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THE EFFECTS OF RECREATIONAL ACTIVITY ON ELK DISTRIBUTION AND USE OF A PIPELINE RIGHT-OF-WAY

by

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ABSTRACT

The response of elk to recreational activity along a pipeline right-of-way was studied from September 1984 to December 1985. The study area is located in west-central Alberta, approximately 80 km northwest of Rocky Mountain House.

Seven elk were trapped and fitted with radio collars and monitored by ground triangulation and aerial location from September 1984 to March 1985. Five super 8 movie cameras were modified to expose a single frame every three minutes and were placed along the right-of-way to record human activity as well as elk utilization. Track counts were used to determine habitat preference by elk and also to determine the influence of human activity along the right-of-way on elk distribution.

Data indicate that elk use of habitats adjacent to the right-of-way was affected only marginally by human activity along the right-of-way. However, elk use of the right-of-way declined dramatically during periods of intense recreational activity. Elk used the right-of-way as a feeding area during all times of the year and showed a preference for areas where human activity was lowest. People used the right-of-way as an access route and as a staging area from which they ventured into areas remote from the right-of-way. People activity was greatest in the fall period and was centered on the hunting season. Elk distribution in relation to activity along the right-of-way is affected by the type of cover available, weather conditions, time of year, and the duration and intensity of human activity.

It is suggested that pipeline right-of-ways provide elk with unique high quality feeding areas. The availability of these areas to elk during critical periods of the year is affected by human activity along the right-of-way. If elk are to take advantage of these areas without high expenditures of energy, then wildlife managers should develop means of controlling use of these areas by humans.

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1.0 INTRODUCTION

The objectives of this study were to document elk (*Cervus elaphus nelsoni*) and human use of a pipeline right-of-way at various times of the year, and to determine the effects of human activity on elk distribution and their use of the pipeline right-of-way. Human disturbance of big game is a universal and very old concern of wildlife managers, dating back at least to the late middle ages (Geist 1975, 1978a). The ecology of a big game animal is the product of habitat, food preferences, security strategies and the learned experiences from exposure to humans (Geist 1971, 1978a). Human disturbance can cause increased energy expenditures, death, reduced reproduction, range avoidance or abandonment resulting in reductions in the animals range, reduced availability of resources and increased energy costs for existence (Geist 1971, 1978a, Tennessen 1979). Batcheler (1968) studied the effect of controlled hunting on the health and habitat use of the red deer (*Cervus elaphus elaphus*) in New Zealand. Results of his study showed that increased hunting pressure disrupts the ability of animals to exploit preferred habitat. Animals responded to increasing hunting pressure by using nonpreferred, marginal habitat and remaining on summer range during the winter. As a result animals were in poorer condition and had lower reproductive success. Yarmoloy et al.(in press) studied the behavioral response and reproduction of female mule deer subjected to experimental harassment. The harassed females shifted feeding activity to darkness, used cover more frequently, increased flight distances and left their home range more often, compared with nonharassed females. Reproduction of harassed females was significantly reduced compared with that of unmarked females and the control animals in their study.

The behavior of big game animals towards human beings is a consequence of our behavior towards them (Geist 1971). Big game animals can be expected to treat humans at first as any unfamiliar object, and thereafter adjust their response to us based on our behavior towards them (Geist 1971). Animals that are stalked, hunted or repeatedly harassed by humans will flee. In contrast, big game animals that are not harassed will eventually ignore humans (Geist 1971, 1978a). Geist (1971) shows several examples of mule deer (Odocoileus hemionus hemionus) and bighorn sheep (Ovis canadensis canadensis) coexisting with humans in national parks of Canada and also cites other researchers who have been able to habituate study animals to their presence, thus allowing close observation of animal behavior. However, habituation of some species , such as bears, is not a good idea since it puts humans at risk of attack and will probably lead to the unnecessary death of an animal (Herrero 1985). In general, animals have the ability to generalize stimuli, localities, and experiences (Geist 1971). When an unfamiliar object appears, an animal may become alarmed and prepare itself physiologically for flight or attack (Geist 1971, Herrero 1985, Stemp 1983). If the animal is then disturbed, it may develop a strong aversion towards the object or situation. If the disturbance is encountered again, the animal may: become excited and remain so even after the object disappears; avoid the locality where the disturbance occurred; and generalize the stimulus to other similar objects and localities, and avoid them (Geist 1971, Herrero 1985). An animal's reaction to disturbance is a product of the learned experiences of the individual, its personality, its aggressiveness, wether it has off spring present, and the proximity of the animal to the source of disturbance (Herrero 1985).

MacArthurs et al.'s (1982) study of the responses of mountain sheep to human disturbance illustrates the degree to which animals can become habituated to common human-related stimuli and confirms that animals function best in a predictable environment (Geist 1979). In his study the focal point of human activity was a road leading through the study area. Sheep showed few responses, as measured by a change in heart rate, to approach by people walking from parked vehicles. The strongest responses were recorded when animals were approached by people from over a ridge or when people were accompanied by dogs. Most sheep encounters with humans were in the proximity of the road and were related to approach by amateur photographers. Approach over a ridge was a departure from the usual experience of these sheep, while the reaction to people with a dog is related to canids being predators of sheep. Disturbances, which are not common and localized in time and space, are likely to be more detrimental because they are not predictable and are usually avoided with the animals leaving the vicinty of the disturbance.

Geist (1971, 1978a), in his review of behavior, makes note of the herding requirements in reindeer to maintain calm, undisturbed grazing. Disturbance in these animals leads to excessive weight loss, increased abortion and absorption of fetuses, and greater susceptibility to disease. Herding activity, food quality and availability were determined by Reimers (1972) to be the primary causes of observed differences in dressed weights and diastema lengths between wild and domestic reindeer in Norway.

In the mid 1970's concern was being expressed as to the impacts of oil and gas development on wildlife populations, particularly in northern environments. In Canada the proposed MacKenzie Valley pipeline project focused the attention of wildlife managers on potential harmful effects on barren-ground caribou (Rangifer tarandus). Concerns expressed about this project involved: increased access; disturbance by aircraft and ground vehicles on caribou calving grounds; interruption of spring migration of caribou; and disturbance of animals on winter range. All of these disturbances could have adversely affected the health of caribou herds (Berger 1977).

Klein (1971) reviewed the effects of industrial development on reindeer in Sweden in order to anticipate problems with caribou related to oil and gas development in Canada and Alaska. Where highways and railroads transected reindeer ranges, reindeer were reluctant to cross either highways or railroad tracks. With increasing traffic, there was an increase in reindeer mortality from collisions, and the increasing frequency of trains caused abandonment of part of the reindeer range. The increase in roads and highways brought greater numbers of tourists, sportsmen and others into reindeer areas. This increase in traffic and people made control over reindeer by herders much more difficult.

Research into the effects of disturbances specific to the petroleum industry are limited. Klein's (1973) review of the impact of oil development on northern environments showed that the construction of pipelines, roads, and railroads pose threats to the free movement of caribou. Development of temporary winter roads plowed in snow have been known to disrupt normal migration movements of caribou. This is particularly serious as traditions in movement of caribou are maintained by learning in young animals as they accompany older animals in their migration. Obstructions to movements resulting in delays or failures of animals to reach calving or seasonal ranges can affect future distributions, result in range abandonment, and reduce the overall population level. Geist (1975) provided a detailed review of available literature on the effects of harassment of large mammals related to energy development in the arctic region of North America. Other studies have been completed that describe the effect on wildlife of human activities resulting from other industrial developments. Results from these studies may be applicable to similar human activities involving petroleum exploration and development (Bromley 1985).

Bergerud et al (1984) have shown that many of the presumed impacts of oil and gas development on northern caribou herds have not occurred. Their study of demography of eight caribou herds revealed increasing populations despite intense oil and gas development. Declines in specific caribou populations were a result of overhunting and predation. The presence of roads, pipelines, power lines, and other man made features did not affect caribou population numbers. Increased harvest, as a result of improved access, and predation appear to be the key factors regulating caribou populations.

In 1977 the Alberta Government released "A Policy for Resource Management of the Eastern Slopes" which outlined wildlife as being one of the most important resources in this part of the Province and designated a number of areas as "critical wildlife" (Stubbs and Markham 1979). Critical wildlife areas consists of ranges or habitats essential to the survival of specific wildlife populations. For example, such areas may be winter ranges, migration routes, calving areas or mineral licks. Oil and gas development activity increased dramatically in Alberta and a significant discovery in 1977 resulted in some of the most extensive exploration and development activity on the continent (ibid). This intensive development created problems for wildlife, including disruption of migration, range abandonment, increased access and disturbance causing declines in existing ungulate populations (Stubbs and Markham 1979, Tennessen 1979). Ungulates were prevented from taking advantage of newly created habitats such as timber cut blocks, seismic lines, and pipeline rights-of-way (Stubbs and Markham 1979, Tennessen 1979). Recent studies of barren-ground caribou and moose (Alces alces) have shown that the presence of the Trans-Alaska pipeline has not affected movements of either of these species (Eide et al. 1986, Sopuck and Vernam 1986). Caribou movements across the pipeline were only influenced by vehicle traffic on roads adjacent to the pipeline right-of-way (Curatolo and Murphy 1986). Caribou were found to hesitate for up to 10 minutes when approaching the elevated pipeline before attempting to cross. Moving vehicles on adjacent roads caused caribou to retreat from the pipeline or interrupt their attempt to cross (ibid). The physical presence of the elevated pipeline does not influence caribou or moose movements. However, human activity along the right-of-way (i.e on adjacent roads) does appear to cause changes in direction of movement of caribou trying to cross. Smith and Cameron

(1985) reported that large (>100) mosquito-harassed groups of caribou infrequently crossed beneath elevated pipelines. In many instances these caribou repeatedly attempted to cross under the pipeline but were unsuccessful, resulting in substantial increases in energy expenditure. The implication was that the increase in energy expenditure, particularly if it occurred several times over the summer, would result in a net decrease in fat accumulation. Unless compensatory increases in forage intake occur these animals would be in poorer condition, and more susceptible to disease, starvation, and predation.

The effects of industrial development on the biology of elk has been the subject of research throughout North America. The majority of this work has centered on the effects of the logging industry primarily because logging activities can greatly alter the appearance of the land. Prior to 1960 there was a general feeling among wildlife managers that game populations were too large for available winter range (Lyon et al. 1985). Logging was considered beneficial to wildlife as new foraging areas were created and the road development provided access into remote areas allowing for hunting of unexploited wildlife populations. In general the idea that "good timber management was good wildlife management" was a prevalent attitude among biologists (Thomas 1979). However, during the 1960's there was concern among biologists that logging activities, easy access, and the loss of tree cover were having an adverse effect on some elk populations (Lyon et al. 1985). Large clear-cuts and the development of roads were perceived as direct threats to elk habitat, security for animals and their use of remaining undisturbed habitat, and their subsequent use of the altered landscape.

