 (see Fig. 2). Winter 1994-95 aerial relocations are shown in Fig. 3, for comparison. These data resulted from 3 flights: January 31, March 18, and April 12, 1995.

During winter 1995-96, 126 relocations were obtained within the boundaries of the BC study area (50 during winter 1994-95). Forty-two percent of relocations on the BC study area during this period wintered between Lake and McCoy Creeks, compared to 44% in winter 1994-95. Twenty-one percent of relocations occurred between McCoy and Beaver Creeks in winter 1995-96 compared to 18% in 1994-95. The area between Beaver and Stone Creeks provided 32% of relocations in 1995-96 and 28% in 1994-95. Figure 4 shows one relocation southeast of Whiskey Creek and 3 between Grouse and Martin Creeks, in areas totally devoid of relocations during the previous winter. These data points, however, were from the November 20, 1995 flight (very early winter 1995-96) and Figure 3 (winter 1994-95) does not contain any data prior to January 31, 1995. All telemetered elk located during winter flights over the BC study area in 1995 and 1996 were below approximately 2800 m (9200 ft) elevation, with the exception of one relocation on November 20, 1995 at approximately 3000 m (9800 ft). These data indicate strong similarities in elk winter distributions between the 2 years.

Ground-based relocation data for winter 1995-96, are summarized in Table 1. General geographical descriptions were used because accurate point estimates could not be obtained from ground-based telemetry (Phillips and Alldredge 1996). Several general locations were outside the boundaries of our study areas. Appendix 2 includes a description of general locations. In some cases (Unknown), it was impossible to determine a likely location for a received signal.

Numbers provided in Table 1 are not numbers of elk, but numbers of relocations associated with a general location over the winter. We periodically conducted telemetry from a circuit of locations around each study area. Completion of each circuit resulted in 1 estimated general location per animal for which a signal was received. Table 1 includes multiple circuits and, therefore, multiple relocations per animal per general location.

Data in Table 1 supplement flight location data presented in Fig. 4. As in winter 1994-95, the greatest concentrations of relocations on the Beaver Creek study area occurred from Lake Creek to Stone Creek, reinforcing the importance of the northern perimeter of the BC study area as elk winter range. Not all elk captured on the BC study area remained there over winter. Approximately fourteen elk moved westward off the BC study area, wintering from the Squaw Creek drainage to the Brush Creek

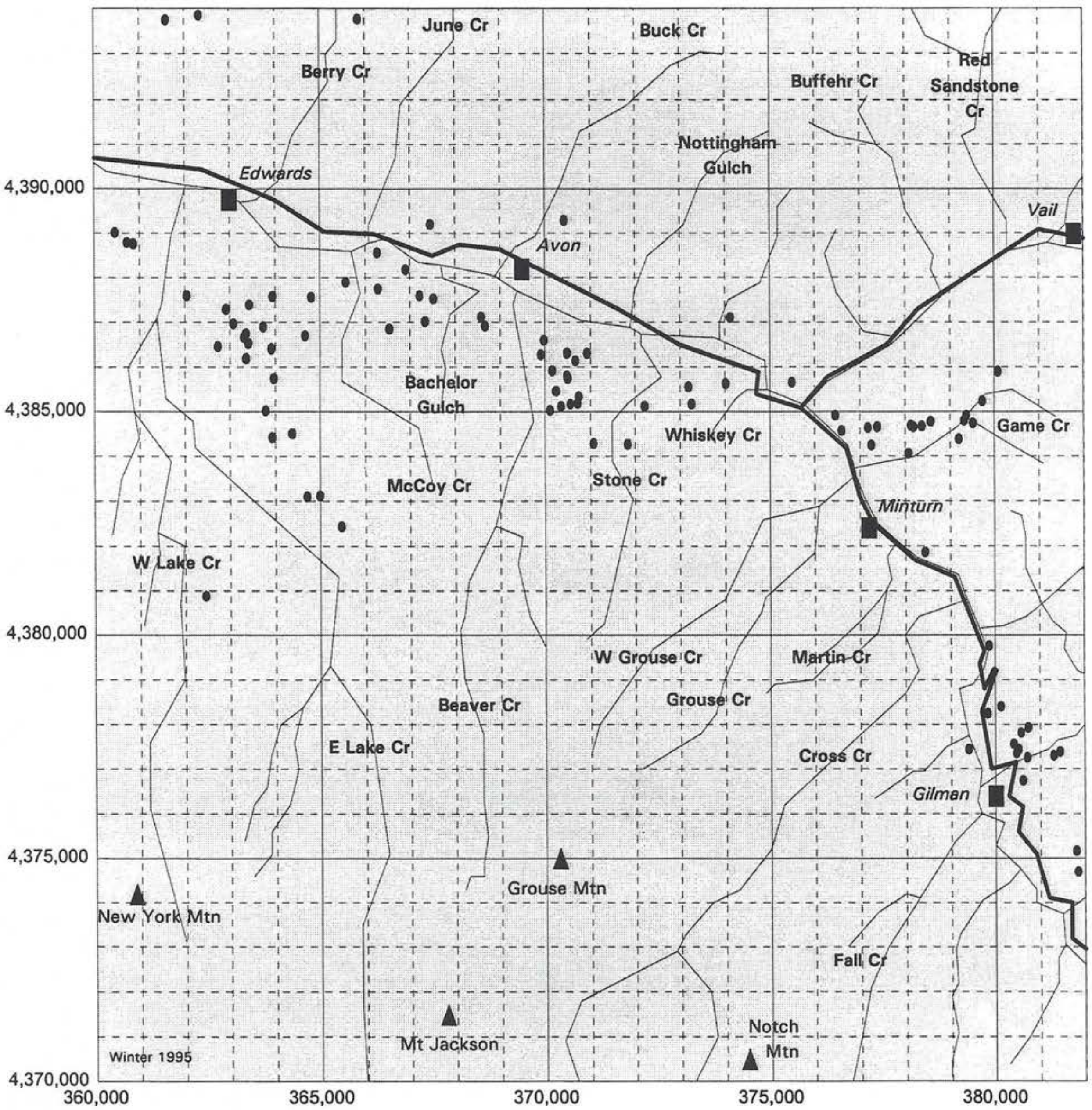

Figure 3. Elk locations from aerial telemetry for late winter, 1994-95 (BC study area). UTM grid units in metres.

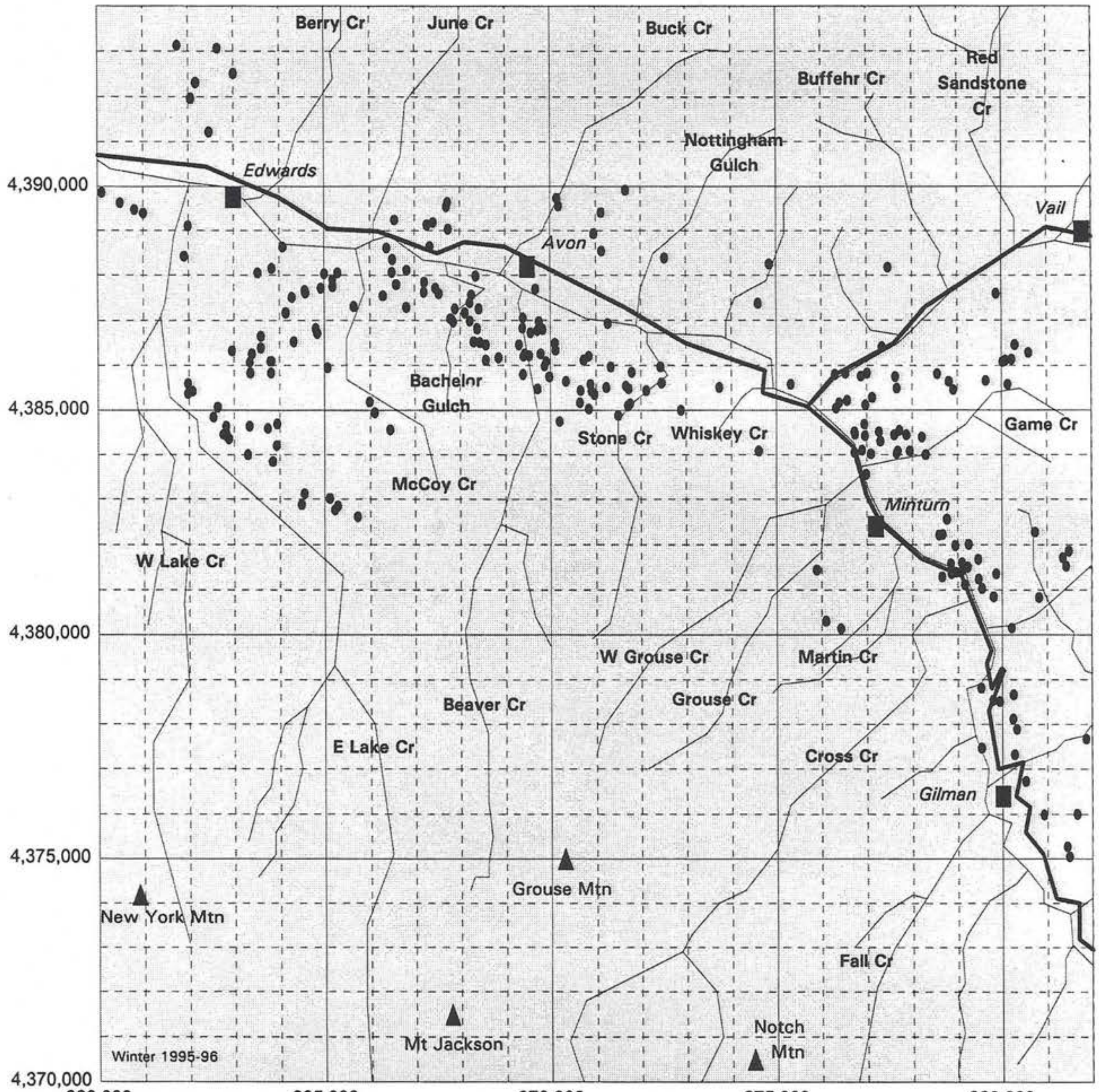

Figure 4. Elk locations from aerial telemetry for winter, 1995-96 (BC study area). UTM grid units in metres.

Table 1. General locations of elk associated with the Vail and Beaver Creek study areas from November 26, 1995 to April 15, 1996, obtained using ground-based telemetry and visual observation.

Study Area	General Location	Number of Relocations
Vail	Arkansas River Drainage, Above Leadville*	6
	Battle Mountain/Rock Creek	100
	Dowds Junction	390
	Eagle River, East Fork	29
	Game Creek	137
	Leadville, South of*	1
	Lionshead	402
	North of Interstate 70, Dowds Junction*	13
	Red Cliff, South of	20
	Resolution/McAllister/Camp Hale	46
	Tennessee Park*	1
	Turkey Creek Drainage	270
	Two Elk Creek Drainage	6
	West Vail	59
	Unknown	152
Beaver Creek	Beaver Creek	426
	Bellyache Ridge*	1
	Brush/Salt Creek*	7
	Edwards Area*	11
	Grouse Creek	1
	Lake Creek Drainage*	342
	McCoy Creek/Bachelor Gulch	361
	McCoy/Eagle River Confluence	29
	Meadow Mountain/Whiskey Creek	26
	North of Interstate 70, Dowds Jct - Edwards*	81
	North of Interstate 70, Edwards - Red Canyon Cr*	84
	North of Interstate 70, Wolcott*	12
	Squaw Creek*	91
	Stone Creek	155
	Unknown	287

* General location is partially or completely off of study area.

drainage. Approximately 18 wintered north of Interstate 70. Most of these elk returned to the BC study area sometime during spring or summer.

Winter 1994-95 aerial telemetry relocations of randomly sampled elk are shown in Fig. 5 for the VA study area. Only 2 flights are represented in Fig. 5: March 18 and April 12, 1995. We were unable to conduct the January 31 flight over the VA study area. Winter 1995-96 aerial relocations are shown in Fig. 6. These data resulted from the same 6 flights represented in Fig. 4.

3.1.2 Elk Distributions in Early May

Two flights were conducted in early May, 1996. This period may be viewed as intermediate between winter and calving season. Relocation data are provided for these flights for the BC study area in 1995 and 1996 (Figs. 7 and 8, respectively) and for the VA study area in 1995 and 1996 (Figs. 9 and 10, respectively).

3.1.3 Elk Distributions During Calving Season

Documenting spatial use by elk during calving seasons is an important objective of our study. We estimated the period of peak calving activity for elk on our study areas using elk reproduction data from previous studies. Bear (1989) observed and Byrne (1990) estimated parturition dates, and Freddy (1989,1993) estimated conception dates for elk in Colorado. Based on these data and a median gestation period of 255 days (Bubenik 1982), we established a treatment period from May 26 to June 19, to coincide with the peak calving period. Treatment applied during this period should affect approximately 85 to 94% of postpartum cows. To describe spatial use by elk during calving season we will use a longer time frame. Data from studies cited above indicate that, in Colorado, over 90% of calves are born between mid-May and the end of June. We use elk location data within this time frame to represent spatial use during calving season.

From May 21 to June 26, 1995, 9 flights produced 180 relocations within the BC study area (Phillips and Alldredge 1996). Figure 11 show these relocation data for comparison with 1996 data. Nine flights in 1996, from May 22 to June 27 (see Fig. 2 for flight dates), produced 250 relocations within the BC study area (Fig. 12). From a visual examination of these maps, it appears that elk were more widely dispersed across the study area and were at higher elevations in 1996 than in 1995. Only 17% of relocations were obtained between Lake and McCoy Creeks in 1996 compared to 32% in 1995. Nine percent of relocations occurred between McCoy and Beaver Creeks in 1996 (18% in 1995). In 1995, 40% of relocations were between Stone and Cross Creeks, with no relocations from upper reaches of Grouse and West Grouse Creeks or from Grouse Mountain. Sixty-three percent of relocations in 1996 came from these areas. In 1996 elk were farther up all drainages on the BC study area, with

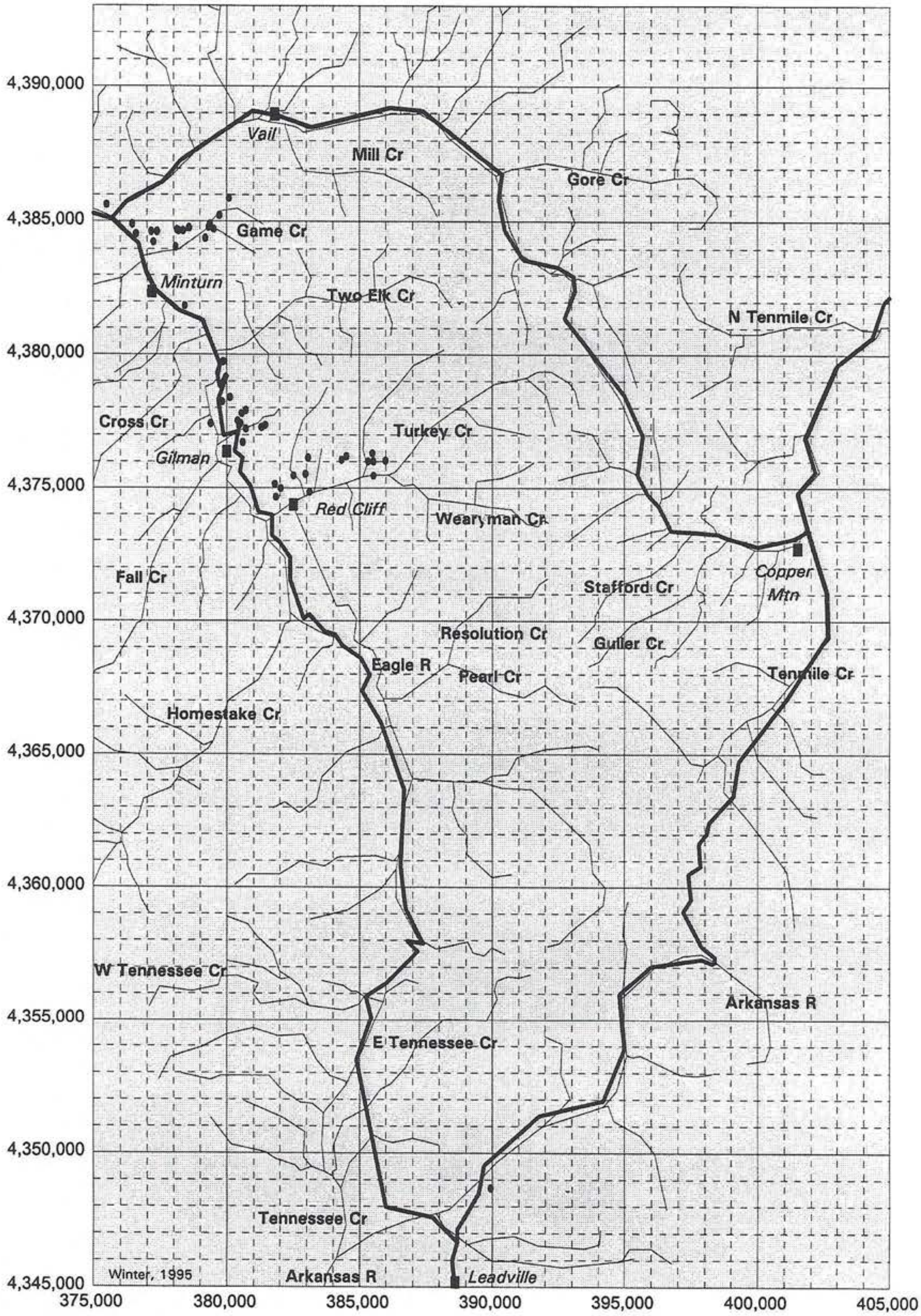

Figure 5. Elk locations from aerial telemetry for late winter, 1994-95 (VA study area). UTM grid units in metres.