As a result of these concerns a cooperative Elk-Logging study was initiated in Montana in 1970 and completed 15 years later (ibid). Similar concerns about timber salvage operations in the Blue Mountains of Oregon resulted in the development of guidelines for the protection of wildlife habitat during timber harvest operations (Thomas 1979).

Studies conducted on elk in Michigan have shown that elk are displaced from habitat adjacent to drilling activity but will return within several weeks of site abandonment (Bennington et al. 1981, Knight 1980). Wellsite development is confined to a specific location, is relatively noisy and of long duration. Elk have a long period of exposure to the disturbance and can adapt to it. Elk have been found to be more sensitive to seismic activity because it is mobile and continually changing location. Consequently, elk cannot predict the nature of the disturbance and respond by moving away (Knight 1980, Tennessen 1979). None of these studies attempted to quantify the effects on wildlife by increased human use of access created during seismic and drilling operations.

Most petroleum industry developments are linear and have a high ratio of edge to total area. This would tend to benefit wildlife as the edge created produces a distinct habitat type and also creates vegetation diversity in areas with monotypic forest cover (PRISM 1984). Pipeline rights-of-way, where adjacent vegetation is allowed to encroach onto the right-of-way, produce browse species preferred by ungulates (Brusnyk and Westworth 1985). These authors also observed that elk selected areas of the right-of-way that were predominantly grass covered, presumably as a response to the increase in forage produced from seeding of the right-of-way after construction. Timothy (*Phleum pratense*), Kentucky bluegrass (*Poa pratensis*), orchardgrass (*Dactylis glomerata*), smooth bromegrass (*Bromus inermis*), wheatgrass (*Agropyron* sp.), creeping red fescue (*Festuca rubra*), intermediate wheatgrass (*Agropyron intermedium*), slender wheatgrass (*A. trachycaulum*) and clover (*Trifolium* sp.) are some of the species used in pipeline revegetation that are important sources of food for elk (Hobbs et al. 1979, Kasworm et al. 1984, Marcum 1979, Miller et al. 1981). Ungulates may not be taking full advantage of these potential food sources because of the increased use of these areas and surrounding habitats by people (Stubbs and Markham 1979).

Every activity involved in oil and gas development is contingent on the development of access, either temporary or permanent. Access and associated activities have been identified as major factors in alienation of habitat and over-exploitation of some wildlife populations (PRISM 1984, Hershey and Leege 1976). Increased elk harvest and the subsequent decline in elk populations have both been directly linked to increased hunter success as a result of road development in important elk habitat (Leege 1976, Thiessen 1976). Similar findings have been reported by Lynch (1973) for moose (*Alces alces*), and by Pendergast and Bindernagel (1977) for mountain goat (*Oreamnos americanus*).

Marcum (1975) studied the selection and use of summer and fall habitat by an elk herd in western Montana. Grouping of three years of data showed that elk selected against habitat areas under 137 m from open roads and for habitat greater than 1599 m from open roads. This study showed that during the fall in the absence of hunting, elk were in closer proximity to open roads than during the hunting season. During the hunting season there was a substantial increase in elk use of areas greater than 1600 m from open roads. Roads, and areas near roads, with high levels of traffic were avoided by elk. Marcum (1975) also observed that some elk left areas near open roads just prior to the opening of hunting season in response to increased human activity resulting from hunters scouting for game, establishing camps and occasionally sighting their rifles.

The location of the road, the type of road, aspect and vegetation also influence elk response to human activity. Roads within 0.2 km of meadows on west and south facing slopes resulted in reductions of elk use of these areas (Perry and Overly 1976). They also found elk use of open forest cover type increased with increasing distance from roads. Roads developed in direct line of sight of meadows or other feeding and resting areas have caused reductions in elk use of these areas (Lyon 1979a, 1979b). Main roads located through meadows resulted in a 95 percent reduction in elk use, while primitive roads caused the least reduction (Perry and Overly 1979). This suggests that the quality of the road influences elk use of adjacent habitats. Because the level of human activity is related to the quality of the road, it is the level of human activity on the road that affects elk distribution and use of adjacent habitats. If primitive roads received the same level of use as main roads then one would anticipate similar avoidance by elk.

Hershey and Leege (1976) found that elk avoided clear-cuts and other cover types within 400 m of main and secondary roads. Only 27 percent of all the locations of radio-collared elk were within 400 m of a road, but the area within 400 m of roads accounted for 56 percent of the entire study area. Elk use of an area declined in proportion to the density of roads, intensity of human use, and season of use. Increased use of roads by hunters forced elk to disperse to areas farther from the roads, while increased hunter success resulted in elk being eliminated from some areas.

These results are supported by the work of Morgantini (1979), who found a shift in elk distribution during a winter elk hunting season from lowland grasslands transected by roads to higher road free elevations. During the hunting season elk use of grassland areas decreased by 70%, while use of open mountain slopes and forested areas increased by 65 and 20 percent, respectively.

Elk have been found to be more sensitive to approach by people on foot than approach by vehicle (Schultz and Bailey 1978). Ward (1976) gathered data on the behavior of elk in relation to timber harvest and traffic on the Medicine Bow Range in Wyoming. Using telemetry, one of his radio-collared elk was found to be within 300 m of a well travelled road, four of the five times located. This elk was pursued five times and in each instance, as soon as the vehicle stopped on the road and the people unloaded, this elk became alert and moved away. Ward (1984) found that two radio-collared cow elk were located at least 800 m away from people gathering firewood 91 percent of the time. The radio-collared elk were located within 800 m of people on foot only 9 percent of the time.

Cover can modify the response of elk to human activity on roads and in adjacent habitats (Ward 1984). In instances where radio-collared elk were between 400 and 800 m of firewood gathers, the elk were in good conifer cover. One radio-collared elk resting in good conifer cover did not move away when a motorbike passed within 50 m. Ward (ibid) also found that distance of response for elk and deer to human activities on roads becomes greater on winter ranges which lack conifer cover. In areas with roads closed to vehicle travel, foot travel by people has increased (Lyon et al. 1985). In these areas cover has influenced elk response to increased human activity; elk avoided areas with increased foot travel by people in open grassland areas, whereas elk did not leave forested areas despite increased human activity (ibid.).

Redgate (1978) investigated the use of clear-cuts by elk in relation to roads in the Athabasca Valley of northwestern Alberta. His findings revealed nearly a 100% increase in elk use beyond 40 m from roads in older clear-cuts. The presence of dense forest cover adjacent to roads in older clear-cuts decreased the avoidance distance for elk in his study.

Other factors besides human activity influence elk use of habitats adjacent to roads. Studies conducted by Burbridge and Neff (1976) and Painter (1980) show that factors such as weather, terrain and introduced grass species, along with levels of human activity, influence elk distribution and use of habitats. Depending upon the area, low levels of human activity, introduced plant species, and the lack of snow accumulation would tend to attract elk.

Increased human activity in elk feeding areas as a result of road access can adversely affect elk use of these areas, resulting in major changes in diet composition (Morgantini 1979, Morgantini and Hudson

1985). Shifts in diet during critical times of the year (winter), caused by increased levels of human activity, can adversely affect the health of individual animals by lowering the quality and quantity of food ingested, thereby affecting the nutritional condition of the animal (Morgantini and Hudson 1985). The intake of energy in ruminants is relatively low and the conversion of energy to fat is an inefficient process (Geist 1978a). For every calorie of energy stored as fat, one is lost in the conversion process to fat (Blaxter 1962).

Geist's (1978b) review outlines the strategies used by individuals of a species to maximize their reproductive fitness and thereby ensure the survival of the species. The first rule of reproductive fitness is to minimize expenditures of energy, in excess of those required for maintenance, thereby maximizing energy resources available for reproduction. If an animal is disturbed it prepares itself physiologically for a reaction to the disturbance. This excitation elevates the animal's metabolism and increases the energy cost of living, thus competing for energy available for reproduction. Increased human activity caused by increased access may adversely affect elk by increasing energy requirements for maintenance and thereby reducing energy available for reproduction. Disturbance of reindeer has caused loss in body weight, weakened the animals, and increased the animals susceptibility to disease (Zhigunov, in Geist 1971). Increased disturbance of red deer through hunting was shown by Batcheler (1968) to result in animals of poor conditon and with lower reproductive success. The consequences of disturbance may be similar for elk. Disturbance could result in poor reproduction, increased loss of calves through abortion, and calves of smaller size and poorer condition. The overall affect would be a declining elk population.

The access problem is a complex issue involving licensed hunters, year-round native hunting, and recreational use of access routes for off road travel with trail bikes, ATVs, 4X4s, and snowmobiles. These factors result in increased disturbance of wildlife and a higher wildlife kill - legal and illegal. The increasing network of roads, seismic lines and pipeline rights-of-way and the uncontrolled use of them by the public remains a major problem in wildlife management (PRISM 1984). In many instances, wildlife managers have been forced to adopt special regulations to govern hunting (Stubbs and Markham 1979), or to implement land-use regulations which require companies to regulate use of their access routes (Bromley 1985, PRISM 1984, Stubbs and Markham 1979). To date there is no published literature on the success of these measures in protecting wildlife.

This research investigates the response of elk to recreational activity along a pipeline right-of-way using three different approaches: telemetry, time-lapse photography, and track counts. Elk were chosen for this study because they are the most abundant ungulate species in the study area, and when disturbed, they travel long distances (Altmann 1956, Geist 1982). Consequently, they will provide more information on the affect of human activity on their movements and distributions, than deer, for instance. Their numbers provide for greater opportunities for successful trapping and collaring of study animals. There are approximately 15,000 elk in Alberta, with a management goal of increasing this population to 30,000 (AENR 1984).

Elk are also a highly sought-after and economically important big game animal. In Alberta during 1981, elk hunters spent 357,000 person days and an estimated 13 million dollars in pursuit of this animal (Adamowicz and Phillips 1984).

Pipeline rights-of-way provide a means of access into relatively remote portions of wildlife range, and provide a unique component of elk habitat that is not used by elk because of high levels of human activity. One of the objectives in expanding the elk population in Alberta is to eliminate or minimize killing and harassment outside of the hunting season (AENR 1984). One way of meeting this objective is to determine the influence on elk of increased access caused by pipeline development in remote portions of elk range.

2.0 HYPOTHESES

In order for wildlife managers to predict and mitigate the potential problems associated with pipeline development on elk populations, it is necessary to determine the amount of human activity along these facilities and the effects of this activity on elk distribution and use of the pipeline right-of-way. This study was designed to test the following null hypotheses:

1. People, vehicle and ATV activity along the pipeline right-of-way is independent of seasons of the year.
2. People, vehicle and ATV activity is independent of disturbance category (disturbed category was September 16 - December 1, 1984 and 1985; undisturbed was December 2, 1984 - September 15, 1985 and December 2 - 31, 1985).
3. People, vehicle and ATV activity along the pipeline right-of-way is independent of activity period (sunrise, midday and sunset) and disturbance category.
4. The distances of individual radio-collared elk from the pipeline right-of-way are independent of the level people, vehicle or ATV activity along the right-of-way.
5. The distances of elk from the pipeline right-of-way are independent of the time-of-day and level of people, vehicle or ATV activity along the right-of-way.
6. Elk use of the pipeline right-of-way is independent of disturbance category.
7. Elk use of the pipeline right-of-way is independent of

activity period (sunrise, midday and sunset) and disturbance category.

8. Elk use of the pipeline right-of-way is independent of the seasons of the year.
9. The distribution of elk tracks in relation to the pipeline right-of-way is independent of sampling period (November, January and March).
10. The frequency of elk use of individual cover types is in proportion to its availability within the study area.
11. The frequency of elk tracks crossing transects is independent of cover type and distance for each sampling date.

3.0 STUDY AREA

To meet the objectives of this study it was necessary to find a study area with the following characteristics: had a limited amount of road access; was transected by a pipeline right-of-way; was located such that it could be easily accessed by a large number of people; had a resident elk population; and hunting was not restricted by special license or season.

The study area chosen is centrally located within a 2 to 2.5 h drive of Edmonton or Calgary, with road access limited to a single road. The study area is transected by a wide pipeline right-of-way, and has a resident elk population, with hunting not restricted by special license or season.

Based on a review of the literature, I expected that the higher proportion of cover in this study area compared with that of other studies would lessen the effect of human activity on elk distribution. As the study area contains a relatively small percentage of open grassland, elk use of the pipeline right-of-way was expected to be high during all times of the year. Since the study area has limited road access, use of the pipeline right-of-way as an access corridor was expected to be high, especially during the hunting season.

The study area, located at latitude 52°30' and longitude 115°50', centers on a north-south gas pipeline owned by NOVA Corporation of Alberta (Figure 1). The Brazeau River, which flows in an easterly direction, bounds the study area on the north. The Nordegg River, which also flows in an easterly direction, transects the southern portion of the study area. The east and west boundaries were arbitrarily chosen

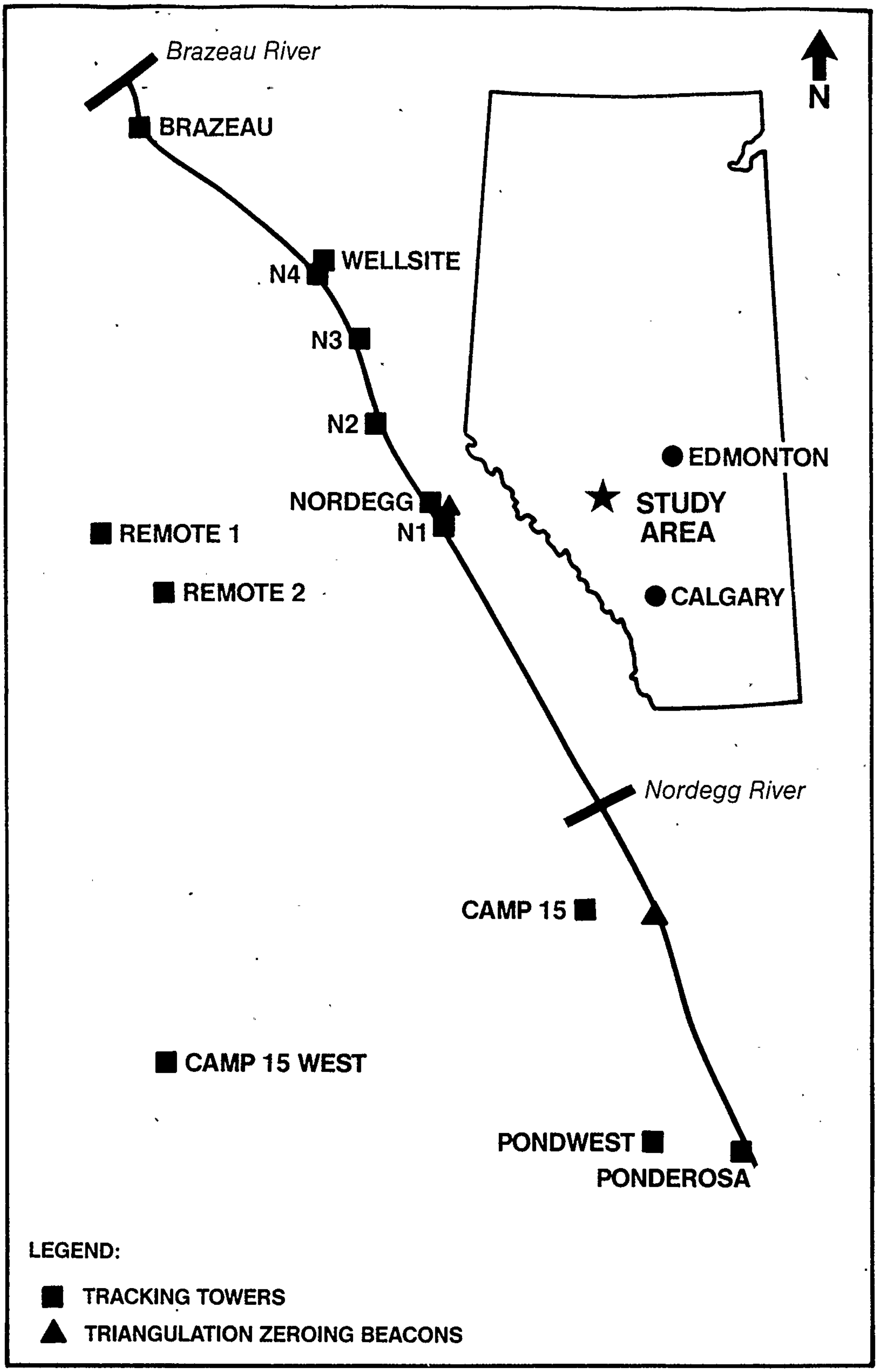

Figure 1. Study area location and detail of right-of-way with tracking tower locations.

imaginary lines parallel to, and 1600 m from, the pipeline right-of-way.

NOVA's pipeline was originally constructed in 1965 and subsequently looped in 1970. The pipeline right-of-way is approximately 38 m wide by 8,900 m long.

Access to the study area is gained by travelling 29 km west of Rocky Mountain House on Highway 11, then north on the Sunchild - O'Chiese road for 39 km, then west for 16 km along Canterra Energy's, access road for the Nordegg River gas plant. Access through the study area can be gained by travelling the pipeline right-of-way with either a 4X4 vehicle or all-terrain vehicle (ATV). Details of physiography, geology and climate are found in Appendix I.

3.1 Vegetation

The study area can be divided generally into coniferous dominated, deciduous dominated, mixed coniferous/deciduous or treed muskeg cover types (Figure 2). A small portion of the study area (3.6 %) can be classified as grasslands, and these are located along the pipeline right-of-way (34.5 %) and within the floodplain (65.5 %) of the Nordegg River. Table 1 provides a breakdown of the area of each cover type within a 3.2 km wide band centering on the pipeline right-of-way.

The predominant species within the coniferous cover types are lodgepole pine (*Pinus contorta*) and black spruce (*Picea mariana*). Brusnyk and Westworth (1985) found, within the same general area, that lodgepole pine and black spruce accounted for 42% and 46%, respectively,

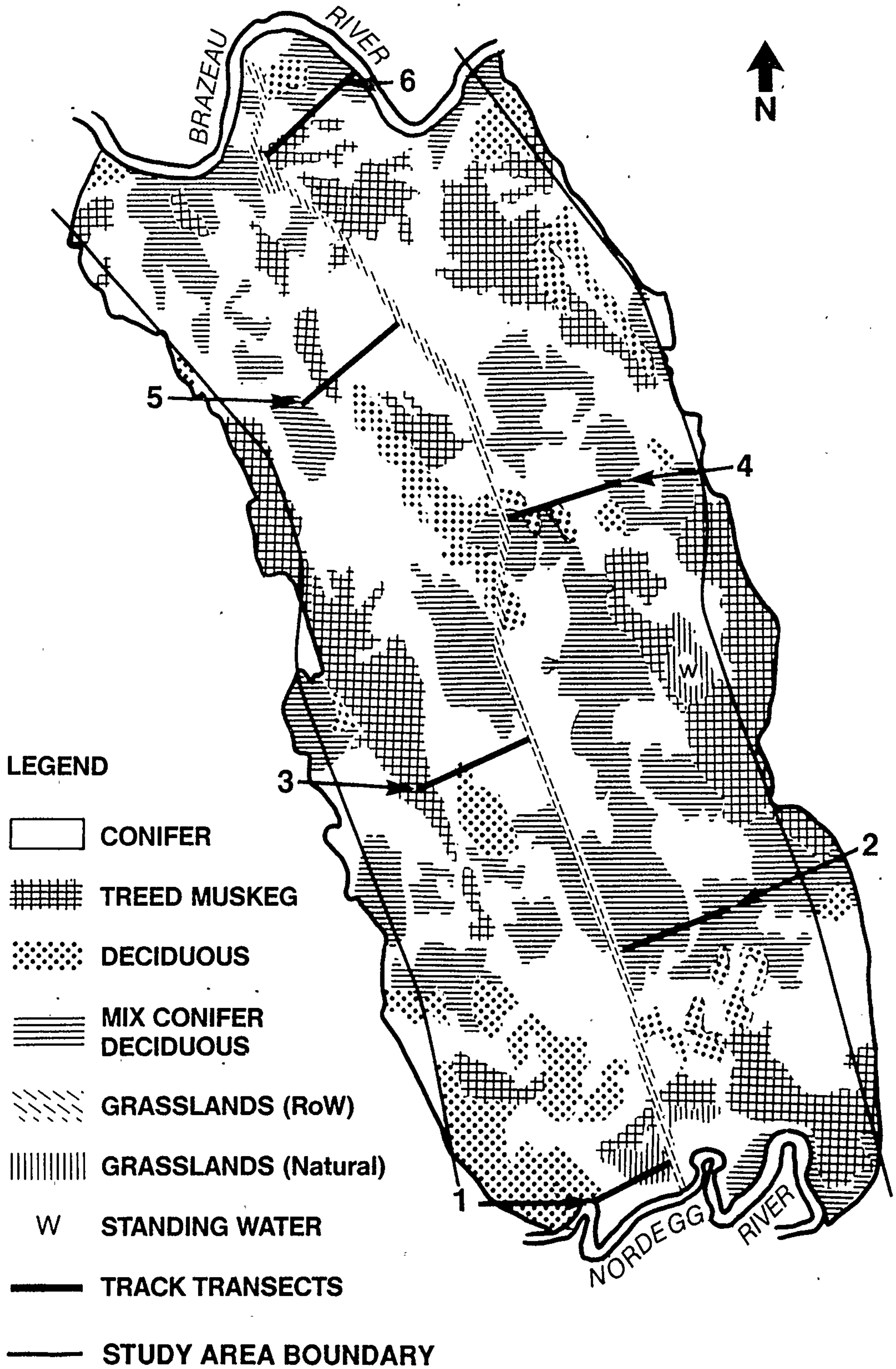

Figure 2. Distribution of cover-types within 1.6 km of either side of the pipeline right-of-way between the Brazeau and Nordegg rivers.