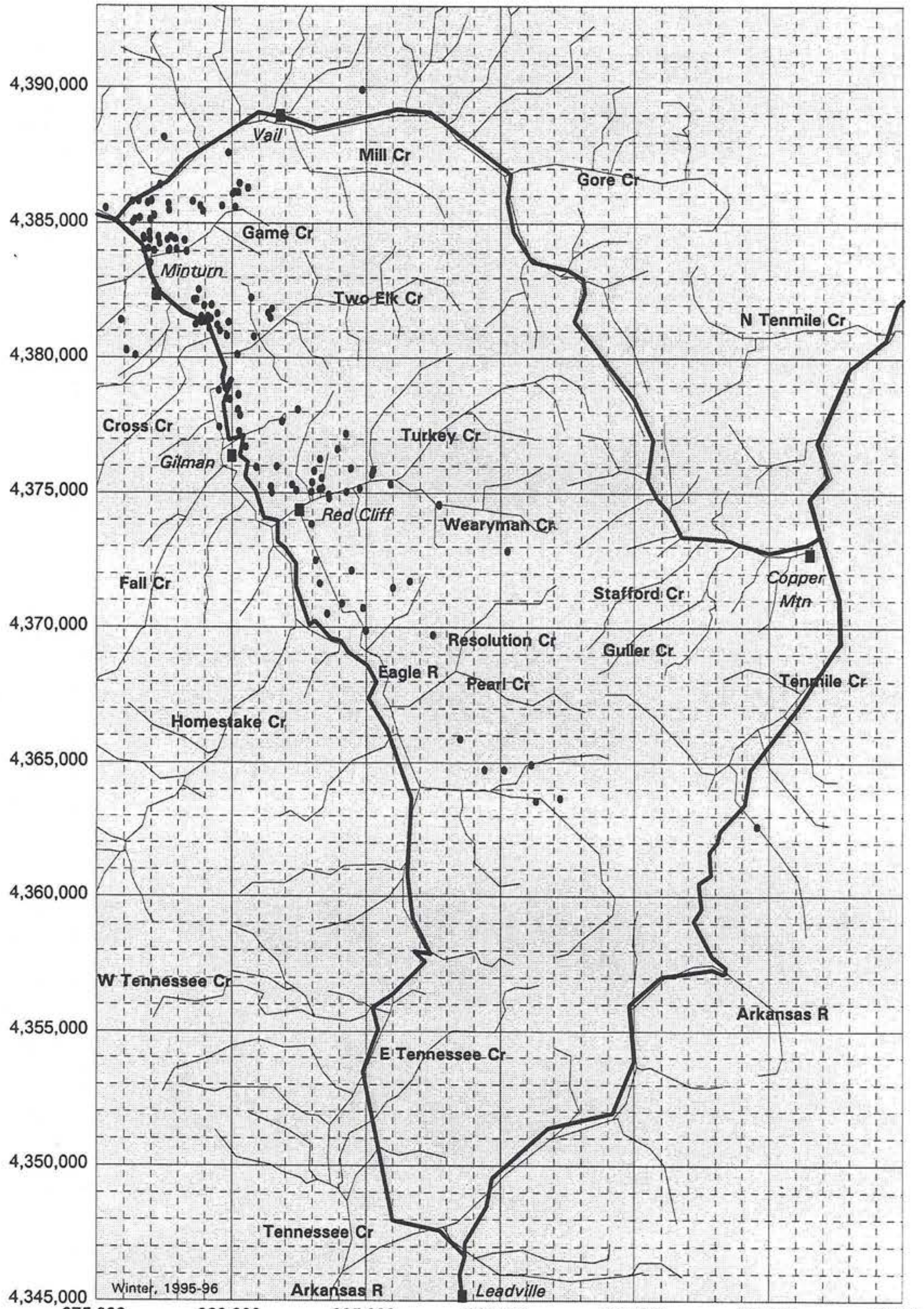

Figure 6. Elk locations from aerial telemetry for winter, 1995-96 (VA study area). UTM grid units in metres.

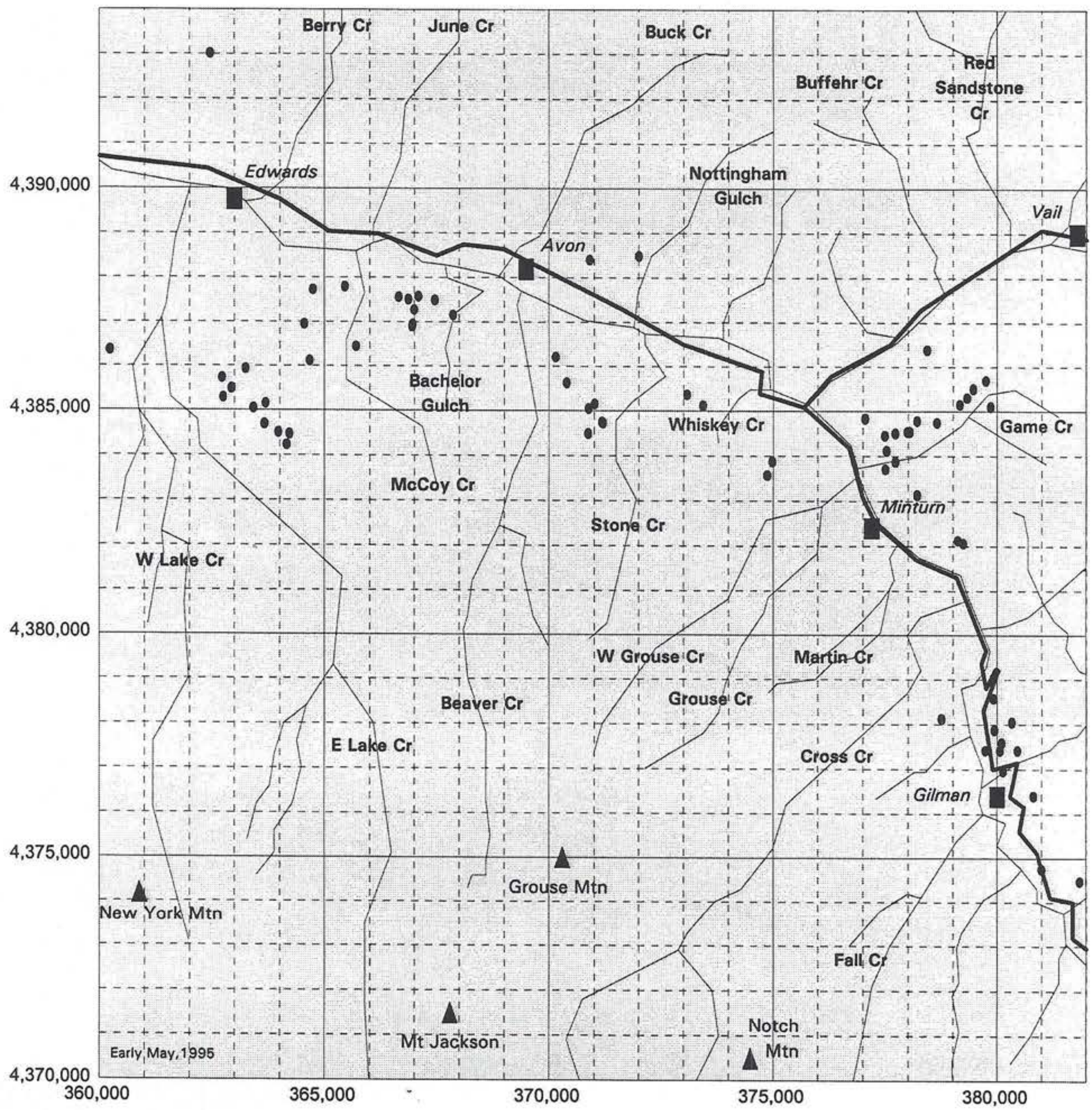

Figure 7. Elk locations from aerial telemetry for early May, 1995 (BC study area). UTM grid units in metres.

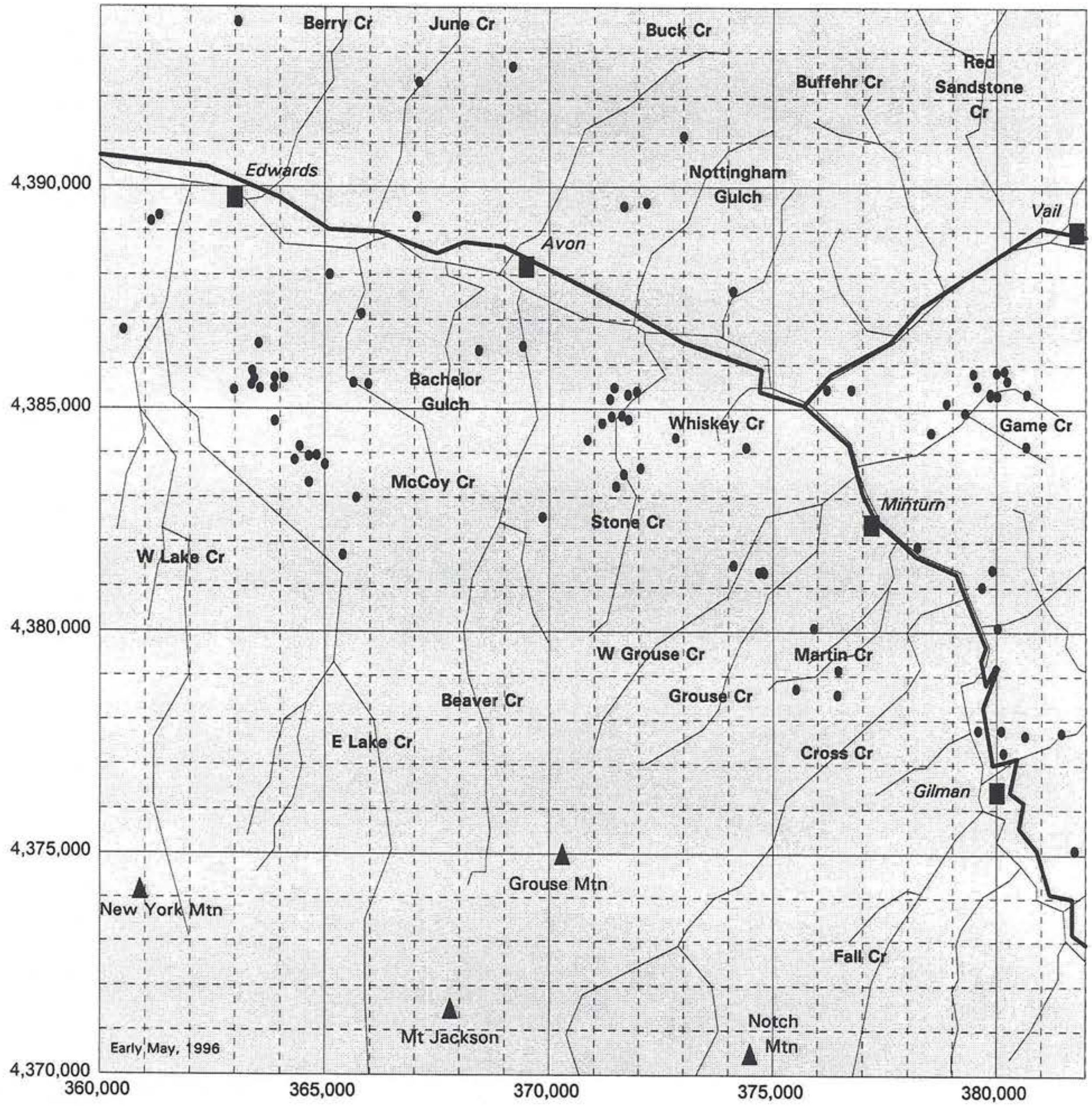

Figure 8. Elk locations from aerial telemetry for early May, 1996 (BC study area). UTM grid units in metres.

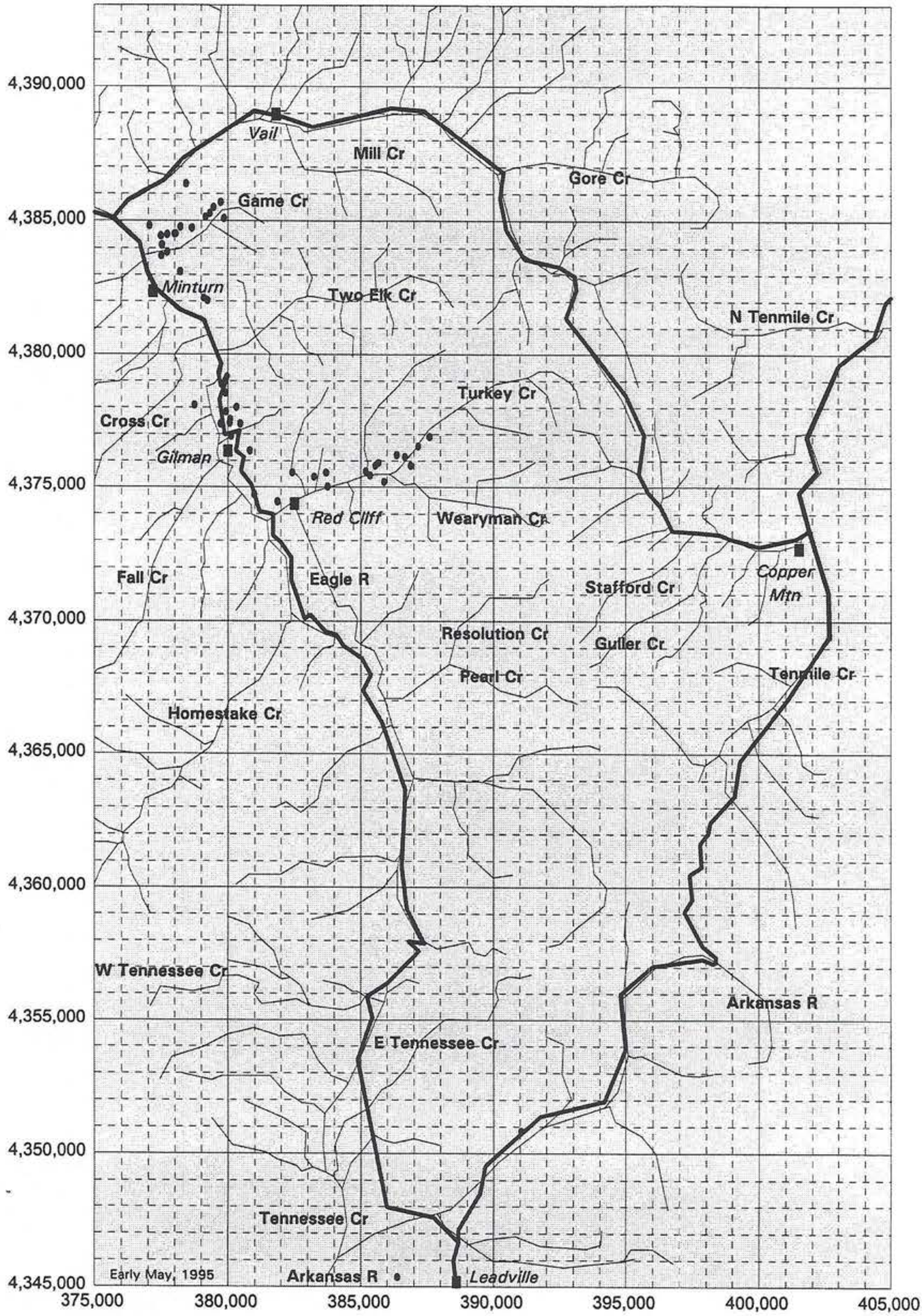

Figure 9. Elk locations from aerial telemetry for early May, 1995 (VA study area). UTM grid units in metres.

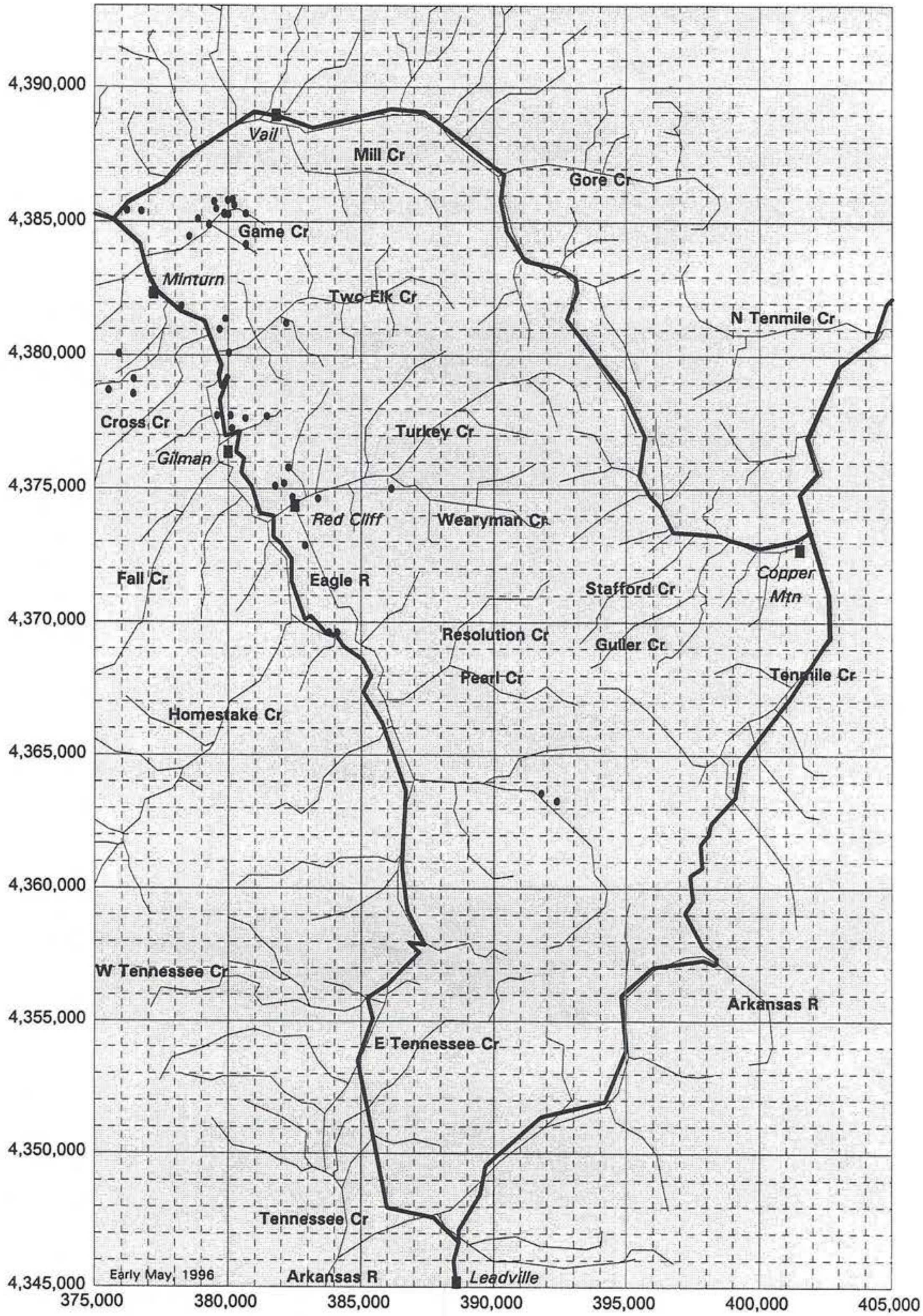

Figure 10. Elk locations from aerial telemetry for early May, 1996 (VA study area). UTM grid units in metres.