Table 1. Summary of cover-type areas for a 3.2 km wide band centering on the pipeline right-of-way.[1]

Cover Type	Area(ha)	%
conifer	1194.8	44.0
deciduous	248.8	9.2
treed muskeg	495.7	18.3
mixed conifer/deciduous	676.7	24.9
grassland	98.1	3.6
Total	2714.1	100.0

of the total number of stems per hectare within their classification of coniferous forest. White spruce (*Picea glauca*) and balsam fir (*Abies balsamea*) are also found within this cover type but in relatively small (<10 %) proportions (Brusnyk and Westworth 1985). The understory within the coniferous cover type consists of bog cranberry (*Oxycoccus quadripetalus*), dwarf bilberry (*Vaccinium caespitosum*), Labrador tea (*Ledum groenlandicum*), bearberry (*Arctostaphylos uva-ursi*) and green alder (*Alnus crispa*). Predominant grasses found within the coniferous cover type include wild rye (*Elymus* sp.), reed grass (*Calamagrostis* sp.)

[1]Alberta Forestry, Lands and Wildlife. Phase III Forest Inventory Maps, Townships 43 and 44, Ranges 12 and 13, west of the 5th meridian.

and timothy. Predominant forbs are bunchberry (*Cornus canadensis*), Bishop's-cap (*Mitella nuda*) and wintergreen (*Pyrola* sp.) (ibid.).

Black spruce and tamarack (*Larix laricina*) are the coniferous species found within the treed muskeg cover type. In poorly drained, shallow and closed water catchment areas, ground vegetation consists of feathermoss (*Sphagnum* sp.), Labrador tea, swamp birch (*Betula pumila*), bog cranberry and Three-leaved Solomon's-seal (*Smilacina trifolia*) (Dutchak n.d). In other areas where open water is more common, tamarack is the predominant conifer species. Ground cover in these areas consists of sedges (*Carex* sp.), reeds and grasses (ibid).

Aspen (*Populus tremuloides*) and balsam poplar (*P. balsamifera*) are the predominant tree species found within the deciduous cover type. The understory within this cover type is characterized by low-bush cranberry (*Vaccinium vitis-idaea*), bracted honeysuckle (*Lonicera involucrata*), green alder, rose (*Rosa* sp.), willow (*Salix* sp.), saskatoon (*Amelanchier alnifolia*), aspen and balsam poplar along with seedlings of white and black spruce. The most common grass species are hairy wild rye (*E. innovatus*) and reed grass (ibid.).

The vegetational components of the mixed cover type are more complex. Coniferous species found are white spruce, black spruce, balsam fir and lodgepole pine. If the site is conifer dominated, then white spruce, black spruce and lodgepole pine are represented about equally, while aspen is the predominant deciduous tree species. If the site is deciduous dominated, then aspen and balsam poplar are represented about equally but lodgepole pine is the predominant coniferous species. Balsam fir is absent in deciduous dominated mixed cover type. The understory within this cover type is composed of bog cranberry, dwarf bilberry, Labrador tea, bearberry, green alder, low-bush cranberry, rose, aspen, balsam poplar and seedlings of white spruce, black spruce and lodgepole pine (ibid.).

Grasslands are of two types, those that occur naturally and those created by the influence of man such as on the pipeline right-of-way. Natural grassland within the study area consists of northern awnless brome grass (*Bromus pumpellianus*), hairy wild rye, bearded wheatgrass (*Agropyron subsecundum*), slender wheatgrass, tufted hairgrass (*Deschampsia caespitosa*) and sedges (*Carex* sp.).

The pipeline right-of-way is a man-made feature and provides a unique floristic composition within the study area. After the initial pipeline construction, the right-of-way was seeded with a mixture of agronomic grass species. What is present today along the right-of-way is a result of seeding after two construction disturbances and also invasion from the surrounding forest cover. Grass species found along the right-of-way include timothy, Canada bluegrass (*Poa compressa*), reed canary grass (*Phalaris arundinacea*), smooth brome grass, creeping red fescue, tall wheatgrass (*A. elongatum*), alsike clover (*Trifolium hybridum*) and red clover (*T. pratense*). The immediate area covering the two buried pipelines is kept exclusively in grass cover.

Over the last 17 years, shrubs and trees from the surrounding forests have encroached onto the pipeline right-of-way. Generally this band of encroachment extends approximately 10 m into each side of the right-of-way from the adjacent forest. Species involved are green alder, balsam and aspen poplar, rose, willow, saskatoon , white spruce and lodgepole pine. Green alder, willow and balsam poplar are the predominant species. The abundance of individual species within the zone of encroachment is dependent upon the adjacent forest vegetation type.

3.2 Study Area Background

Since the construction of the pipeline in 1965, the study area has been subjected to timber harvest, seismic activity, wellsite development and pipeline construction. In 1965 only two seismic lines crossed the pipeline right-of-way, but by 1984 the number of lines had increased to 11. In addition, two wellsites have been constructed within a quarter mile of the right-of-way. This increase in oil and gas activity has resulted in the development of access routes into this previously inaccessible wildlife habitat. The development of seismic lines and wellsites has modified the habitat within the study area by increasing the amount of edge and the availability of highly palatable agronomic grass species. These changes in habitat may have changed elk numbers and distribution within the study area.

The study area lies within Wildlife Management Unit (WMU) F328, and utilization of the wildlife in this area is mainly in the form of hunting. The hunting season for ungulates generally opens in mid-September and closes at the end of November. Black bear (*Ursus americanus*) are hunted in the spring and fall seasons, while grizzly bear (*Ursus arctos*) are hunted only in the spring. Until 1985 only male elk were legally hunted, but in 1985 a cow elk season lasting four days was implemented during the last week of the season.

Compulsory registration of all elk shot in Alberta has been in effect since 1972 to provide harvest information on a WMU basis. Data for WMU F328 is available from 1975 to 1985 (Table 2) and can be considered to provide a minimum estimate of the total number of elk harvested. These data show that the kill from 1972 to 1985 has

Table 2. Compulsory elk harvest information for WMU F328, 1975 to 1985.

Year	Harvest
1975	12
1976	9
1977	13
1978	18
1979	20
1980	26
1981	32
1982	35
1983	47
1984	36
1985	64

increased, but this does not mean that the elk population is increasing. The increased harvest is probably a result of an increased compliance with compulsory registration and increased hunter success due to improved access.[2]

There are no aerial-survey data available for any of the ungulate species, but according to government sources, elk and moose are consider the most abundant species.[3] Ungulate species utilizing the study area are elk, moose, white-tailed deer (Odocoileus virginianus), mule deer. Carnivores present are black bear, grizzly bear, wolf (Canis lupus), coyote (C. latrans) and lynx (Lynx canadensis).

Little information is available on recreational use of the study area. Hunting, fishing and camping occur within the study area during the spring to fall period. Winter recreational activities are snowmobiling and cross-country skiing (personal observation). Undoubtedly other activities such as berry picking and woodcutting also occur.

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[2] Bruns, Eldon. 1987. Personal communication. Alberta Forestry, Lands and Wildlife, Fish and Wildlife Division, Rocky Mountain House, Alberta.

[3] ibid.

4.0 METHODS

4.1 Study Design

This project required the collection of data on human and elk activity along the pipeline right-of-way as well as data on elk geographical distribution in relation to the right-of-way.

I chose to study only fully grown, adult cow elk to reduce variability because:

1. Adult cow elk are less variable in body size than are adult males (Flook 1970, Houston 1982, Greer and Howe 1964).
2. From a wildlife management perspective of maintaining reproduction, cow elk are the most important unit in an elk population.
3. Cow elk comprise the greatest proportion of an elk population.
4. Daily and seasonal distributions of cow elk are somewhat less variable than for male elk.

The small number of elk chosen for this study was based upon accepted practices in large mammal research as followed in other telemetry studies (Craighead et al. 1973, Baker and Hansen 1985, Edge and Marcum 1985, Edge et al. 1985, 1986, Gillingham and Bunnell 1985, Grover and Thompson 1986, Gruell and Roby 1976, Irwin and Peek 1979, Kuck et al. 1985, Luick and White 1986, MacArthur et al. 1979, 1982, Marcum 1975, McCorquodale et al. 1986. Pierce and Peek 1984, Regeline et al. 1985, Renecker and Hudson 1985, 1986, Ward 1976, Wickstrom et al. 1984 , Yarmoloy 1983, Yarmoloy et al. (in press)). These authors used relatively small numbers of representative study animals, favoring accuracy of results over large, but less intensively investigated samples.

The design of this project was as follows:

1. Elk locations were to be determined through ground and aerial telemetry of seven radio-collared elk. Ground telemetry of radio-collared elk was planned for a three-day period each week, beginning on Friday and ending on Sunday. The telemetry schedule called for weekly tracking of the elk during the hunting season (September 18, 1984 - December 1, 1984) and once per month tracking until September 1985. Readings were scheduled to be taken every four hours during the tracking period, resulting in a potential of 252 locations for each radio-collared elk during the study. Aerial locations of collared elk were scheduled on a weekly basis during the hunting season, then monthly until September 1985.
2. Elk and human activities were to be documented through time-lapse photography using five Super 8 mm movie cameras (Diem et al. 1973, Montalbano III et al. 1985) placed at various locations along the pipeline right-of-way.
3. The counting of elk tracks along transect lines was the method chosen to determine if elk were affected by human activity along the pipeline right-of-way. Transects were 1000 meters in length and placed perpendicular to the pipeline right-of-way. All transects were to be placed systematically along the

right-of-way with the exception of the first transect location which was to be chosen randomly.

4.2 Equipment and Materials

4.2.1 Capture of Elk

Elk were to be trapped in four clover traps, baited with salt, placed near the pipeline right-of-way. Captured elk were to be immobilized with an injection of Xylazine Hydrochloride (Rompum, 100 mg/L), administered through a dart fired from a Pneu-dart rifle. Once elk were captured and immobilized radio-transmitter equipped collars (150-151 MHz, Wyoming Biotelemetry) were to be fitted around the neck of the animals.

4.2.2 Telemetry Equipment for Monitoring Elk Movements

Ground telemetry of radio-collared elk were to be done using a Telonics Inc. RA-NS Precision DF Antenna Systems. These systems employ two "beam" antenna arrays, critically separated by a lightweight metal crossboom (Telonics 1982). The signals received from each antenna are combined precisely out of phase using a Telonics TAC-5 combiner. Antenna arrays were to be pairs of two-element H antennas, and four or five element Yagi antennas. These antenna systems were to be mounted on 10.7 meter-high towers located throughout the study area. A portable 3.7 meter-high tower was to be mounted in the box of a 3/4 ton 4x4 truck.

Once the antenna systems were built and installed on the towers, the systems were to be zeroed to a reference beacon and all subsequent readings were to be in relation to this beacon. The transmitted signals were to be received using Telonics TR-2 receivers.

Locations of radio-collared elk were to be determined from the air by using a Bell 206 Jet Ranger helicopter equipped with two H antennas, each attached to the end of a wooden crossboom mounted to the landing skids of the helicopter. Antennas are mounted with a downward tilt of 30 degrees and looking sideways 90 degrees from the body of the helicopter. Signals are transmitted from the antennas through coaxial cable to a TAC-2 RLB antenna control unit to a Telonic's TR-2 receiver. When a signal is detected the TAC-2 RLB unit is used to determine whether the signal is on the left or the right of the helicopter by monitoring first the left antenna alone and then the right. The side receiving the strongest signal determines the direction of search.

4.2.3 Time-Lapse Photography

Five Sankyo EM-40XL Super 8 mm movie cameras were modified to expose a single frame approximately every three minutes (Table 3). These cameras are powered by six-volt batteries. Built-in light meters are used to switch the cameras "on" and "off". The cameras switch on approximately 10 minutes past sunrise and shutoff when light conditions are unfavorable, generally about one-half hour past sunset.

Developed films were to be viewed using a Lafayette Instrument Company Model 925 single frame analyzer. The number of people, vehicles, ATVs and elk observed on each frame were to be counted and recorded on data sheets.

Table 3. Exposure interval for each camera used in this study.

Camera	Exposure interval (seconds)
C1	186
C2	192
C5	165
C6	188
C7	195
C8	212

4.3 Field Techniques

4.3.1 Elk Capture

Elk were trapped and fitted with radio-collars between June 24 and August 5, 1984. Once an elk was trapped, one of two methods was used to restrain it so a radio-collar could be placed around its neck. In three cases the captured elk were immobilized with Xylazine Hydrochloride (Rompun, 100 mg/L). Care was taken to ensure that drugged elk were down in a sternal recumbent position, with the neck up and head down to prevent any regurgitated material or excess of saliva from moving into the lungs. In the other four instances the trap was collapsed on the captured elk. Collapsing the trap effectively pinned the elk to the ground in sternal recumbent or recumbent position. A portion of the trap netting near the head of the elk was removed, allowing for placement of the collar. Radio-transmitter equipped collars were placed on the elk, the collars checked for proper operation, and then the elk were released. Drugged elk were observed from a distance and allowed to recover from the effects of the drug undisturbed.

All female elk used in this study were normal, healthy females of middle age. I found no signs of abnormalities in body structure, health, or size. Therefore, any findings of this study would be more applicable to the overall population of elk in the study area than had I chosen adult male elk, yearlings or calves.

4.3.2 Monitoring Elk Movements

Elk were monitored using radio-collars and a ground-based antennae system, a method which was not free of difficulties. Of the seven elk originally collared only six provided useful triangulation data. The collar on the seventh elk fell off just prior to the collection of field data.

Transmitted signals were received simultaneously from either two or three tracking-tower locations. From September 18, 1984 until October 31, 1984 two tower locations were used. Three tower locations were utilized from November 1 to December 1, 1984 and during the once monthly tracking periods from December 1984 until March 1985. The use of three tower locations greatly increased the potential to receive an adequate number of signals for determining the location of a radio-collared elk. Sampling during November, 1984 resulted in 49.6% of all the locations of the radio-collared elk. This proportionately greater number of locations is a result of using three tracking-tower locations simultaneously as well as fewer equipment failures and a greater number of sampling days. Also, the animals may have been closer to the right-of-way during this month.

Initially, the tracking system consisted of two permanent towers and one antenna system mounted in the back of a 4x4 truck. Tower locations (Figure 1) used during this initial phase were N1 and Ponderosa (permanent sites) and N2, N3 and N4 (truck mounted sites). However, right-of-way travel conditions deteriorated because of heavy rains and snow during the first four days of the field work to the point where the truck mounted system collapsed. At this point the two permanent tracking-tower locations were used, but their locations proved to be ineffective in maximizing the number of signals received and additional tower sites had to be established within the study area. Permanent towers were established at Remote 1, which was a camp located on a height of land approximately 3.2 km west of the pipeline right-of-way, and at the Nordegg and Brazeau locations (Figure 1). Additional tower locations were established primarily in an effort to maximize the number of signals received. For example, the Brazeau tower location was abandoned (October 21, 1984) in favor of the Wellsite tower location while Remote 1 was moved (November 3, 1984) to Remote 2 location in a effort to increase the number of signals being received from the radio-collared elk.

Signals from every collared elk could not be received at all times. Therefore, the initial plan of taking readings every four hours from Friday to Sunday was abandoned in favor of taking readings every two hours, starting at 0500 hours and terminating at 2100 hours on Friday and Saturday. This had the effect of potentially increasing the number of observations per radio-collared elk from six to nine per day. This new procedure was instituted, starting on the first sampling day in

October, 1984. Taking readings after 2100 hours and before 0500 hours was terminated because of the few signals received during this time period.

Equipment failure, poor ground access and inclement weather complicated the sampling program. Data collected on September 18 and 19, 1984 were collected using the peak of the signal rather than the null and could not be utilized. In addition, a heavy wet snowfall caused the collapse of the antennas on the tracking towers on September 21. These factors, along with the low number of signals received for each animal, resulted in an extremely low number of locations (N=16) of the radio-collared elk during September, 1984. Inclement weather prevented sampling on October 19 and 20, 1984. On November 3, 1984 sampling did not occur since it was necessary to move Remote 1 camp to Remote 2 location to try to increase the number of individual signals received.

Readings began on Friday and ended on Saturday of each weekend during the period October 5, 1984 to December 1, 1984. Once-per-month tracking periods were conducted during December, 1984, and during January to March, 1985. Attempts were made to take readings of radio-collared elk during May to September, 1985 but these were unsuccessful because of poor signal reception. This factor reduced the number of potential locations per radio-collared elk by 55 percent, resulting in smaller sample sizes than expected.

4.3.3 Time-lapse Photography

Eight locations were chosen for collecting data on human and elk activity along the pipeline right-of-way (Figure 3). The cameras

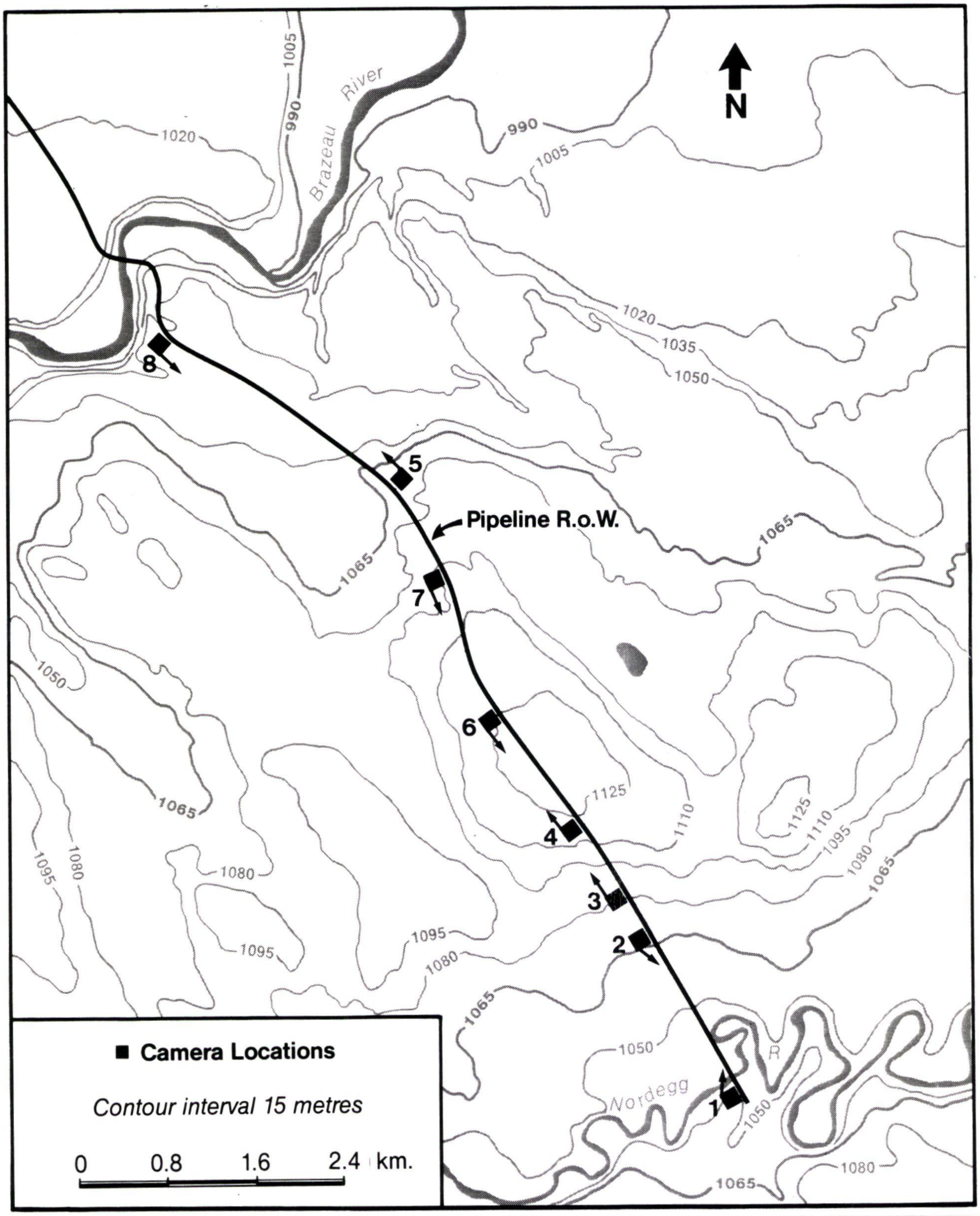

Figure 3. Camera location and direction of view along the pipeline right-of-way.

were placed in specially-constructed boxes and mounted on platforms in trees adjacent to the right-of-way at the chosen locations. Initially, cameras C6, C7 and C8 were to be alternated on a two week basis between locations 3 and 6, 4 and 7, and 5 and 8, respectively, but equipment and battery failure made it impossible to continue this format. Instead, cameras were setup at locations 1, 2, 6, 7 and 8. In 1985 a sixth camera was added so that camera location 5 could be sampled over the same period as in 1984 (Table 4).

Table 4. Total observation time in hours, and date camera was installed and removed at each camera location from June, 1984 to December, 1985.

Camera Location	Observation Time (hours)	Date: Installed	Date: Removed
1	2863.83	June 15, 1984	December 31, 1985
2	3128.96	August 31, 1984	December 31, 1985
3	5.54	September 12, 1984	October 15, 1984
4	48.53	September 12, 1984	October 31, 1984
5	367.47	September 12, 1984	November 9, 1984
	228.53	September 17, 1985	November 3, 1985
6	2888.99	November 4, 1984	December 31, 1985
7	2070.41	November 4, 1984	December 31, 1985
8	3585.51	November 11, 1984	December 31, 1985

Weather, equipment and battery failure played an important role in determining the amount of data that was actually collected. As can be seen from Table 4, camera locations 3 and 4 had substantially less data collected than all other locations. This was a direct result of equipment malfunctions and problems with the battery power. Because of the small amount of data at these two locations, these data were not included in data analysis.