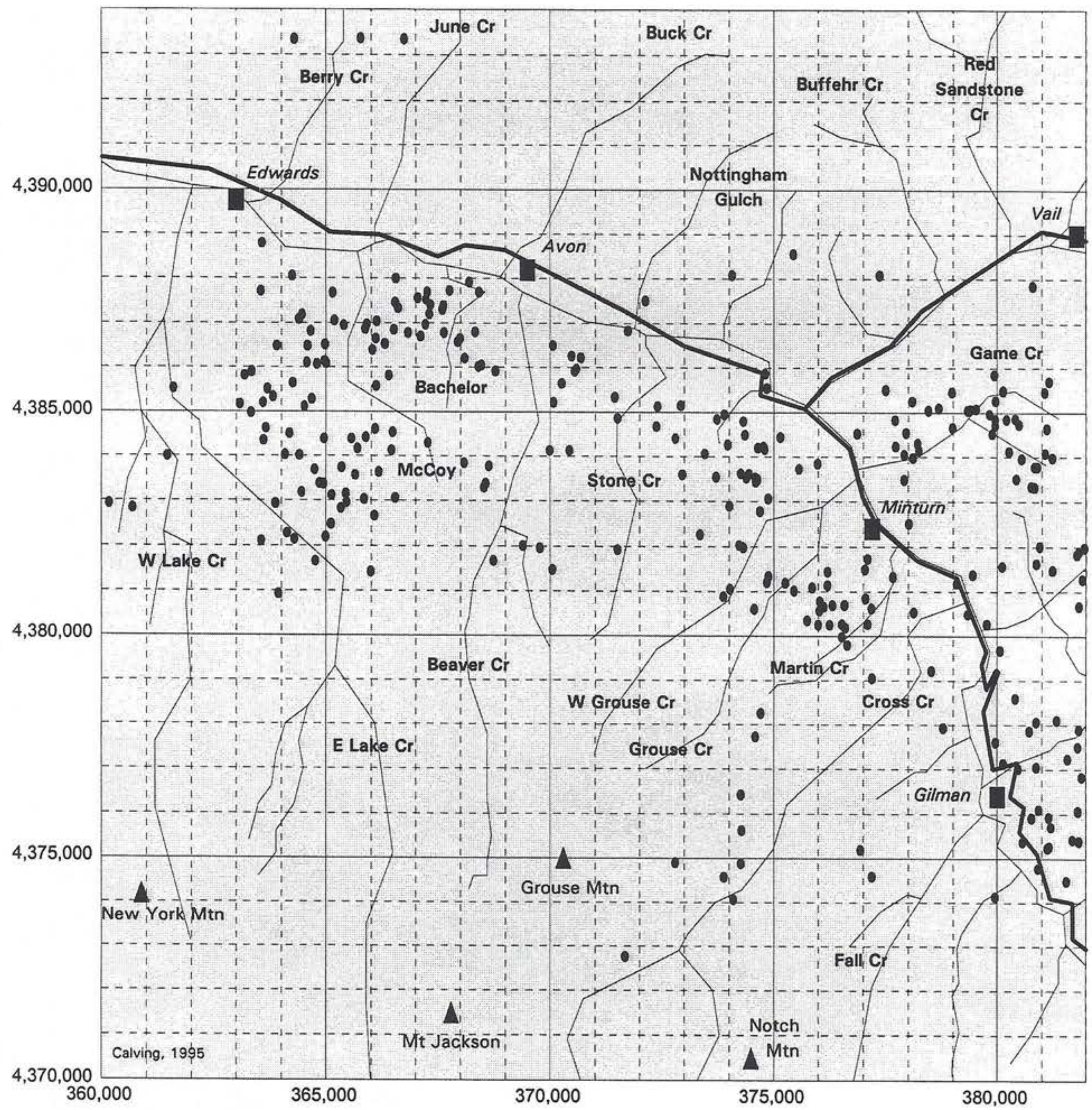

Figure 11. Elk locations from aerial telemetry for calving season, 1995 (BC study area). UTM grid units in metres.

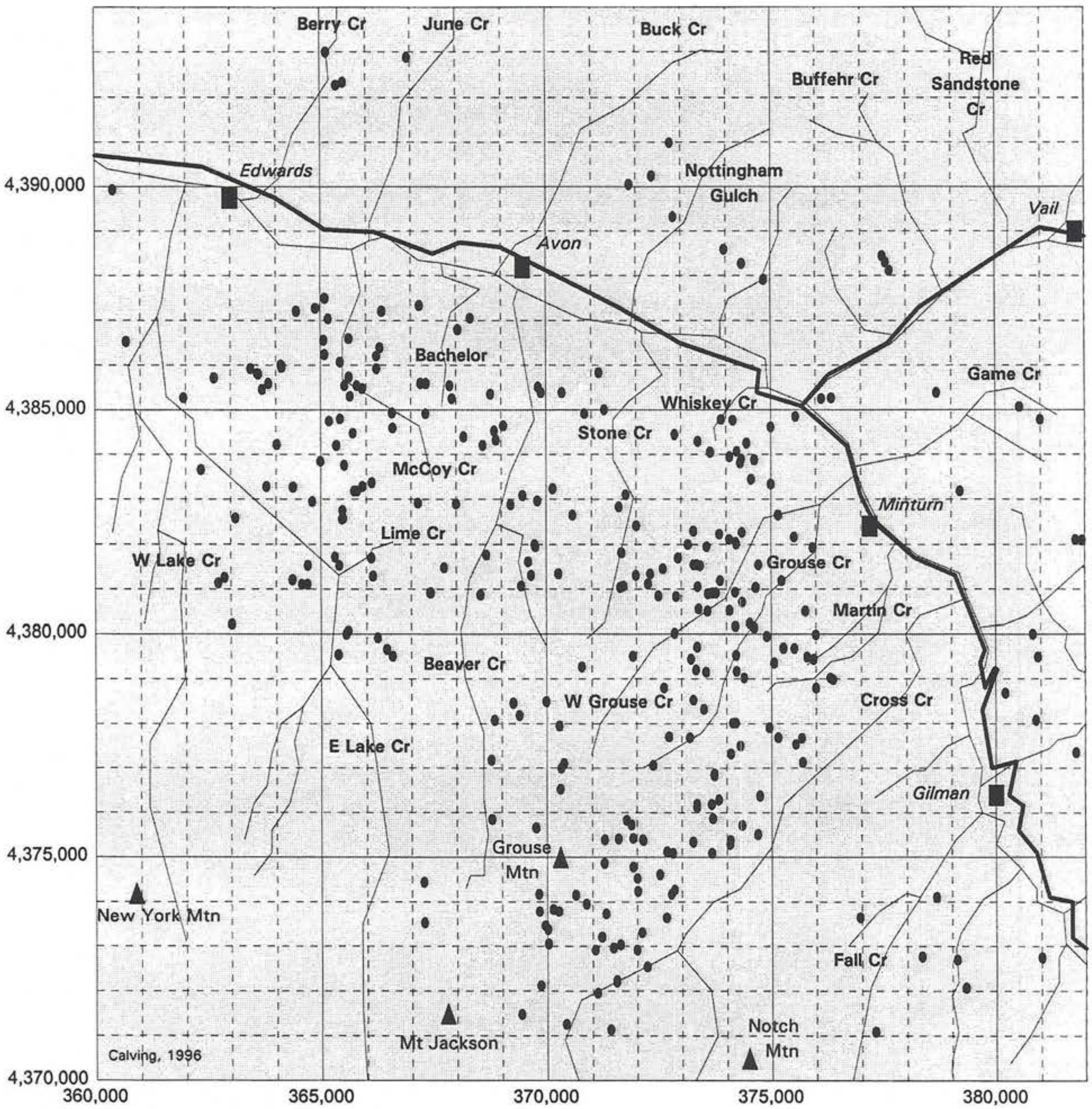

Figure 12. Elk locations from aerial telemetry for calving season, 1996 (BC study area). UTM grid units in metres.

many relocations obtained from Grouse Mountain, especially on the south and east faces.

At least 2 factors may have contributed to differences in calving-season spatial use patterns of elk between 1995 and 1996. The first factor is snow cover and related forage availability. Based on our observations on the study area, spring/summer snow depth and coverage were much greater, and high-elevation forage quantity was much lower in 1995 than 1996. Accessibility of high-elevation ranges was probably restricted and incentive for elk to move to higher elevations was probably low. The second factor was an increase in human activity in 1996, associated with construction in Bachelor Gulch and with our application of treatment. We maintained a regular presence and an intense level of activity during most of the calving season in "accessible" (mostly lower elevation) areas of the BC study area. More details are provided in section 4 of this report, including maps showing distributions of treatment effort.

Aerial-telemetry elk relocations are shown for calving season on the VA study area for 1995 (Fig. 13) and 1996 (Fig. 14). The number and dates of flights are the same as for Figs. 11 and 12, except that only 8 flights were conducted during calving season in 1995 over the VA study area: the May 31 flight was canceled due to poor weather. Spring/summer snow depth and coverage was greater on the VA study area in 1995 than 1996, however, as far as we know, levels of human activity during calving season were similar for both years. There are some distinct differences in elk distributions between 1995 and 1996. Game Creek and the west facing slope between Gilman and Red Cliff were heavily used in 1995, but not in 1996. In general, elk appeared to be at higher elevations in all drainages on the west side of the VA study area in 1996. Also, more elk were occupying the summer ranges in the upper Tenmile Creek drainage, south of Interstate 70 (e.g. Wilder, Stafford and Guller Creeks) in 1996 than 1995. All of these observations are consistent with the idea that heavy snow cover in 1995 restricted and delayed the typical west to east movement of elk from winter to summer ranges on the VA study area.

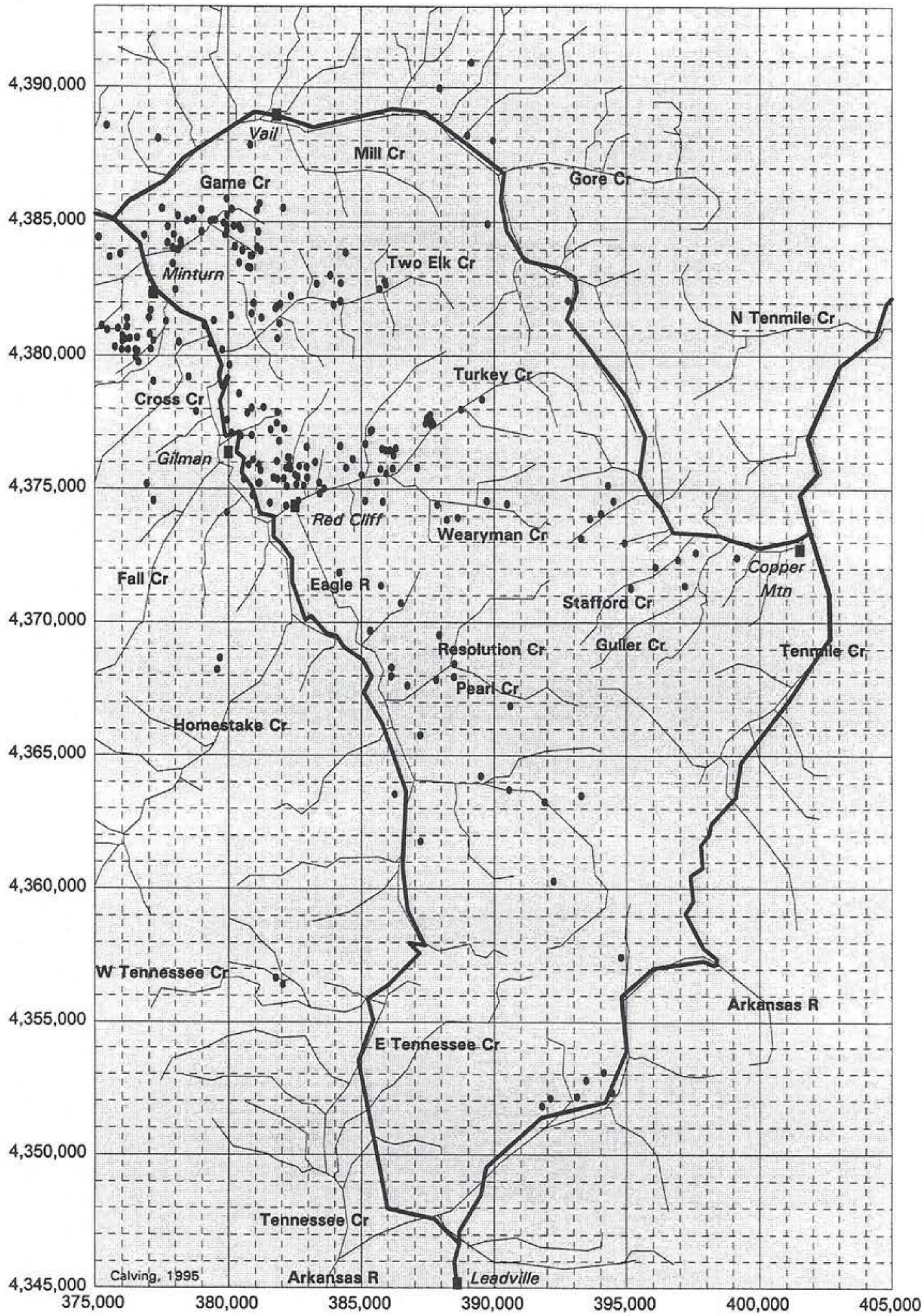

Figure 13. Elk locations from aerial telemetry for calving season, 1995 (VA study area). UTM grid units in metres.

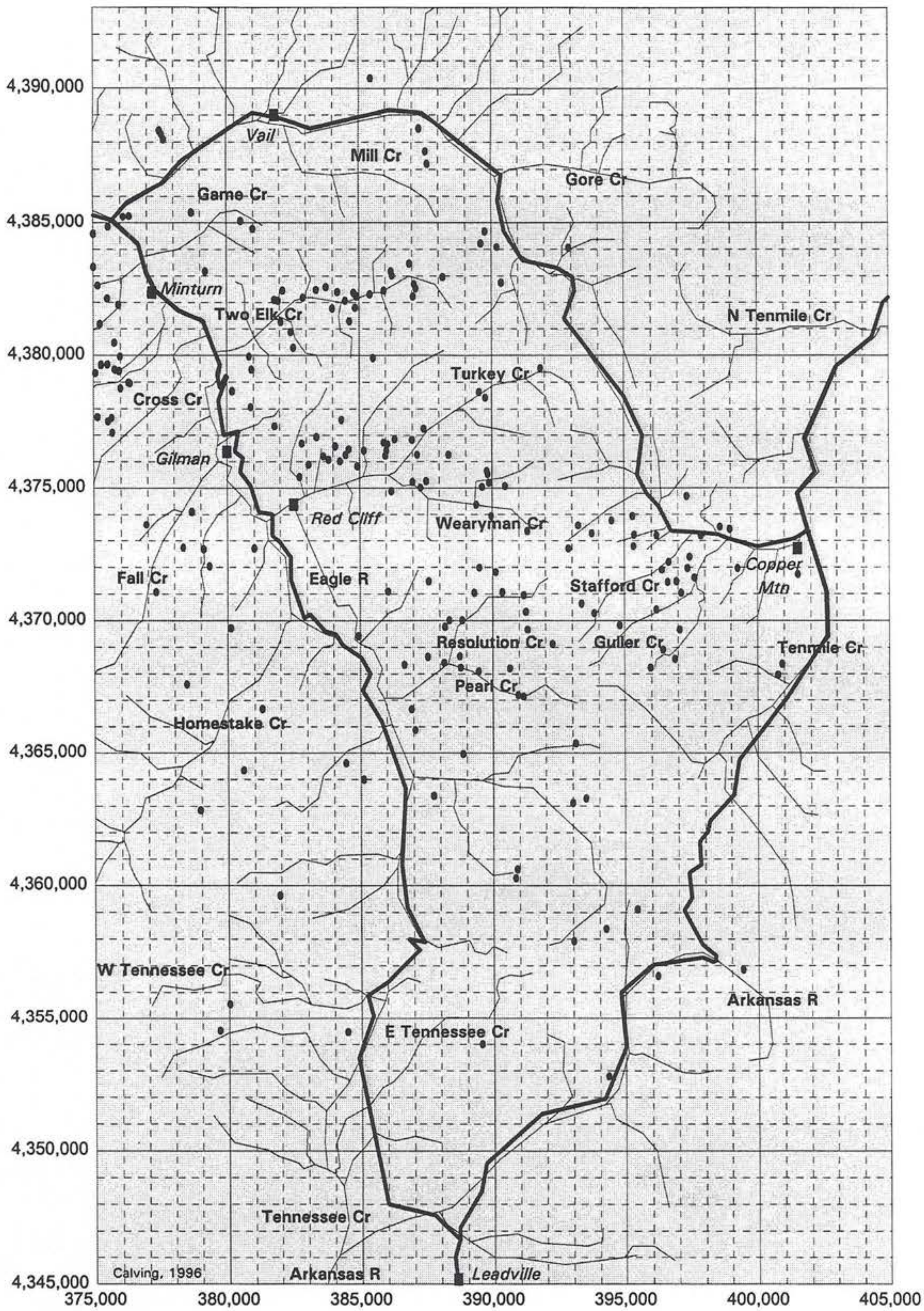

Figure 14. Elk locations from aerial telemetry for calving season, 1996 (VA study area). UTM grid units in metres.

3.1.4 Elk Distributions During Hunting Seasons

Three flights were combined to describe the distribution of elk during the 1995 archery season (Phillips and Alldredge 1996). A map showing these relocations on the BC study area (Fig. 15) is provided for comparison with 1996 data. In 1996, one flight was conducted on August 27 (2 days prior to the start of archery season) and 2 flights during the archery season (see Fig 2 for flight dates). These data are shown in Figs. 16 and 17, respectively. Similarly, relocations for the VA study area are provided for 1995 (Fig. 18), August 27, 1996 (Fig. 19) and archery season 1996 (Fig. 20).

In both 1995 and 1996, 1 flight was conducted between archery and first rifle seasons. In both years, there was 1 flight per regular rifle season, occurring from 1 to 3 days after opening day. Relocation data for each of these flights are provided for both study areas in Figs. 21-28.

3.2 Summary of Elk Mortality

In Table 2 we summarize 24 mortalities of telemetered elk that occurred in 1996. Fifteen VA animals and 9 BC animals died in 1996. The largest cause of mortality was hunter harvest (12), followed by starvation (5), road kill (4), mountain lion predation (2) and 1 of unknown causes.

Table 3 describes 3 animals of unknown fate. Two of these elk (2H and 4E) were probably hunting mortalities since they disappeared during hunting season. Because K6 disappeared in May, it will be difficult to classify her fate if she does not reappear. We will continue to monitor these frequencies until the end of the study.

In 1995, we had 1 animal of unknown fate that disappeared during hunting season. The collar (2A) was recovered in June, 1996. The transmitter was completely destroyed, apparently by a bullet, confirming that the animal was a hunting mortality.

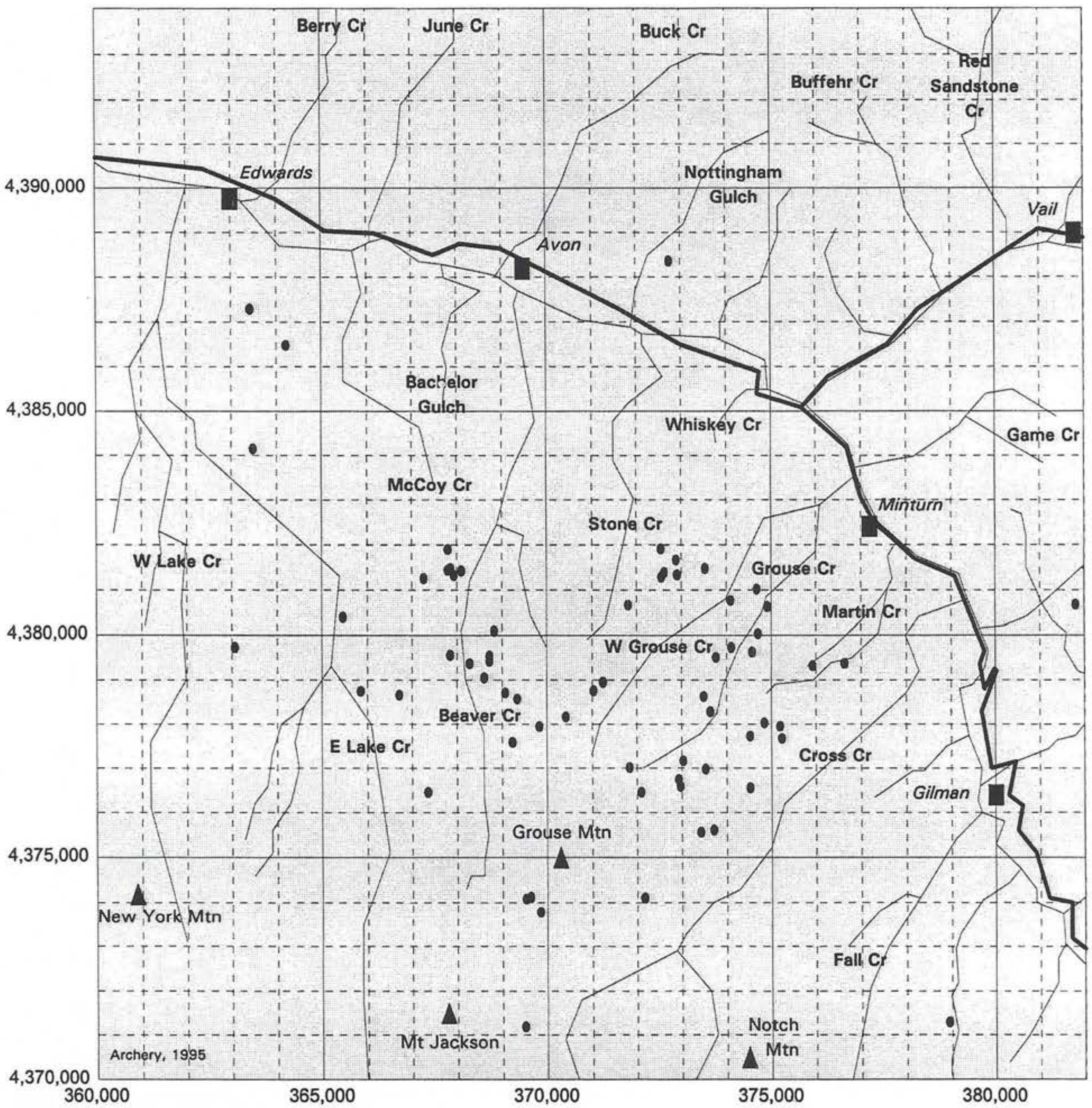

Figure 15. Elk locations from aerial telemetry for archery season, 1995 (BC study area). UTM grid units in metres.

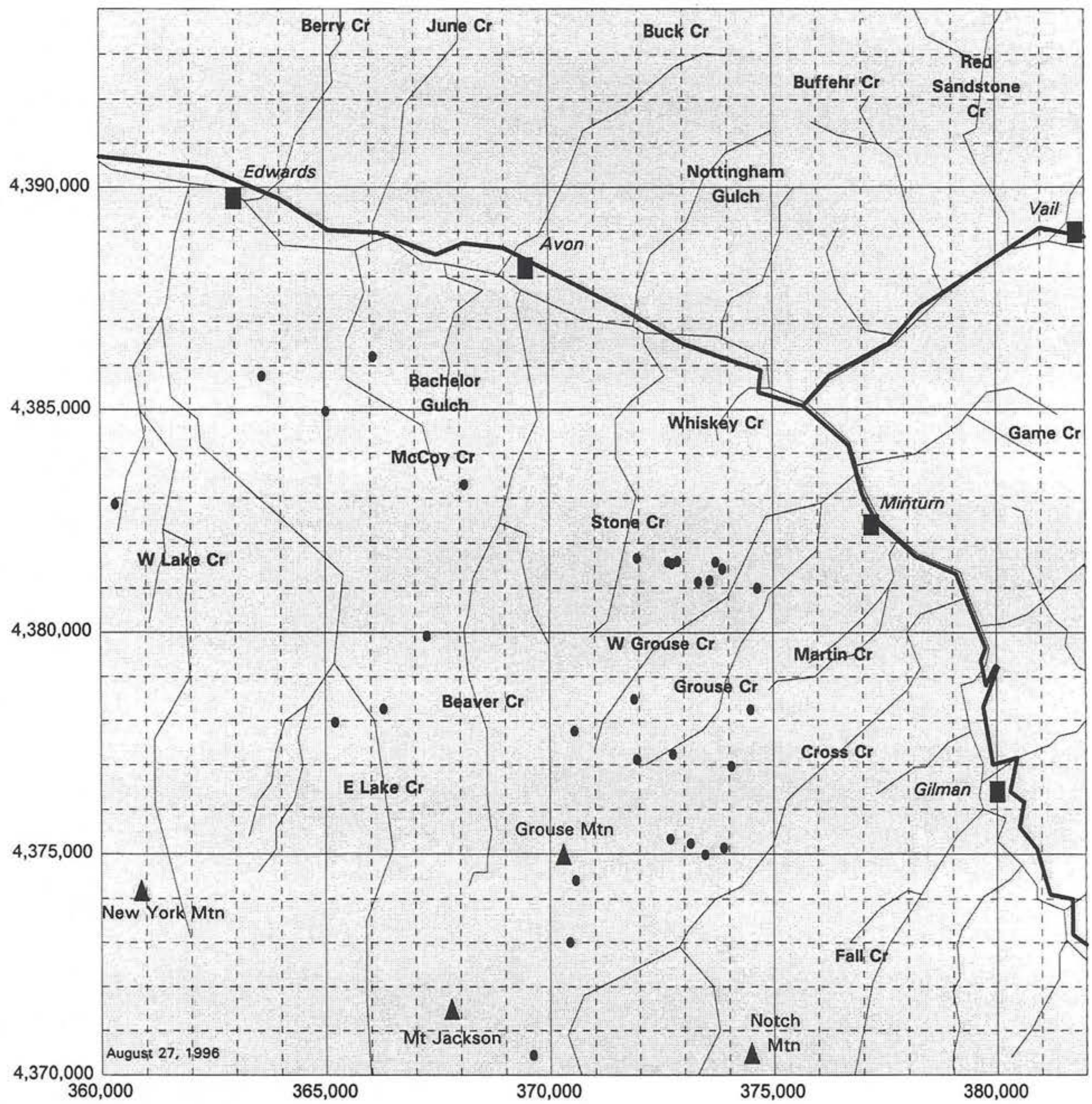

Figure 16. Elk locations from aerial telemetry for August 27, 1996 (BC study area). UTM grid units in metres.

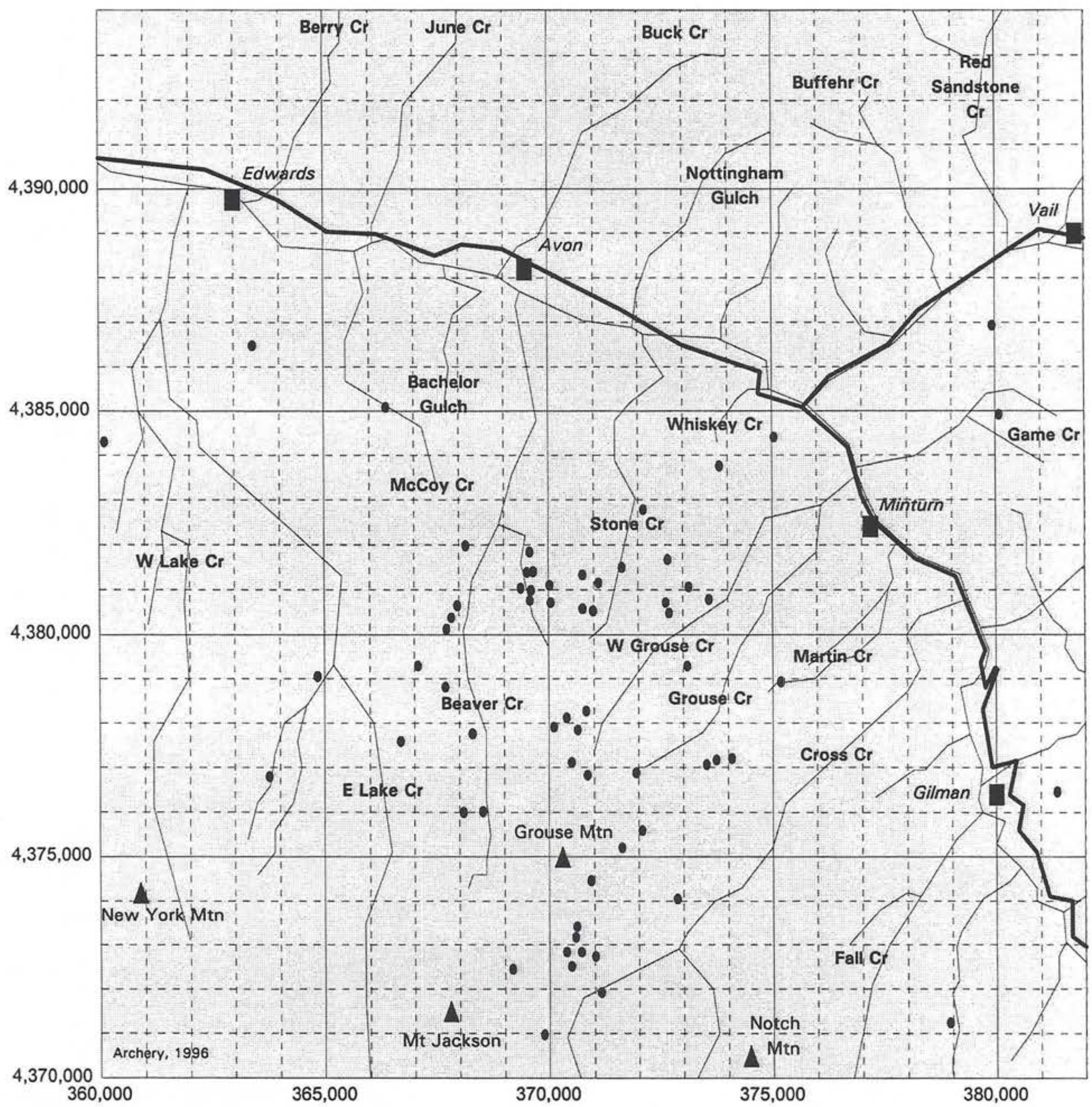

Figure 17. Elk locations from aerial telemetry for archery season, 1996 (BC study area). UTM grid units in metres.

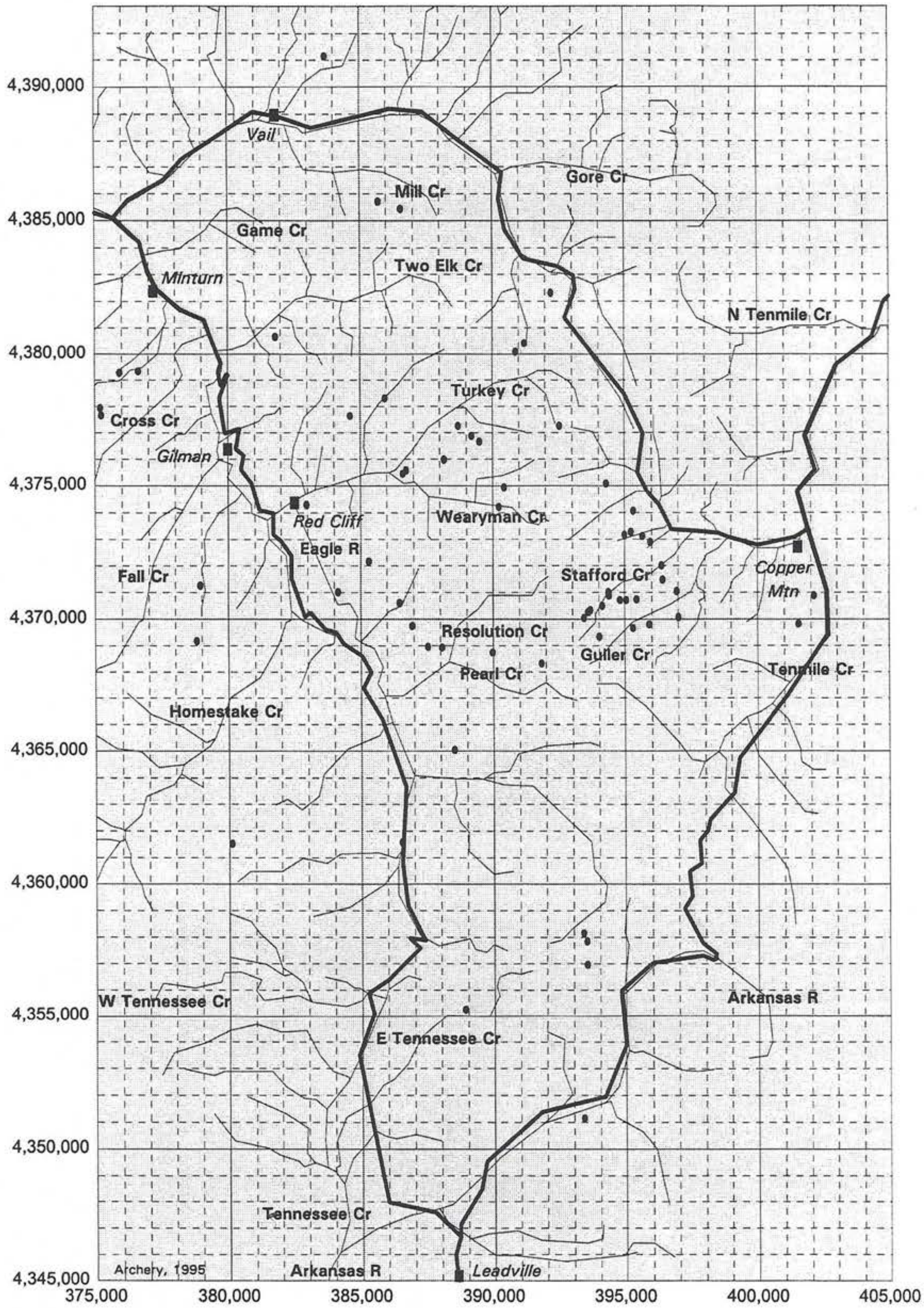

Figure 18. Elk locations from aerial telemetry for archery season, 1995 (VA study area). UTM grid units in metres.

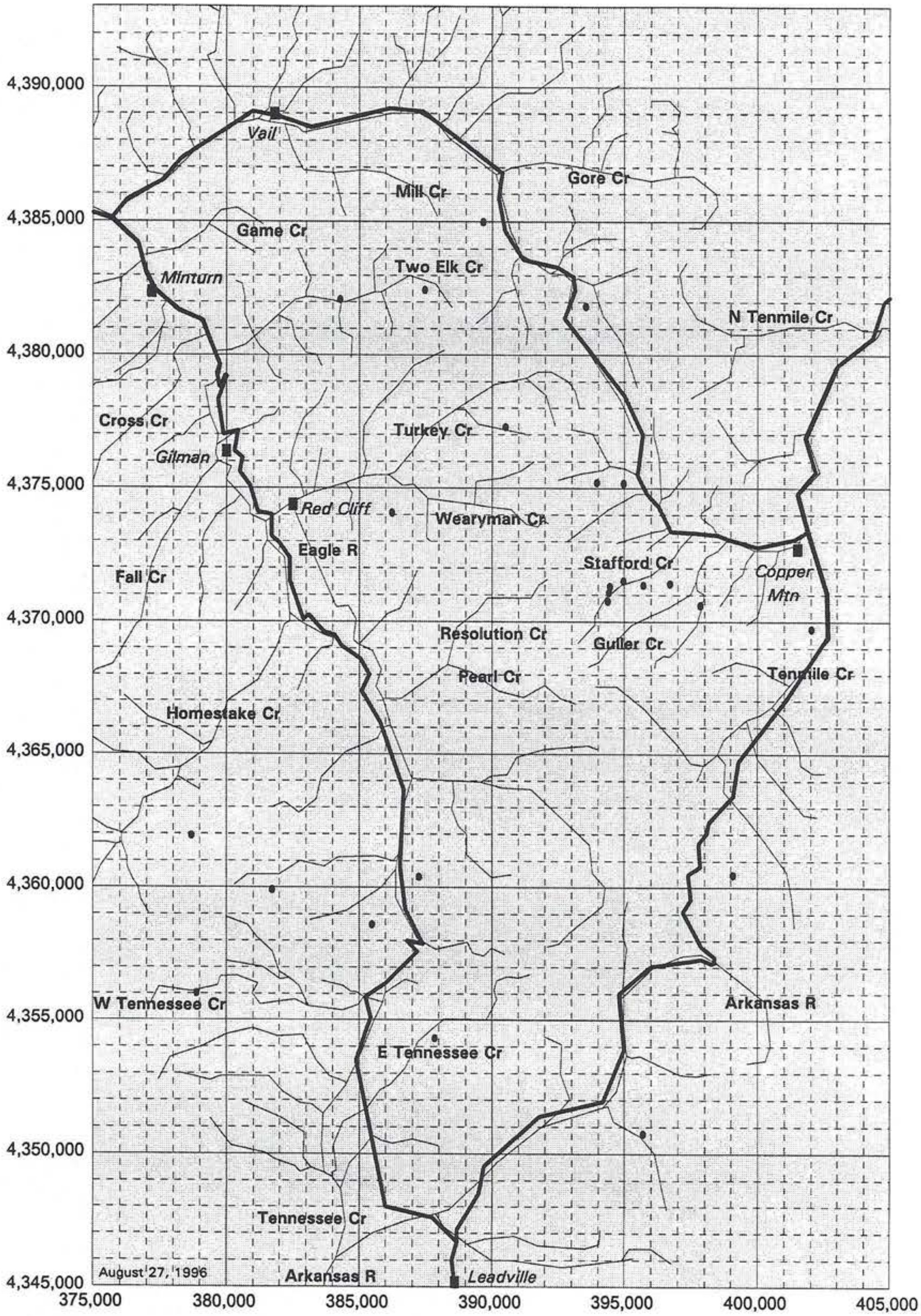

Figure 19. Elk locations from aerial telemetry for August 27, 1996 (VA study area). UTM grid units in metres.