Battery failure was the predominant cause of camera malfunction at all locations. Extremely cold temperatures affected the operating efficiency of the batteries. Initially, two six-volt 3.5 amp.-hr gel cell batteries connected in parallel circuits were used to power each camera. These batteries were replaced every two weeks with newly charged batteries, and then were recharged. This type of battery cannot withstand frequent and repeated occurrences of discharging and charging. Consequently, from January to March 1985, these batteries provided inconsistent power, resulting in frequent camera failure and a reduction in the amount of data collected. In April, 1985 larger six-volt lead acid batteries replaced the gel cell batteries as a source of power to the cameras. These batteries were Prestolite low maintenance industrial batteries with a 134 amp.-hr rating. In addition, these batteries needed charging only once per month in extremely cold conditions and once every two months during the spring, summer and fall. The change in batteries resulted in improved camera performance. However, some problems still occurred, with camera shutters freezing open in extremely cold temperatures, and frost on camera lenses further reducing the amount of usable data. The actual operating dates for each camera are found in Appendix II.

There are some inherent problems when using cameras to collect biological field data. Theses problems include controlling the field-of-view, operating period and exposure time. These problems become increasingly important when sampling with several cameras. In this study, each camera was setup to expose a frame every three minutes. Actual exposure interval ranged from 2 min. 45 sec. to 3 min. 32 sec., depending on the camera (Table 3). In addition, the field-of-view and direction of view were not identical at each camera location. For example, the camera at location 1 looked north along the pipeline right-of-way and the field-of-view was the full width of the pipeline right-of-way for approximately 350 m. In comparison, the camera at location 2 looked southeast along and across the pipeline right-of-way with a field-of-view of approximately 200 m. As a result of the discrepancies in the field-of-view, operating periods and exposure intervals between cameras, data analysis was confined to comparisons for individual cameras rather than between cameras.

It was also important that the field-of-view for each camera did not include too much sky. If this occurred the camera improperly measured the amount of light required to correctly expose an individual frame, resulting in the pipeline right-of-way appearing too dark to allow determination of elk or human related activity.

4.3.4 Track Counts

Six transect lines were established perpendicular to, and placed systematically along, the pipeline right-of-way. The first transect was chosen randomly within the first 500 meters of the right-of-way and subsequent transects were spaced every 1600 meters on alternate sides of the right-of-way (Figure 2). The transects were originally planned to be 1000 meters in length. The Nordegg and Brazeau rivers prevented transects one (700 m) and six (925 m) from being this length. Transect five was only 925 m because of an error in measurement.

Each transect line was subdivided into 25-meter sections and within each section the major forest cover types were classified as conifer, mixed conifer/deciduous, deciduous, grassland or treed muskeg (Table 5). A 100-meter chain was used for all measurements and a compass was used to ensure the transect was perpendicular to the pipeline right-of-way. The beginning of each transect was marked using fluorescent-orange survey ribbon. This ribbon was also used to delineate the 25-meter sections of the transect.

Ungulate tracks were recorded for each 25-meter section on each transect. If possible, tracks were identified to species, and if not, they were assigned an unclassified rating. Only tracks crossing a transect were counted, although no attempt was made to determine the fate of a set of tracks. Consequently, an animal could easily be counted more than once should it cross the transect again, or cross another transect. If a group of animals crossed the line and the number of animals could not be determined, then the crossing was classified as

Table 5. Track transect length in meters and major cover types and percentages for each transect line.

Transect	Length (m)	Major cover types	% of Transect
1	700	mix conifer/deciduous	14.3
		grassland	28.6
		conifer	57.1
2	1000	mix conifer/deciduous	62.5
		conifer	30.0
		treed muskeg	7.5
3	1000	mix conifer/deciduous	37.5
		conifer	30.0
		grassland	2.5
		deciduous	17.5
		treed muskeg	12.5
4	1000	mix conifer/deciduous	50.0
		conifer	42.5
		treed muskeg	7.5
5	925	conifer	40.5
		treed muskeg	59.5
6	925	mix conifer/deciduous	51.4
		conifer	16.2
		treed muskeg	32.4

a trail. A record of all trails crossing the line was kept for each 25-meter section along the transect. After each set of tracks were recorded they were obliterated to prevent counting on subsequent sampling dates.

Three sampling periods were established to coincide with periods of high and low recreational activity. Track counts were done on November 28 and 29, 1984 to correspond to the period of high recreational activity, while track counts were done on January 24, 1985 and March 4 and 5, 1985 to correspond to the period of low recreational activity. There was no attempt to conduct track counts within a specified period after a snowfall, although this would have been ideal.

4.4 Data Analysis

4.4.1 Triangulation Data

Telemetry data reduction was done using a triangulation and mapping program developed by the Computer Services Department affiliated with the Faculty of Environmental Design of the University of Calgary. The triangulation program determined the location of an elk at a particular time from either two or three readings. The program then calculated the distance of the elk from the pipeline right-of-way. The antenna systems used in this study had an accuracy of plus or minus two degrees. The two tower triangulation system implies a precise location of an animal at the intersection of two angles. However, with the accuracy of this system the actual location of the animal is somewhere within a polygon formed by the intersections of the two sets of innermost and outermost possible bearings from the two locations. This polygon is called an "error polygon", the shape and area of which is determined by the following: (1) the accuracy of the directional antenna system, (2) the distance between the tower locations, (3) the distance of the transmitter from the receiving towers, and (4) the angle of the transmitter between from the receiving towers. The distance of the animal from the right-of-way was assumed to be the intersection of the two bearings where in fact the location of the animal is somewhere within an error polygon. The individual locations determine through two tower locations may infact be closer or perhaps farther from the right-of-way than indicated. With the three tower triangulation system the animal is assumed to be at the center of the triangle formed by the intersection of the three bearings. The results of this program were stored in a database, to be used in future data analysis.

Three timeperiods were established to determine if elk changed their distribution in relation to the pipeline right-of-way with time of day. The timeperiods were:

timeperiod 1 = 0500 - 0900 h.

timeperiod 2 = 1100 - 1500 h.

timeperiod 3 = 1700 - 2100 h.

The triangulation data were also grouped into disturbed and undisturbed categories. The disturbed category corresponded to the period of greatest human activity; September 16 to December 2, 1984. The undisturbed category was from December 11, 1984 to March 21, 1985. Although there was no possible a priori reason for the data from triangulation to be normally distributed, the data were tested for normality using the Kolomogorov one-sample test (Zar 1984). This test showed that the triangulation data were not normally distributed.

Consequently, nonparametric statistical procedures were used for subsequent data analysis, namely the Mann-Whitney U-test (M-W) (Siegel 1956, Zar 1984) and the Kruskal-Wallis (K-W) test (Siegel 1956). The Mann-Whitney U-test is appropriate for comparisons between two samples, while the Kruskal-Wallis test is appropriate for comparisons among three or more samples. The Mann-Whitney U-test was used to determine if differences in distance from the pipeline right-of-way for each radio-collared elk was independent of disturbance category, and disturbance category and time-of-day combined for individual elk. The Kruskal-Wallis test was used to determine if there was a difference in distance from the right-of-way among radio-collared elk.

4.4.2 Time-lapse Photography Data

Observation time was defined as the camera exposure interval for each frame multiplied by the number of elk, people, vehicles or ATVs observed on each frame. Observation time was expressed as a ratio of observation time for each activity for a specified period divided by total exposure time for that period. For example, camera C5 had an exposure interval of 212 seconds, and exposed 17 frames every hour. The ratio of elk observation time to total observation time for an hour would be the number of frames with elk multiplied by the number of elk on each frame, and then multiplied by the exposure interval time, yielding total elk-seconds. This would then be divided by the total exposure time in an hour (3600 seconds). If there were three frames with four elk on each frame, then the ratio would be $(3 \times 4 \times 212)/3600 = 0.7067$. It was necessary to use ratios for data comparisons because the length of comparison period, camera operating period, and amount of daylight were not equal among comparison periods. Because of variations in day-length between days, months and seasons it was necessary to make comparisons between sunrise and sunset periods. The work of Craighead et al. (1973) and Collins et al. (1978) show that elk are actively feeding generally for a period of two hours immediately after sunrise and immediately before sunset. The time between the two categories is used by elk for bedding, travel and ruminating. Consequently, three categories for grouping of time-lapse photography ratios were used. These categories were:

1. Sunrise period (2 hr. period starting at sunrise)
2. Midday period (1200 h to 1400 h)
3. Sunset period (2 hr. period ending at sunset)

Comparisons of time-lapse photography ratios were made among these activity periods between disturbance category.

Comparisons were made among seasons for each camera to determine if the ratios of elk, people, vehicle and ATV observation time to total observation time were different at various locations along the pipeline right-of-way. The seasons were defined as:

Winter: December 1, 1984 to March 31, 1985 and December 1-31, 1985.

Spring: April 1 to June 15 of 1984 and 1985.

Summer: June 16 to August 31 of 1984 and 1985.

Fall: September 1 to November 30 of 1984 and 1985.

The Kolmogorov-Smirnov one-sample test was used to test the time-lapse photography ratios for normality. This test showed the time-lapse photography ratios to be not normally distributed. Consequently, nonparametric statistical tests were used. The Mann-Whitney U-test was used to test if the ratio of vehicle, people, ATV and elk observation time to total exposure time along the pipeline right-of-way was independent of disturbance category, and disturbance category and activity period combined by camera location. The Kruskal-Wallis test was used to determine if elk, people, vehicle and ATV activity was independent of seasons of the year by camera location. The Mann-Whitney U-test was also used to test for differences in elk, people, vehicle and ATV activity between seasons of the year.

4.4.3 Track Count Data

All track transects were not of equal length but were at least 700 m in length. Therefore, only track data recorded within the first 700 m from the right-of-way were used for comparative purposes and for statistical analysis. In addition, the length of time between sampling periods was not equal. The first snow storm which resulted in the study area being permanently covered with snow occurred on October 17 and 18, 1984. October 19, 1984 was used as the start date from which tracks accumulated prior to the first sampling period. The track data were multiplied by a correction factor, in order to make the time between sampling periods equivalent to 40 days. Consequently, the November and January data were multiplied by 0.9524 and 0.8163, repectively, to adjust the data to an equal length of time between sampling periods. In conducting the track counts in this manner the following assumptions were used: (1) there were no snow falls between sampling periods that obliterated elk tracks, (2) the number of tracks observed is an accumulation of tracks over an equal time period, and (3) the number of tracks observed are randomly distributed throughout the time period between sampling dates.