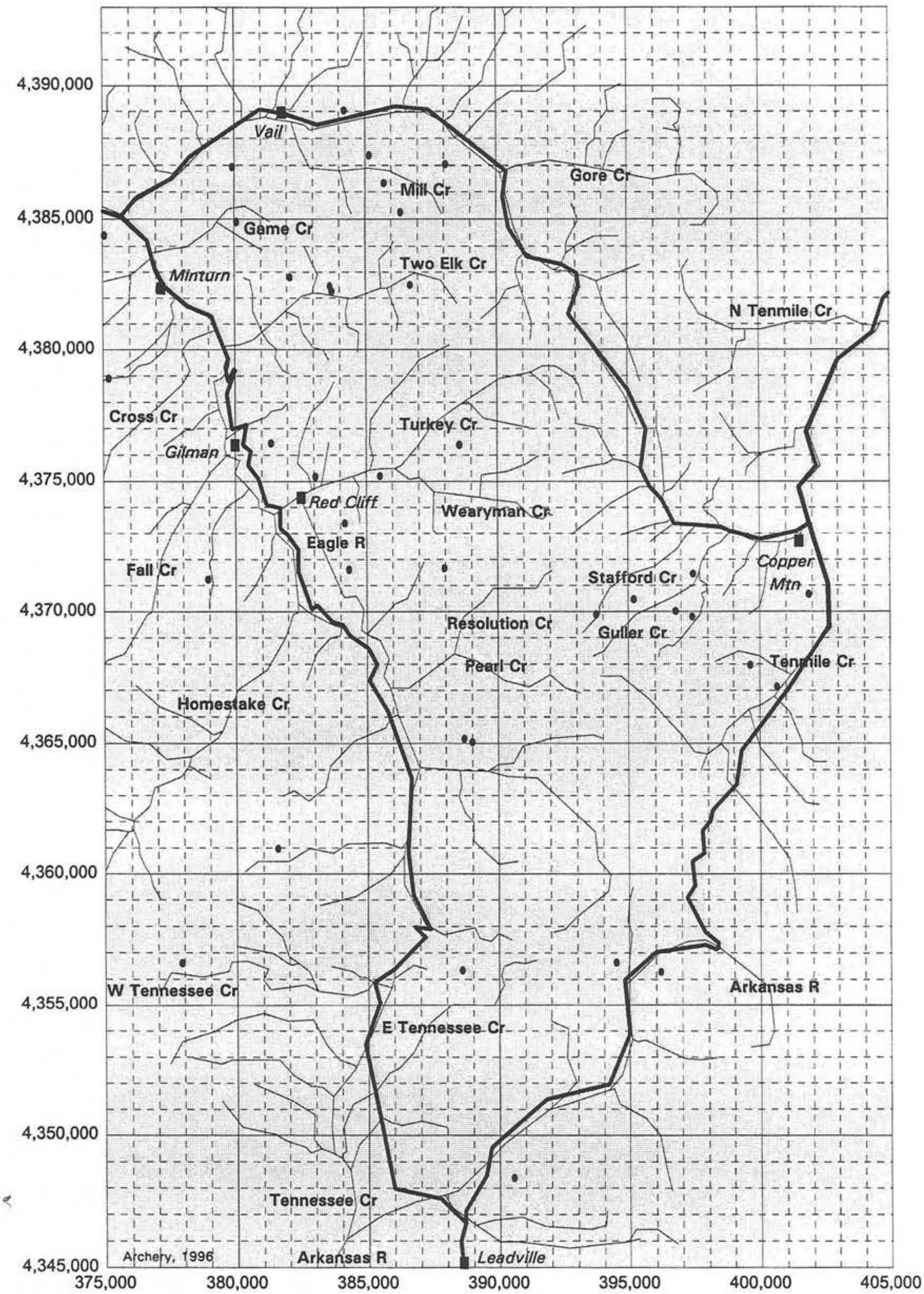

Figure 20. Elk locations from aerial telemetry for archery season, 1996 (VA study area). UTM grid units in metres.

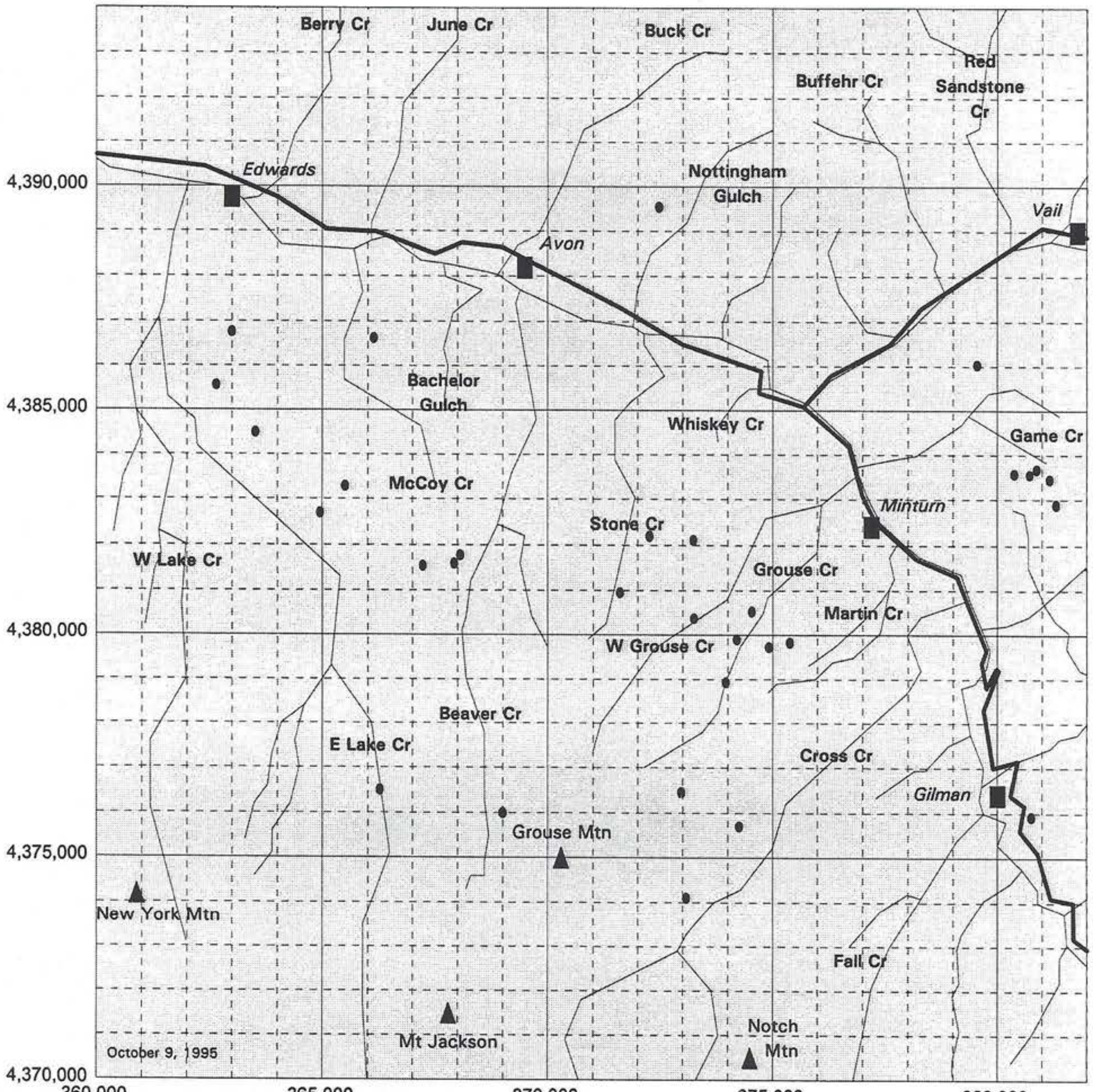

Figure 21. Elk locations from aerial telemetry for October 9, 1995 (BC study area). UTM grid units in metres.

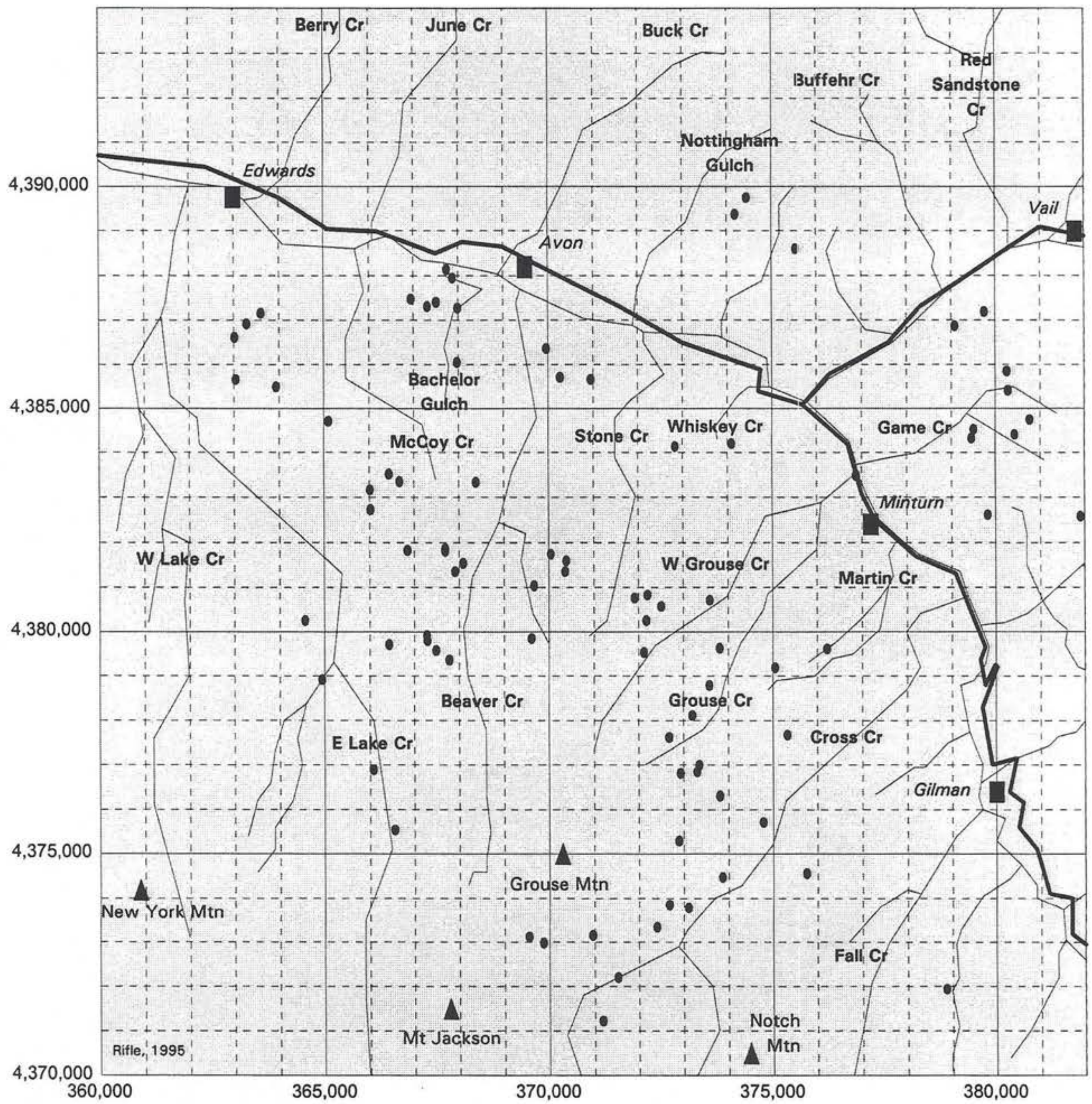

Figure 22. Elk locations from aerial telemetry for rifle seasons, 1995 (BC study area). UTM grid units in metres.

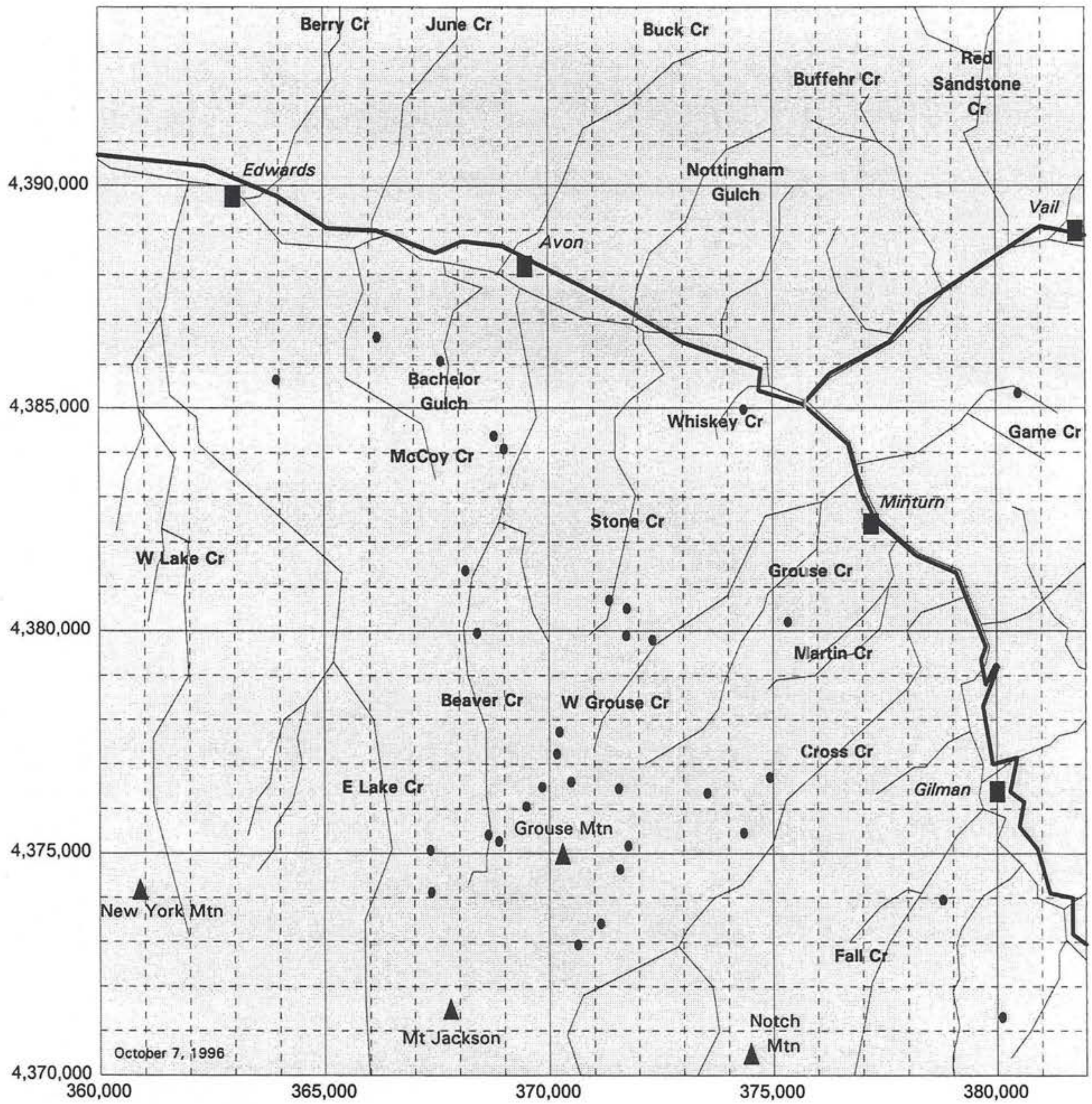

Figure 23. Elk locations from aerial telemetry for October 7, 1996 (BC study area). UTM grid units in metres.

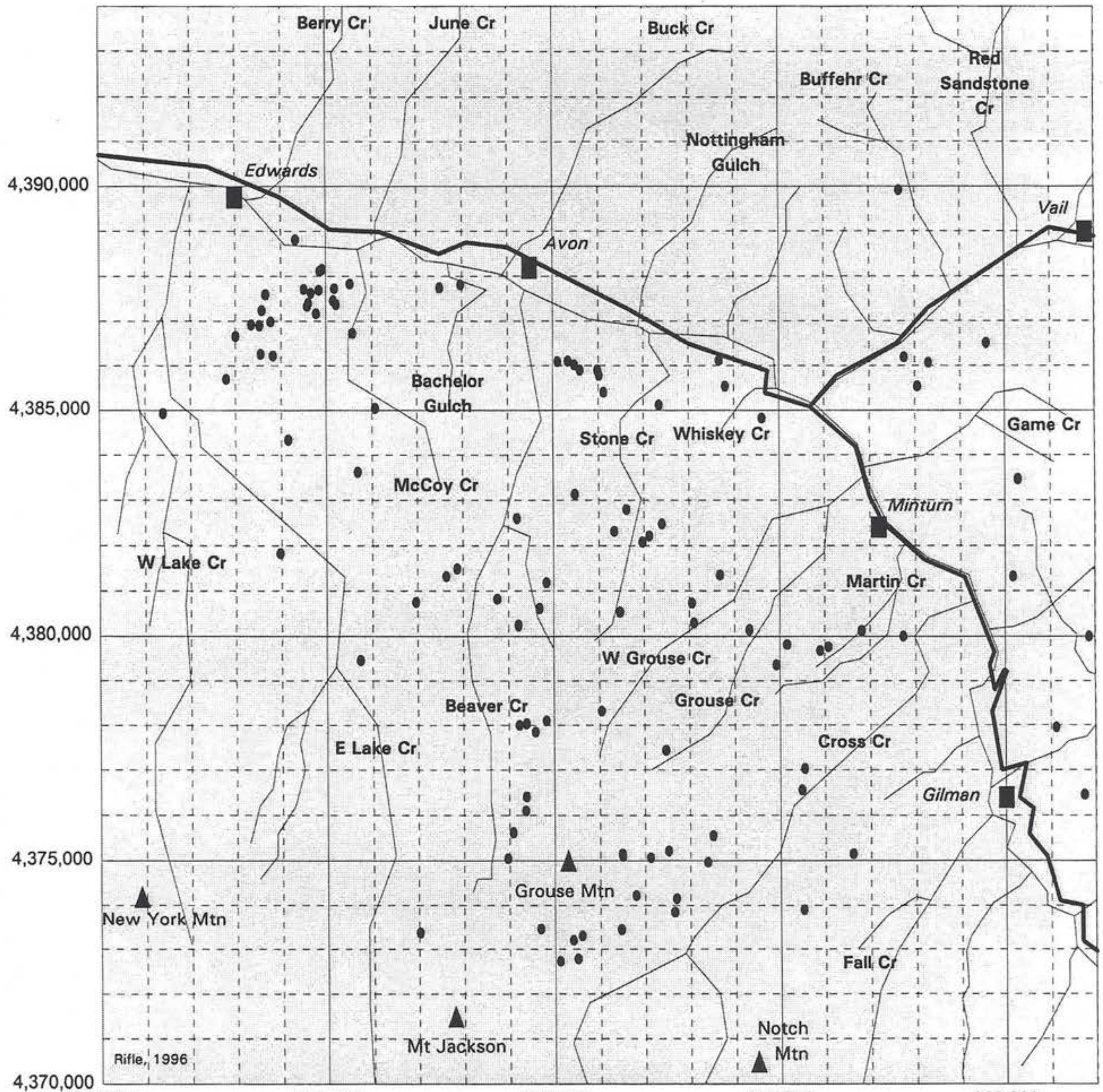

Figure 24. Elk locations from aerial telemetry for rifle seasons, 1996 (BC study area). UTM grid units in metres.

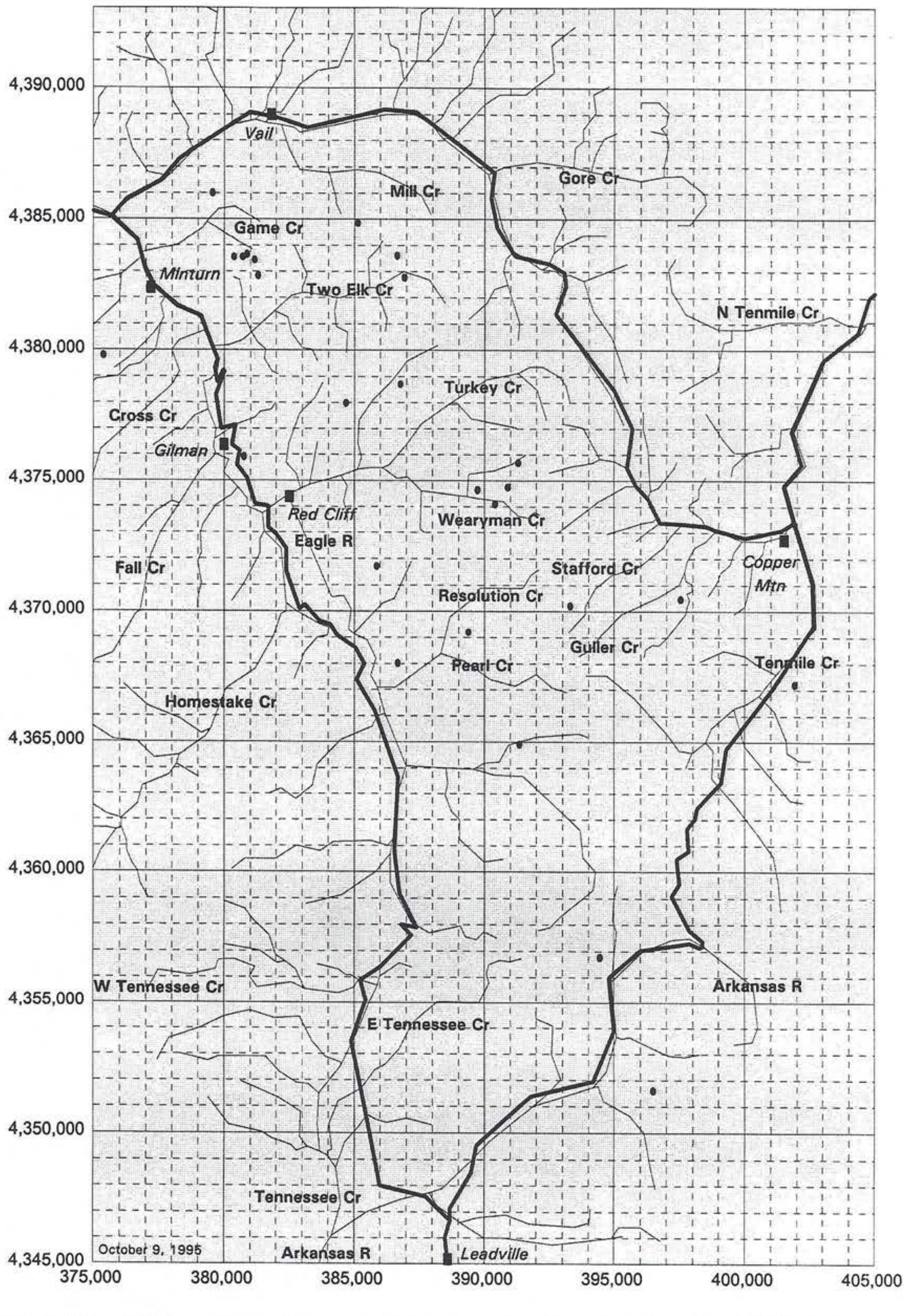

Figure 25. Elk locations from aerial telemetry for October 9, 1995 (VA study area). UTM grid units in metres.

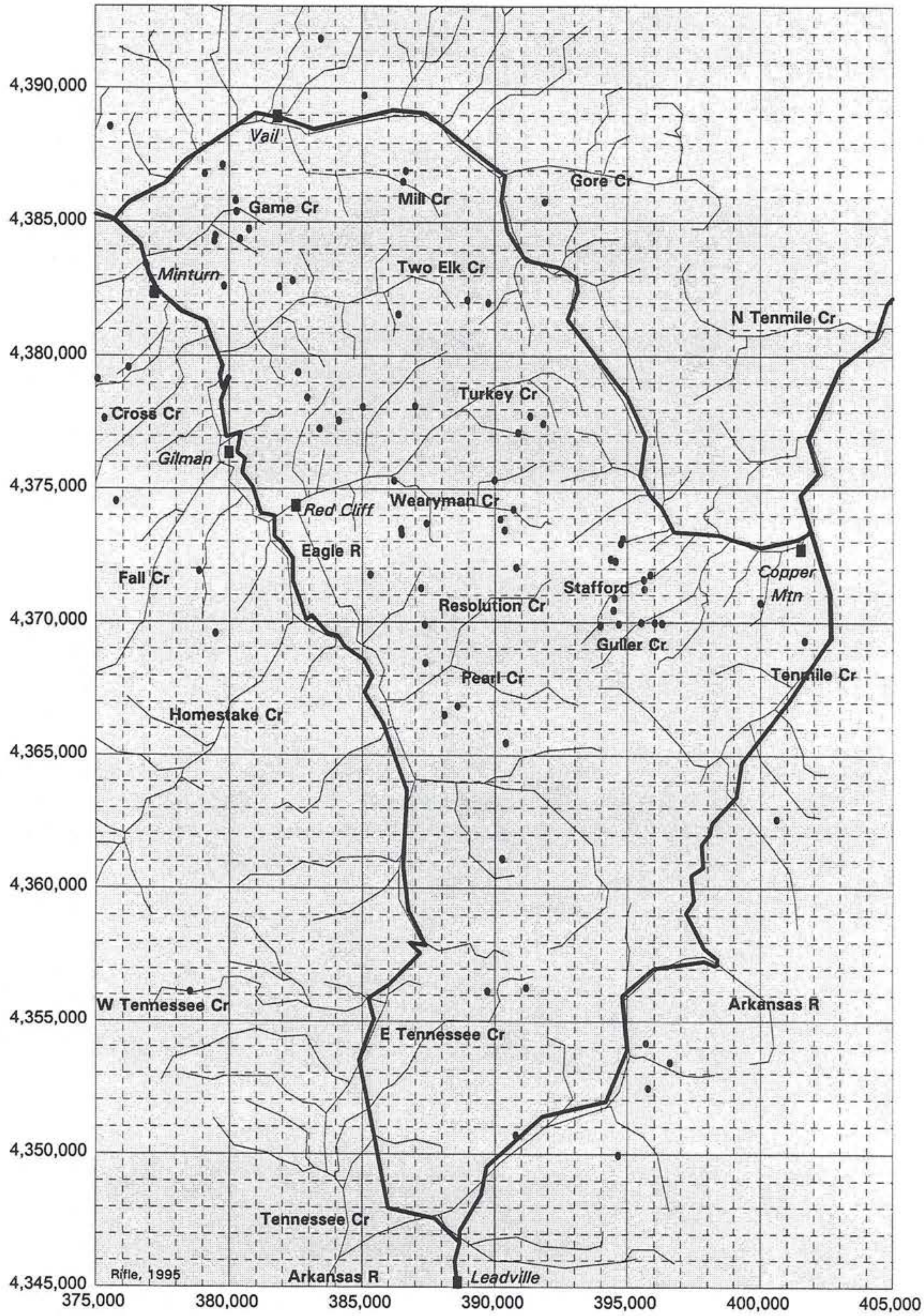

Figure 26. Elk locations from aerial telemetry for rifle seasons, 1995 (VA study area). UTM grid units in metres.

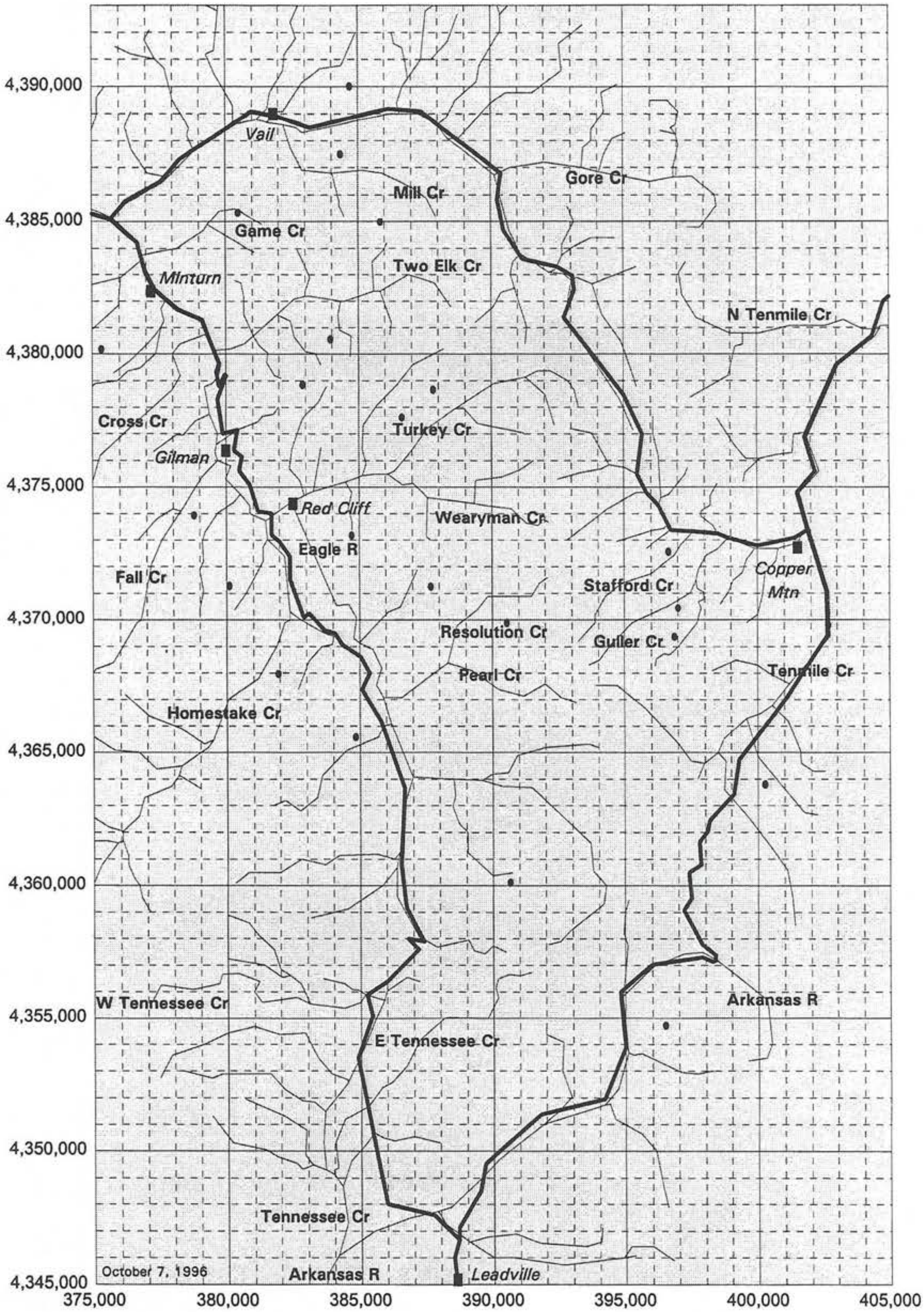

Figure 27. Elk locations from aerial telemetry for October 7, 1996 (VA study area). UTM grid units in metres.

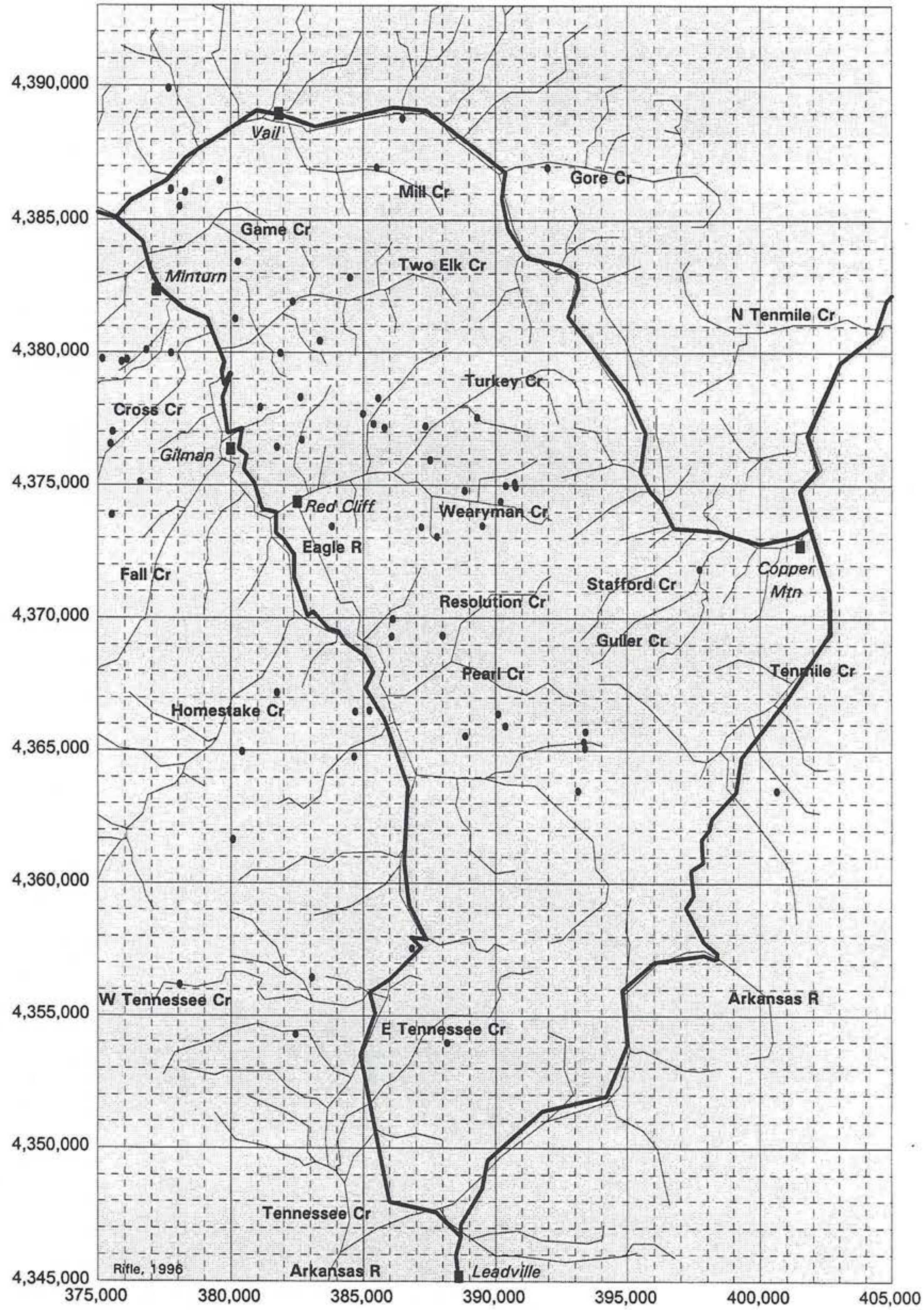

Figure 28. Elk locations from aerial telemetry for rifle seasons, 1996 (VA study area). UTM grid units in metres.

Table 2. Summary of 1996 mortalities for telemetered elk in the Upper Eagle River Valley Elk Study.

Date	ID*	Fate	Location
02-05-96	E2	Road kill	Interstate 70, Dowds Jct
02-06-96	4A	Road kill	Interstate 70, Arrowhead
02-09-96	C7	Road kill	Interstate 70, Dowds Jct
04-12-96	H3	Starvation	Battle Mountain, west side
04-22-96	CJ	Starvation	Beaver Creek, east side
04-24-96	6J	Road kill	Interstate 70, Arrowhead
04-27-96	F1	Starvation	½ km south of Red Cliff
04-27-96	J1	Starvation	Dowds Junction
04-28-96	L7	Starvation	Gore Creek near Dowds Jct
05-01-96	2F	Mountain lion kill	Red Creek Canyon, (north of Interstate 70)
05-06-96	7F	Mountain lion kill	Red Creek Canyon
07-13-96	4	Unknown - a bear was feeding on carcass when collar retrieved	Two Elk Creek, south side, Pete's Bowl
September	2C	Hunter harvest, archery season	Grouse Mountain area
September	L2	Hunter harvest, early rifle season	Vail Ski Area, Blue Ox run
September	H7	Hunter harvest, early rifle season	Wearyman Creek
October	C2	Hunter harvest, second rifle season	Lime Creek (off Turkey Creek)
11-05-96	K2	Hunter harvest, third rifle season	Wearyman Creek
11-07-96	T1	Hunter harvest, third rifle season	Turkey Creek
11-07-96	3F	Hunter harvest, third rifle season	Grouse Creek
11-07-96	7J	Hunter harvest, third rifle season	Grouse Creek
11-07-96	C3	Probable hunter harvest, third rifle season - collar found on side of US Hwy 24 without any sign of elk carcass	1½ km south of Red Cliff
November	A3	Hunter harvest, third rifle season	Willow Creek
November	E7	Probable hunter harvest, second or third rifle season	Sheep Mountain, east side
November	CC	Potential wounding loss - third rifle season ended 11-10-96, normal signal on 11-14-96, mortality signal on 11-18-96, collar not yet retrieved due to snow cover	Collar location: Grouse Mountain, southeast bowl
12-12-96	--	Capture mortality	Turkey Creek

* ID indicates capture location: numeral first indicates BC study area, letter first indicates VA study area. Exceptions: CC & CJ captured on BC study area, 4 captured on VA study area.