Track count data were tested for normality using the Kolmogorov-Smirnov one-sample test, which showed that the data were not normally distributed. Therefore, nonparametric statistical procedures were used in data analysis. The Kolmogorov-Smirnov two-sample test (K-S 2) (Siegel 1956) was used to test if the distribution of tracks, as expressed as distance from the right-of-way, was independent of sampling period. The chi-square test (X^2) (Siegel 1956, Zar 1984) was used to determine if there was a difference in the frequency of tracks between 0-350 m and 350-700 m, between sampling dates. The chi-square test was used to determine if the frequency of elk use of each cover type was in proportion to its availability for each sampling period. The effect of cover type and location on the frequency of elk tracks for each sampling period was also tested using the chi-square technique. The deciduous cover type was not represented in the 0-350 m category, consequently the chi-square test of cover by location for each sampling date was a 2 x 4, rather than a 2 x 5 frequency table.

The number of elk tracks counted along transect lines was used to determine an elk cover preference, based on the method used Curatolo and Murphy (1986). This method involves determining the percentage of each cover type within the study area (i.e. on transects) and the percentage of elk tracks observed within each cover type. Cover preference is calculated by comparing the percent of elk tracks observed in each cover type to the percent availability of each cover type.

Data analysis was carried out on NOVA's mainframe IBM computer using the Statistical Analysis System Institute (SAS) program package and on a Packard Bell XT personal computer using Lotus 1-2-3.

5.0 RESULTS

5.1 Time-Lapse Photography

The use of six cameras at six different locations during this study resulted in exposure of 279,753 frames of film, and a total observation time of 15133.70 hours. Observation time for each camera was a function of the camera operating time and number of daylight hours. The camera operating time was dependent upon the absence of adverse weather conditions which affected the operating capability of the battery-powered system. For example, May, 1985 accounted for 14 percent of total observation time for camera 8. This reflects the greater number of daylight hours, which allowed for more film exposure, and the moderate weather conditions which did not adversely affect the power supply. In comparison, December, 1985 accounted for 4.37 percent of total observation time for camera 8. The lower observation time was due to shorter day length, and adverse weather conditions which frequently caused camera and/or power failure.

Camera 8 accounted for highest percent of the total observation hours, compared to the other cameras. At this camera location (C8) people, vehicle and ATV activities were lowest, while elk activity was highest. Camera 5 operated for the shortest period but recorded the highest levels of people, vehicle and ATV activity and the second highest level of elk activity along the right-of-way (Table 6).

People, vehicle, and ATV activity accounted for 0.34, 1.94, and 0.09 percent of total observation hours, respectively, while elk activity accounted for 0.30 percent.

Table 6. Percent of total observation time for each camera and for each activity by camera location from June, 1984 to December, 1985.

Camera location	Observation Hours	% Hours	% Elk	% People	% Vehicles	% ATVs
C1	2863.83	18.92	0.04	0.19	2.79	0.14
C2	3128.96	20.67	0.02	0.07	0.20	0.06
C5	596.00	3.94	0.28	6.43	32.03	0.85
C6	2888.99	19.09	0.09	0.11	0.51	0.03
C7	2070.41	13.68	0.23	0.04	0.09	0.04
C8	3585.51	23.69	0.97	0.02	0.01	0.03

% hours = Observation hours/total observation hours (15133.70).

$$\% \text{ elk} = \frac{\text{(no. frames with elk X exposure time)}}{\text{Total exposure time for each camera.}} \times 100$$

% people, % vehicles and % ATVs calculated in the same way as % elk.

Periods of greatest human use of the right-of-way occurred during the fall (September 15 - November 30) hunting seasons of 1984 and 1985 and during May 1985. Approximately 91 percent of the people activity, 88 percent of the vehicle activity and 89 percent of the ATV activity occurred during these periods at camera locations C1, C2, C6, C7 and C8 combined. Sixty-four percent of the people activity, 74 percent of the vehicle activity and 71 percent of the ATV activity recorded during these dates occurred at the location C1.

The camera at location C5 was only operational during September, October and November of 1984 and 1985. People activity recorded at this location was 4.4 times higher than levels recorded during the same period at all other camera locations combined, while vehicle activity was 4.5 times higher. ATV activity during the same period was 49.6 percent of the total ATV activity recorded at all other camera locations during the study.

The data from each camera were divided into disturbed (September 16 - December 2, 1984 and September 16 - November 30, 1985) and undisturbed (June 1 - September 15, 1984, December 3, 1984 - September 15, 1985 and December 1 - 31, 1985) categories. The disturbed period was considered to be the fall hunting season for each year, while the dates surrounding each hunting season were considered as the undisturbed period. High levels of human activity recorded on cameras and field observations confirmed this categorization to be correct. The ratios of observation time for elk, people, vehicles and ATVs were tested for differences between disturbance categories for each camera location (Table 7).[4]

People, vehicle and ATV observation times were expected to be different between disturbance categories with higher levels of these activities expected to occur during the disturbed period. Observation time for people and vehicles were higher in the disturbed period and were significantly different between disturbance categories (Table 7). Higher levels of ATV activity were not observed at all camera locations as might have been expected based on the observations for people and vehicle activity. Significant differences observed at locations C1 and C2 are probably related to these areas being near the only access point

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[4]The Mann-Whitney U-test used each day's data within each category for elk, people, vehicle and ATV activity.

Table 7. Comparison of the ratios of observation time for elk, people, vehicles and ATVs to total observation time between disturbed (September 16 - December 2, 1984 and September 16 - November 30, 1985) and undisturbed (June 1 - September 15, 1984, December 3, 1984 - September 15, 1985 and December 1 - 31, 1985) categories by camera location.

Disturbed vs. Undisturbed Categories				
Camera location	Elk	People	Vehicles	ATV
	(P-values)[1]			
C1	0.6681	0.0001	0.0001	0.0001
C2	0.1155	0.0001	0.0001	0.0001
C5	ND[2]	ND	ND	ND
C6	0.0372	0.0001	0.0001	0.1041
C7	0.0025	0.0001	0.0001	0.0097
C8	0.0001	0.0002	0.0007	0.8231

[1]Mann-Whitney U-test using each day's data.

[2]ND indicates that no data were available for comparing disturbance categories.

along the right-of-way, consequently human activity is likely to be greater at these locations.

The camera data were grouped into disturbance category and activity period. Comparisons were made between disturbance categories and activity period for observation time of elk, people, vehicle and ATV (Table 8).

People and vehicle observation times were greater in the disturbed period compared with the undisturbed period for most activity periods at all camera locations. The significant differences observed suggests that hunters spend a considerable amount of time hunting on foot or driving along the pipeline right-of-way. Since the use of ATVs for hunting is prohibited by law before 12 noon during the hunting season, it is not surprising to find no difference between disturbed and undisturbed categories for sunrise activity period at all camera locations.

Comparisons (Kruskal-Wallis) were made among seasons to determine if the ratios of elk, people, vehicle and ATV observation time to total observation time were different at various locations along the pipeline right-of-way (Table 9). Observation time for people, vehicles and ATVs during the fall was generally higher at all camera locations compared with all other seasons (Appendix III, Figures IIIa - IIIc). The high levels of human activity recorded in the fall suggests seasonal use of the right-of-way and probably accounts for the significant differences observed for people and vehicle observation time among seasons at all camera locations. The differences among seasons for ATV observation time at locations C1 and C2 is probably due to these locations being near the only access point along the right-of-way. Consequently, the higher levels observed are a result of a greater opportunity to observe people using ATVs rather than people selectively using them in these areas.

Table 8. Comparison of the ratios of observation time for elk, people, vehicles and ATVs to total observation time between disturbed (September 16 - December 2, 1984 and September 16 - November 30, 1985) and undisturbed (June 1 - September 15, 1984, December 3, 1984 - September 15, 1985 and December 1 - 31, 1985) categories by camera location and activity period.

	Disturbed vs. Undisturbed			
Camera & Activity	Elk	People	Vehicles	ATV
	(P-values)[1]			
C1				
sunrise	0.5770	0.0007	0.0001	0.5000
midday	0.4346	0.0230	0.0001	0.0790
sunset	0.4160	0.0005	0.0001	0.0001
C2				
sunrise	0.4882	0.0004	0.1201	0.5000
midday	0.6179	0.0006	0.0001	0.8257
sunset	0.3740	0.1501	0.0010	0.0001
C6				
sunrise	0.2025	0.0063	0.0416	0.4587
midday	0.5470	0.0002	0.0068	0.8202
sunset	0.6922	0.0003	0.0001	0.9034
C7				
sunrise	0.0311	0.0007	0.0088	0.6517
midday	0.5288	0.0001	0.0122	0.3612
sunset	0.6060	0.0335	0.0007	0.0024
C8				
sunrise	0.0091	0.0651	0.0088	0.5329
midday	0.8343	0.5814	0.3841	0.8398
sunset	0.0854	0.0024	0.0818	0.4209

[1]Mann-Whitney U-test using each day's data within each activity period.

Table 9. Comparison among seasons of the ratios of elk, people, vehicles and ATV observation time to total observation time by camera location.

Camera Location[1]	Elk	People	Vehicle	ATV
	(P-value)[2]			
C1	0.3003	0.0004	0.0001	0.0019
C2	0.1792	0.0001	0.0001	0.0117
C6	0.0010	0.0004	0.0017	0.5535
C7	0.0001	0.0027	0.0003	0.0287
C8	0.0001	0.0095	0.0169	0.9181

[1]Camera 5 was not used since it was only operational during the fall of 1984 and 1985.

[2]Kruskal-Wallis test using each day's data

Observation time for people and vehicles were greater in the fall compared with other seasons. Between season comparisons showed that the observation time for people and vehicles were significantly different between the fall and all other seasons for most camera locations (Table 10). This suggests that human activity along the right-of-way is seasonal and is related to the recreational activity of hunting. Human activity along the right-of-way is relatively low during all other seasons at most camera locations, except for the spring season at

Table 10. Results of Mann-Whitney comparisons between seasons for ratios of observation time to total observation time by season and camera for elk, people, vehicle and ATV.

Camera/Season	Elk	People	Vehicle	ATV
	(P-values)[1]			
Camera 1				
Spring/Summer	0.1879	0.0212	0.2314	0.0822
Spring/Fall	0.3933	0.2719	0.0001	0.1202
Spring/Winter[2]	0.1023	0.0310	0.0274	0.2640
Summer/Fall	0.6799	0.0003	0.0001	0.0006
Summer/Winter	0.3186	0.4313	0.0019	1.0000
Fall/Winter	0.2384	0.0054	0.0001	0.0292
Camera 2				
Spring/Summer	0.2120	0.7946	0.9504	0.1992
Spring/Fall	0.6130	0.0049	0.0001	0.1035
Spring/Winter	0.3123	0.3123	0.1533	0.9942
Summer/Fall	0.3426	0.0013	0.0001	0.0039
Summer/Winter	0.0493	0.2221	0.1174	0.2129
Fall/Winter	0.1647	0.0007	0.0001	0.1396
Camera 6				
Spring/Summer	0.6120	0.0854	0.5736	0.1640
Spring/Fall	0.0061	0.0658	0.0515	0.7622
Spring/Winter	0.0017	0.4065	0.6815	0.6473
Summer/Fall	0.0125	0.0009	0.0023	0.2188
Summer/Winter	0.0034	0.2979	0.8489	0.3149
Fall/Winter	0.2200	0.0067	0.0075	0.8681

[1]Mann-Whitney U-test using each day's data

[2]Caution must be used in comparisons with the winter season for cameras C1, C2, C6 and C7 because of the small number of exposed frames due to equipment and battery failure.