Table 3. Summary of telemetered elk of unknown survival status.

Date	ID*	Fate	Location
05-10-96	K6	Fate unknown, last signal received 05-10-96	Last known location: Two Elk/Turkey Creek ridge
10-23-96	2H	Fate unknown, potential hunter harvest - last signal received 10-23-96	Last known location: West Grouse Creek
11-07-96	4E	Fate unknown, potential hunter harvest - last signal received 11-07-96	Last known location: Beaver Creek
* ID indicates capture location: numeral first indicates BC study area, letter first indicates VA study area, CC captured on BC study area.			

4. APPLICATION OF TREATMENT TO ELK ON BC STUDY AREA

The treatment period extended from May 26 to June 19, 1996 on the BC study area. Prior to May 26, the BC sample was reduced by 5 elk due to mortality. No additional mortalities occurred during the treatment period. Of the remaining 81 animals, 4 were never encountered during the treatment period and never seen during the observation period. Flight data indicate they remained off the BC study area throughout both work periods (2 south of and 2 west of the study area). The actual number of marked elk in the BC sample potentially available for treatment and inclusion in recruitment rate estimation was 77.

We used twice-weekly aerial telemetry to monitor elk locations during the treatment period. These flights were useful in allocating treatment effort to areas with high densities of marked elk. In addition to the regular flight sample of 55 randomly selected animals, we maximized flight time to obtain general locations of as many extra BC elk as possible. Figure 29 shows elk relocation data from flights during the treatment period (see Fig. 2 for dates).

We applied a treatment of simulated recreational activity, using radio telemetry equipment to locate and approach collared elk. The rationale behind our treatment effort is that a small number of people targeting a specific group of animals (through the use of telemetry equipment) can create an effect equal to a much greater number of recreationists using the same area in typical recreational pursuits. For 20 of the 25 available days in the treatment period, we had 8-9 receivers in the field from dawn to approximately 1500 hrs. We had from 2-4 receivers in the field during 4 days of the treatment period, and only 1 day with no treatment effort. One to several technicians with receivers were assigned to areas known to have high elk densities. Periodic scans through the complete frequency list for the BC study area provided technicians with a short list of target frequencies to pursue.

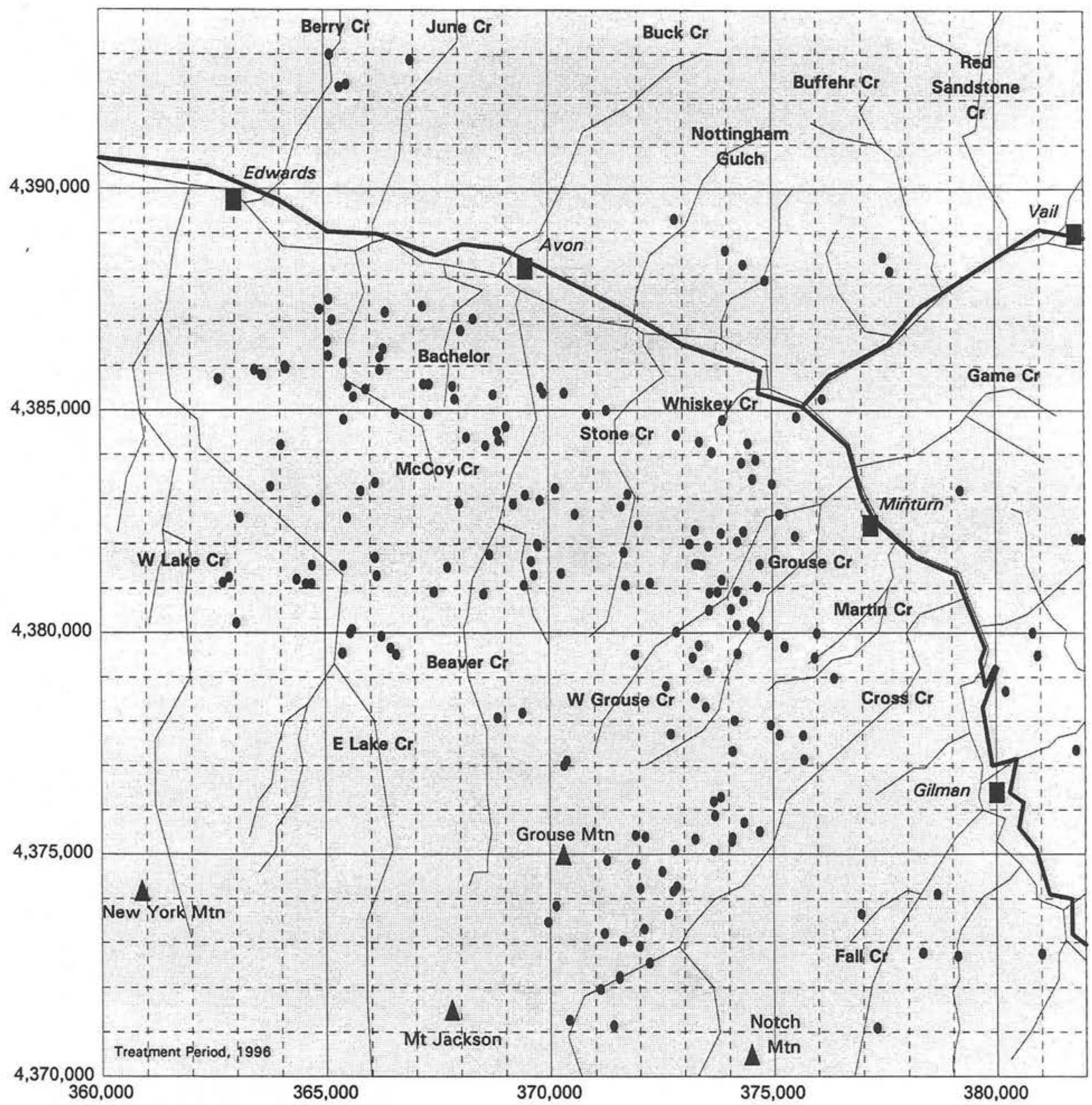

Figure 29. Elk locations from aerial telemetry for treatment period, 1996 (BC study area). UTM grid units in metres.

Treatment consisted of approaching the target animal until she was displaced from the immediate vicinity where originally found. We documented each treatment event by recording animal identification information, time, location and both visual and telemetry evidence demonstrating that the target animal had been treated. The strength of evidence supporting treatment events varied. The surest form of evidence was visually identifying the marked animal (by either alpha-numeric collar code or eartags) and seeing her run away. Evidence relying entirely on telemetry signals was considered less reliable because of potential interpretation errors from terrain-induced changes in signal amplitude and direction.

A preliminary system for classifying treatment data, based on reliability of evidence, is provided in Table 4. We interpret the reliability of the 5 treatment classes as follows: Class 1 is positive evidence of treatment of the target animal, Classes 2 and 3 are extremely strong (similar reliability) evidence of treatment of the target animal, Class 4 is sufficient to say that treatment of target animal probably occurred, and Class 5 data are too unreliable to be used.

We propose using treatment data (number of treatment events per specific individual) as covariates in logistic regression to evaluate whether or not level of treatment effort is related to calf status for marked cows. A hierarchical system may be used to combine data from different classes for graphical representation and analysis. The risk of accepting that a treatment occurred, when it actually did not, increases from Class 1 to Class 4. Starting with our most reliable data, we could use Class 1 data alone. Next, we would give up very little reliability by combining Classes 1-3. Finally, combining Classes 1-4 would result in the most error, but even this would be relatively small.

Treatment data are also useful to indicate the overall magnitude of treatment effort achieved. Even when Classes 1-4 are combined, we believe these data only approximate a minimum level of treatment effort. In some areas it was common to have several collared animals in fairly close proximity, often scattered across rough terrain making it difficult to assess which animals were nearest the technician. It is difficult to monitor multiple frequencies at the same time, which made it easy to disturb a collared elk that was not the immediate target of treatment effort. Daily travel paths of technicians were not fixed, but varied depending on the number, direction and amplitude of received signals. One or more technicians might cross the same area multiple times per day, following different travel paths each time. Additionally, many elk appeared reluctant to leave a particular area; often running only a short distance after treatment or circling back behind the technician. Under these circumstances, many treatments probably went undetected. Based on numbers of animals seen and heard, and on other evidence such as tracks and freshly vacated bedding sites, we know we were moving a large number of elk each day.

Table 4. Criteria for classifying treatment events based on reliability of evidence supporting occurrence of treatment and identification of target animal, and number of treatment events per class (n_t) .

Class (Number in Class)	Classification Criteria
1 (n_t=255)	Positive visual identification of the treated elk based on either alpha-numeric collar code from the side of the collar, or from both colored eartags. Telemetry information not required.
2 (n_t=38)	The collar was seen as treated animal ran away, but neither alpha-numeric code nor eartag combination were fully identified. Telemetry evidence supported close proximity of target animal when collar was observed, and post-treatment telemetry evidence demonstrated a fading signal in the direction that collar was seen to move. Use of crude "triangulation" to establish nearby location of target animal prior to treatment event was especially convincing evidence of animal identification.
3 (n_t=114)	Treatment was inferred by seeing or hearing nearby elk run from technician, along with telemetry evidence supporting the close proximity of target animal at time of treatment and post-treatment telemetry evidence demonstrating a fading signal in the direction that elk were seen or heard to move. Collar not actually observed. Use of crude "triangulation"to establish nearby location of target animal prior to treatment event was especially convincing evidence of animal identification.
4 (n_t=214)	A. Elk were neither seen nor heard. Treatment and animal identification based primarily on telemetry. Supplemental information such as tracks, smell, etc were sometimes available as evidence that elk were nearby and that treatment occurred. B. Elk (collared or not) were seen or heard running away from the technician, but telemetry evidence was not sufficiently detailed to convincingly support that the target animal was treated.
5 (n_t=18)	Insufficient evidence that treatment occurred. Mostly weak or poorly documented telemetry evidence.

Treatment data are presented graphically in several formats. Figures 30-32 show the locations of treatment events throughout the treatment period for Class 1, Classes 1-3 and Classes 1-4, respectively. In comparison with Fig. 29, it appears that we were working in areas where most of the elk occurred. We know, however, that some elk were relatively inaccessible because they moved to high-elevation pockets of open ground that were impractical for us to reach on a daily basis due to deep snow cover. Also, Cross Creek provided an effective sanctuary for elk late in the treatment period, especially the valley bottom itself. The Cross Creek valley is very wide, steep-sided and rugged. However, we were able to cover the upper slopes of the ridge between Grouse and Cross Creeks by having crews work from camps in the backcountry.

Figure 33 shows frequency distributions for number of treatments per animal, for Class 1 treatment data alone, Classes 1-3 combined and Classes 1-4 combined. Figure 34 provides an alternative way of looking at the same data. Percentage of the BC sample is shown as a function of the minimum number of treatments per animal. For example, roughly half of marked elk were treated 8 or more times over the treatment period, based on Classes 1-4 combined.

In addition to our treatment effort, extensive construction activities occurred in Bachelor Gulch and lower McCoy Park during spring and summer of 1996. A network of roads was constructed in Bachelor Gulch to access private building sites and to connect with existing roads from Beaver Creek and Arrowhead ski areas. A new lift was constructed extending from the top of Bachelor Gulch (northern edge of McCoy Park) down into Bachelor Gulch. A new snow-making building was erected in lower McCoy Park and construction was begun on a small snow-making reservoir near the building. In previous years, upper portions of Arrowhead ski area and Bachelor Gulch, and lower McCoy Park, have been closed to human access from May 1 to June 30 to protect elk during the calving period. This closure was temporarily lifted in 1996 to allow construction to begin as early in the spring of 1996 as possible. The closure will resume in 1997.

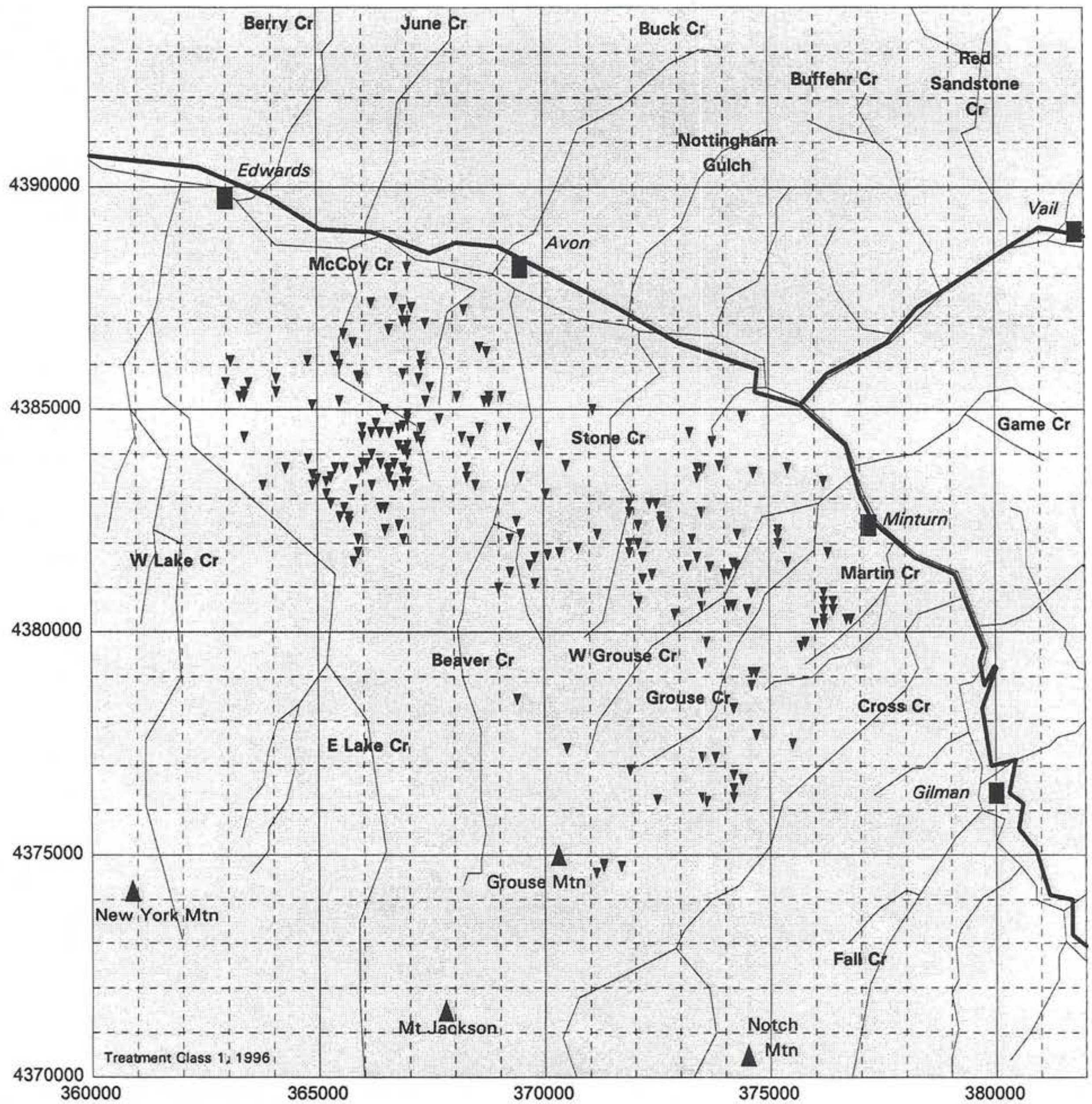

Figure 30. Locations of treatment events (Class 1) between May 26 and June 19, 1996.

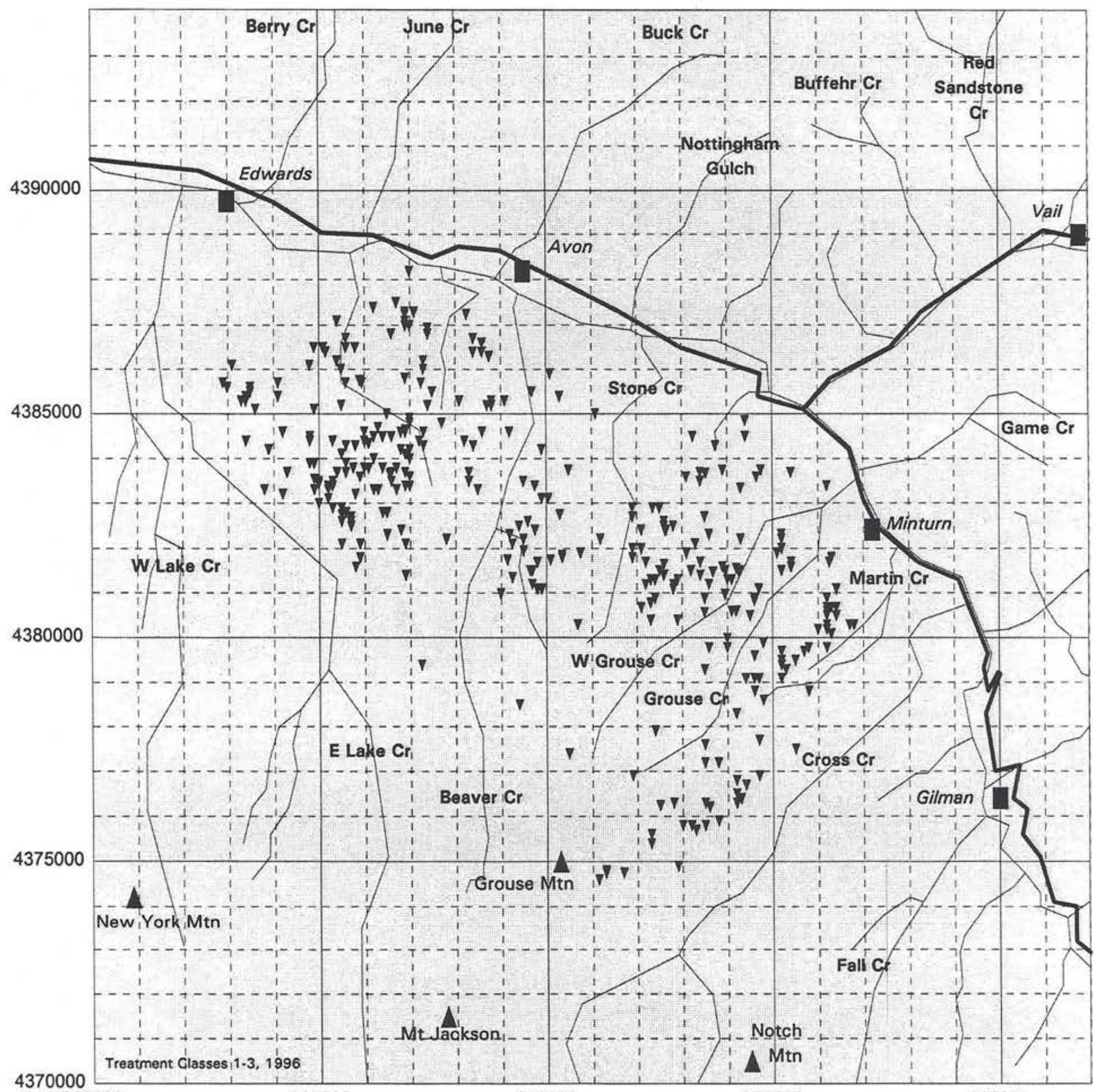

Figure 31. Locations of treatment events (Classes 1-3) between May 26 and June 19, 1996.

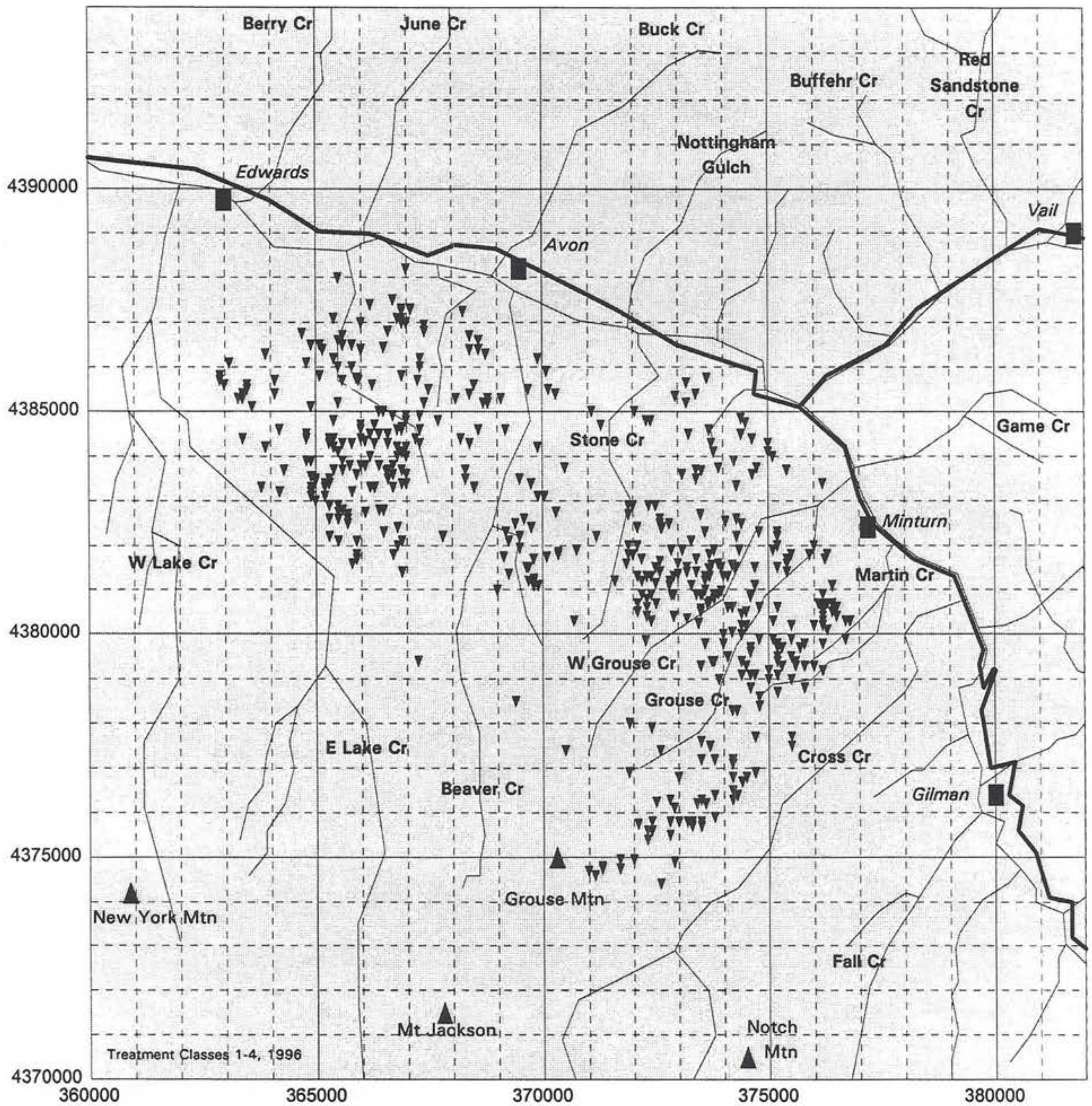

Figure 32. Locations of treatment events (Classes 1-4) between May 26 and June 19, 1996.

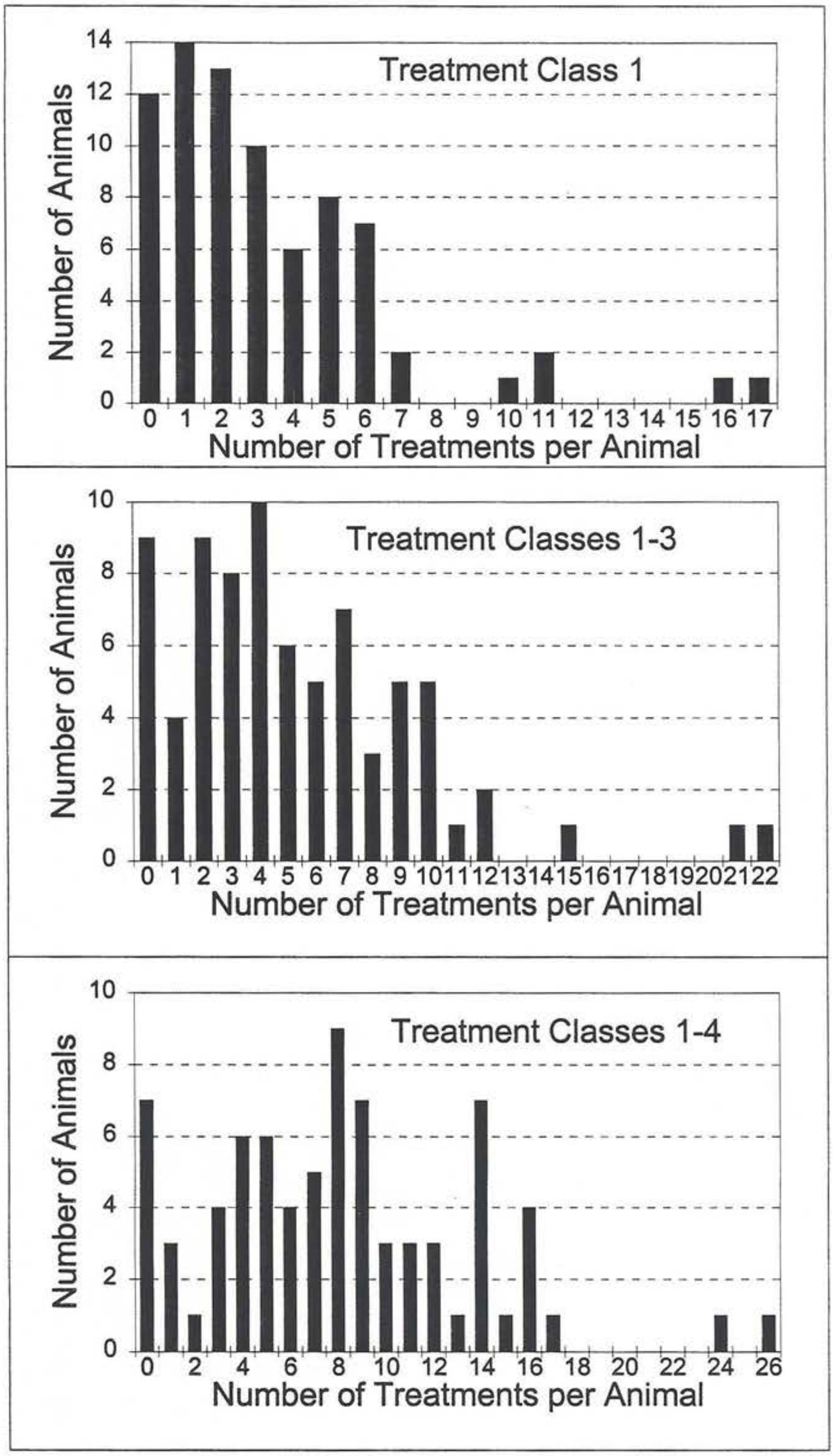

Figure 33. Frequency distributions of numbers of treatments per marked elk in the BC sample (n = 77).

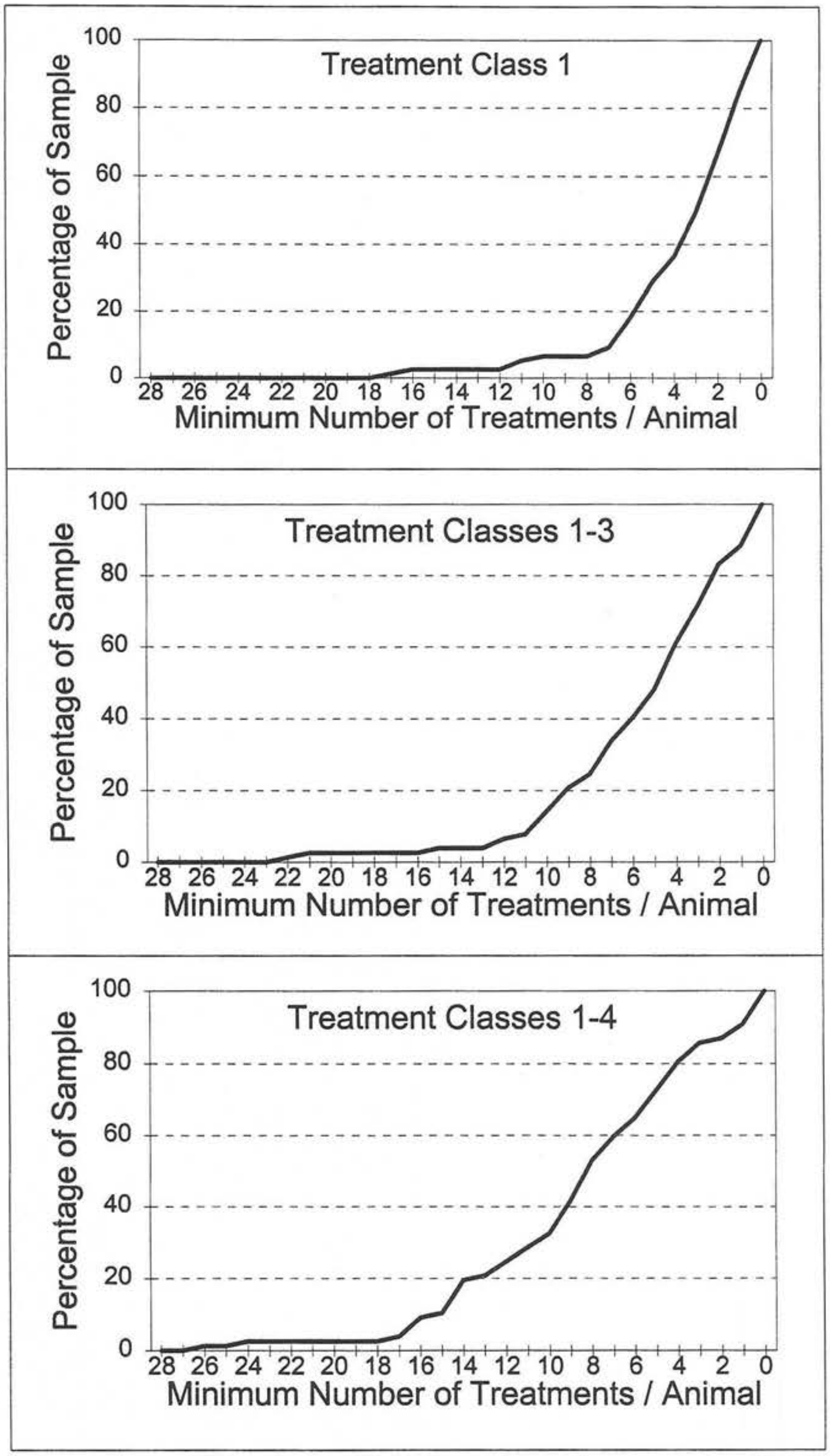

Figure 34. Cumulative distribution of minimum number of treatments per marked elk in the BC sample (n=77).

5. OBSERVATION OF MARKED ELK

In 1996, we discontinued work in Rocky Mountain National Park and the upper Poudre River drainage (PR study area) and focused our observation efforts entirely on the BC and VA study areas. The telemetered cow elk in the PR study area were captured by other researchers, with different objectives than ours. These animals were not marked to enhance long range visual identification. Initially, we thought it possible to obtain adequate amounts of data by relying more heavily on telemetry information to identify individuals. Results from the 1995 observation period indicated that the quantity of data might be insufficient for meaningful statistical analyses. In June of 1996, we met with quantitative biologists and statisticians (Ken Burnham, Phillip Chapman and Gary White) to discuss the advantages and disadvantages of retaining the PR study area. We subsequently decided to confine our work to the primary study areas. Although the 1996 observation data are not yet fully summarized, it appears that we may expect an increased of 5-10 % in the number of cows of known calf status on the BC and VA study areas, compared to 1995.

6. ELK CAPTURE

On December 12 and 13, 1996, we captured and radio-collared 25 new adult female elk: 12 on the BC study area and 13 on the VA study area. One elk, originally captured in 1996, was recaptured to adjust the fit of its collar. One mortality occurred in Turkey Creek during the trapping process, before the elk was collared and released. No further capture-related mortalities occurred. All elk were captured by Helicopter Wildlife Management, Inc., using helicopter net gunning. Our sample sizes of telemetered adult cow elk at the end of December 1996 were 86 in the BC group and 83 in the VA group. The 3 elk of unknown fate listed in Table 3 are not included in these numbers.

We focused capture efforts on areas east of and including the McCoy Creek drainage on the BC study area, and between Dowds Junction and the Turkey Creek drainage on the VA study area. Based on 1995 observation data, animals captured in these areas were more likely to be observed within the 2 study areas in open alpine habitats during summer.

7. PROJECTED 1997 ACTIVITIES

Figure 35 shows the schedule of field activities projected for 1996, including flight dates. We will continue to monitor elk location and survival status using ground and aerial telemetry. Ground telemetry to determine general locations and survival status will end immediately before the start of the treatment period. We will continue with a flight sample of 55 randomly selected elk with 35 and 20 elk from BC and VA

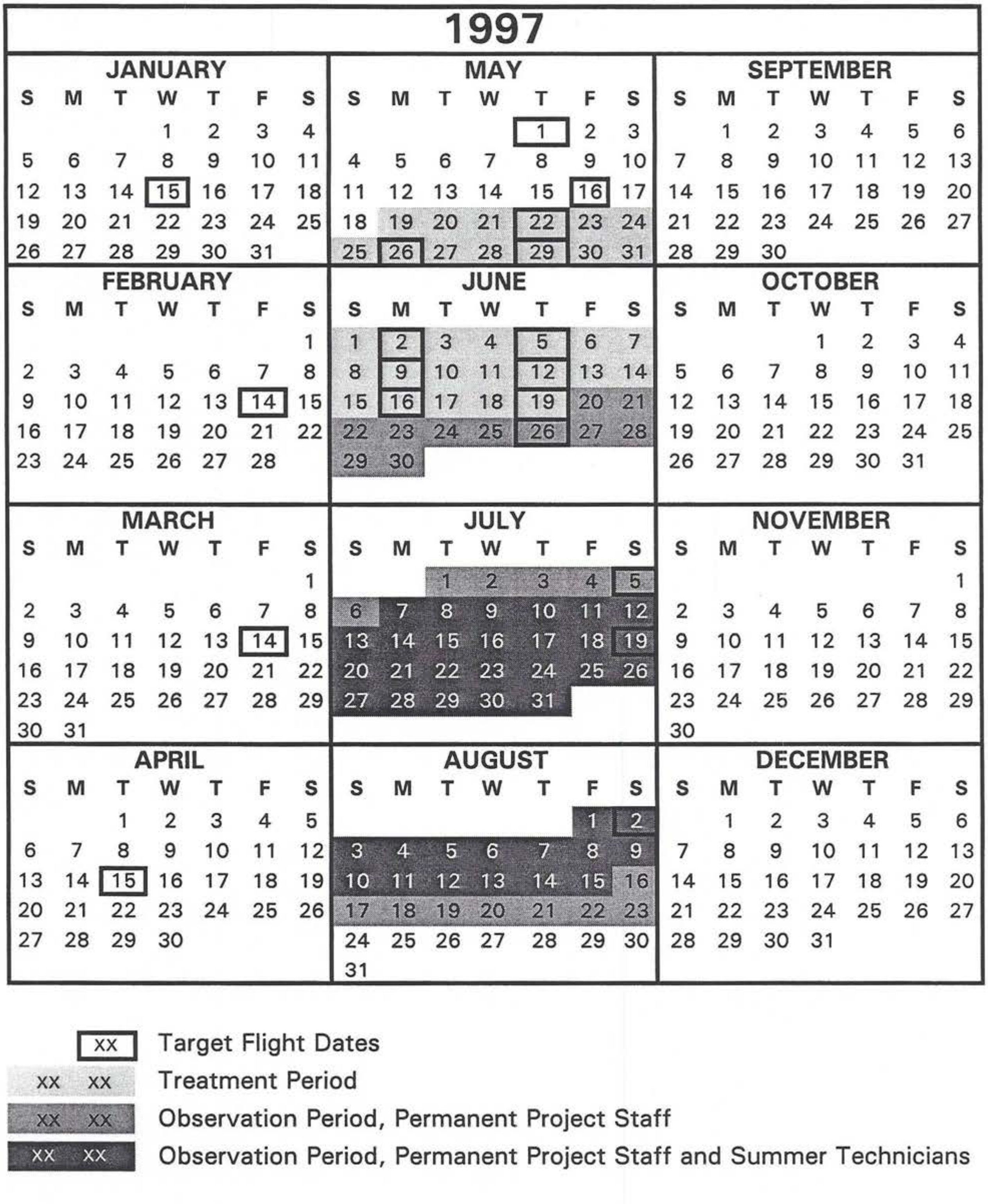

Figure 35. Projected flight schedule, treatment and observation periods during 1997 for the Upper Eagle River Valley Elk Study.

samples, respectively, until June 26. Once the treatment period begins we will conduct aerial surveys twice weekly, weather permitting. In addition to the 55 animals in our regular flight sample, we will determine general locations for as many of the remaining BC animals as possible to further support our treatment effort. The 3 flights in July and August will provide general locations for as many collared elk as possible to support observation-period work.

We have hired 9 technicians and will begin training them on May 19 to help during our treatments, which will begin on May 20 and end June 19. We will document treatment occasions and characteristics of calving sites when encountered.

Four technicians have been hired for the primary observation period which will run from July 7 to August 15. Permanent project staff will extend the observation period to August 23. All field activities, including aerial and ground telemetry, will conclude by the end of August.

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