Table 10. Continued.

Camera/Season	Elk	People	Vehicle	ATV
	(P-values)[1]			
Camera 7				
Spring/Summer	0.0347	1.0000	0.9915	0.1730
Spring/Fall	0.0001	0.0118	0.0026	0.0730
Spring/Winter[2]	0.0076	1.0000	0.4301	0.7062
Summer/Fall	0.0121	0.0147	0.0034	0.0087
Summer/Winter	0.1042	1.0000	0.4153	0.0972
Fall/Winter	0.6194	0.1474	0.0305	0.4273
Camera 8				
Spring/Summer	0.0001	0.2241	0.2241	0.7490
Spring/Fall	0.0001	0.0203	0.0461	0.7434
Spring/Winter	0.0020	0.4333	1.0000	0.9742
Summer/Fall	0.0021	0.0901	0.2023	0.4948
Summer/Winter	0.4701	0.4835	0.1265	0.7635
Fall/Winter	0.0006	0.0178	0.0126	0.6992

[1]Mann-Whitney U-test

[2]Caution should be used in comparison with winter season for cameras C1, C2, C6 and C7 because of the small number of exposed frames due to equipment and battery failure during the winter months.

locations C1 and C2 (Appendix III, Figure IIIa). The amount of human activity during the spring at these locations was related to the spring bear hunting season and also the tendency of people to camp near the

Nordegg river access point. Consequently, there was greater opportunity to observe human activity compared with other locations along the right-of-way. The summer season at location C1 also showed high levels of human activity, which is probably related to people camping near the Nordegg river within the field-of-view of camera 1.

ATV observation time was highest in the fall compared with other seasons at all camera locations (Appendix III, Figures IIIa - IIIc), but was only significantly different for fall/summer period at most camera locations. ATVs were not used as much by people in the fall as might have been expected considering the high levels of people and vehicle activity recorded during this season. Ground conditions along the right-of-way did not prevent travel with 2 or 4 wheel drive vehicles during most of the study. Consequently, there was no need to use ATVs for access along the right-of-way. Personal observations during the study revealed that ATVs were used primarily to access areas away from the right-of-way.

Elk activity on the pipeline right-of-way was highest during October and December, 1984, and May, June and November, 1985 accounting for 74 percent of total observation time of elk activity. Eighty percent of elk activity recorded during these months occured at the camera location C8. Observed elk activity along the pipeline right-of-way was classified into feeding, standing/walking and bedded activities. Feeding accounted for 71 percent, standing/walking 8 percent and bedded 21 percent of the elk activity.

There were no differences between disturbed and undisturbed categories for elk observation time at locations C1 and C2. This reflects the relatively low levels of elk activity at these two camera locations during both disturbance categories. Elk observation time at locations C6, C7, and C8 was significantly different between disturbance categories with elk use being higher in the undisturbed period. The higher levels of elk use at these locations in the undisturbed period maybe related to the relatively low levels of human activities during this period recorded on the pipeline right-of-way.

There were no differences in elk observation time between disturbed and undisturbed periods for the three activity periods for cameras C1, C2 and C6. This reflects the relatively low levels of elk use that occurred at these locations throughout the year. The sunrise activity period was different for elk observation time between disturbance categories for cameras C7 and C8. The differences observed at these camera locations reflect the higher use of the areas by elk and also a response by elk to increased human activity during the disturbed period.

Elk observation time was significantly different among seasons for all locations except C1 and C2. Elk activity along the right-of-way appears to be influenced by the time of year (season). Human activity is also seasonal and could be influencing seasonal use of the right-of-way by elk. Observed human and elk activity did not occur simultaneously at any camera location during anytime of the year.

Generally the spring season received the greatest amount of elk use at most camera locations, while the winter season received the least amount of use, except for location C8 (Appendix III, Figures IIIa-IIIc). Spring green up of grasses along the right-of-way, probably attracted elk, while snow conditions on the right-of-way during the winter may have caused elk to seek more readily available forage. The high level of elk use recorded at location C8, may reflect the phsyical condition of the right-of-way at this location. The pipe through this section of the right-of-way is not burried in a trench but has been placed on the soil surface and then covered with huge amount of soil. Consequently, there is a high pipeline roach, which has been seeded to a mixture of grasses and legumes. Elk may have been attracted to this area because of the grass/legumes growing on the roach and the fact that the roach was almost snow free during the winter due to heat loss from the pipe, melting the snow. Elk were observed feeding along the pipeline roach during spring and winter seasons.

5.2 Elk Movements

There were 453 radio-collared elk locations, of which 292 were obtained from triangulations using two towers simultaneously and 161 from the use of three towers simultaneously. However, with the accuracy of this system the actual location of the animal is somewhere within a polygon formed by the intersections of the two sets of innermost and outermost possible bearings from the two locations. Caution must be used in interpreting the triangulation data, since 65 percent of the locations of radio-collared elk were from only two tower locations. The distance of the animal from the right-of-way was assumed to be the intersection of the two bearings where in fact the location of the animal is somewhere within an error polygon. The individual locations determine through two tower locations may in fact be closer or perhaps farther from the right-of-way than indicated. With the three tower triangulation system the animal is assumed to be at the center of the triangle formed by the intersection of the three bearings. The three tower triangulation system is assumed to be more accurate than the two tower system. However, some error is still present as the size of the triangle formed is affected by the accuracy of the system, distance between towers, location of towers relative to each other, and the location of the transmitter relative to the towers. Mean area of the triangles was calculated for each radio-collared elk for distances 1600 m or less, and greater than 1600 m from the right-of-way (Appendix IV, Table IVa). The mean area of the triangles for observations within 1600 m of the right-of-way was smaller than those for observations greater than 1600 m. This implies greater precision of data within 1600 m of the pipeline right-of-way.

The triangulation data were categorized into observations occuring within 1600 m and greater than 1600 m from the pipeline right-of-way. This distance has been suggested as the maximum distance at which elk are likely to be affected by human disturbance (Marcum 1975, Perry and Overly 1976, Ward 1984, Ward et al. 1980).

Cow elk 1, 4 and 5 accounted for 70.6% of all the locations. Elk within 1600 m of the pipeline right-of-way accounted for 43.5 percent of the total number of elk locations (Table 11). Within this distance, cow elk 5 accounted for 39.6 percent of all the locations, followed by cow elk 1 with 24.8 percent. Cow elk 3 and 6 were least observed within 1600 m of the pipeline right-of-way making up only 2.5 and 5.1 percent of all locations.

Table 11. Number of locations for each radio-collared elk during the period September 19, 1984 to March 21, 1985.

Animal	Number		
	Obs <=1600 m	Obs > 1600 m	Total
cow elk 1	49	63	112
cow elk 2	23	35	58
cow elk 3	5	31	36
cow elk 4	32	76	108
cow elk 5	78	22	100
cow elk 6	10	29	39
cow elk 7	0	0	0
Total	197	256	453

Locations of radio-collared elk at distances greater than 1600 m accounted for 56.5 percent of all locations. Cow elk 1 and 4 accounted for 24.6 and 29.6 percent of these locations, respectively. The number of locations of cow elk 3 and 6 at distances greater than 1600 m were 12.1 and 11.3 percent, respectively.

Sixty-eight percent of the locations of elk were obtained from September to December, 1984, while the remaining 32 percent occurred during the period January to March, 1985. Locations within 1600 m of the pipeline right-of-way during the period of greatest human activity (September 16 to December 2, 1984) accounted for 41.3 percent of all the readings taken during this period (Table 12). Elk were located within

1600 m of the pipeline right-of-way 50.5 percent of the total number of locations during the period of least human activity (December 11, 1984 - March, 1985).

Table 12. Observed number by month of all radio-collared elk locations for the period September 19, 1984 to March 21, 1985.

	Number	
Date	Obs <=1600 m	Obs > 1600 m
September 1984	14	2
October 1984	23	46
November 1984	93	132
December 1&2, 1984	13	23
December 11&12, 1984	12	14
January 1985	16	7
February 1985	9	24
March 1985	17	8
Total	197	256

There was a significant difference among elk in the distance kept from the right-of-way (K-W, $H=87.32$, $df=5$, $P<0.0001$). Consequently, the triangulation data could not be pooled and further analyses are for individual elk.

The triangulation data were grouped into disturbed (September 16 - December 2, 1984) and undisturbed (December 11, 1984 - March, 1985) categories (Table 13). Three of the six elk were significantly different between disturbance categories in distance from the right-of-way, indicating that all elk were not affected by the higher levels of human activity during the disturbed period.

Table 13. Comparison of distance from the pipeline right-of-way between disturbed (September 16 - December 2, 1984) and undisturbed (December 11, 1984 - March 21, 1985) categories by individual radio-collared elk.

	Disturbed vs Undisturbed[1]
Animal	P>|Z|
Cow elk 1	0.0527
Cow elk 2	0.0001
Cow elk 3	0.0625
Cow elk 4	0.0001
Cow elk 5	0.9804
Cow elk 6	0.0001

[1]Mann-Whitney U-test, using each days's data.

The median distance for each elk was calculated by disturbance category (Appendix V, Table Va). Cow elk 5 had the lowest median distance in the disturbed and undisturbed periods (1090 and 915 m), while cow elk 3 had the highest in both disturbance categories (7410 and 9670 m, respectively).

A comparison of distance from the pipeline right-of-way for each elk by disturbance category and timeperiod showed significant differences for cow elk 1, 2, 4, and 6 (Table 14). None of the elk showed significant differences between disturbance categories for timeperiod 3, suggesting no reaction to higher levels of human activity observed in the disturbed category. Four of the six elk had significant differences in distances from the right-of-way between disturbance categories for timeperiod 2. It appears that there was a highly variable response by elk to increased human activity between disturbance categories for each timeperiod.

5.3 Track Counts

All track transects were not of equal length but were at least 700 m in length. Therefore, only track data recorded within this distance was used for comparative purposes and for statistical analysis.

A total of 598 tracks of all ungulate species were recorded during the sampling periods, of which elk accounted for 65.7 percent. The highest percentage of elk tracks occurred during the January and March sampling periods (Table 15). Unclassified tracks accounted for 78.5 percent of the "other ungulate" category, while the remaining 21.5 percent were classified as moose. There were 30 trails recorded on all transects in the November sampling period, while during the January and March sampling periods 24 and 17 trails were recorded respectively. A summary of track data by cover type, location and sampling date is provide in Appendix VI.

Table 14. Comparisons in distances for each radio-collared elk by timeperiod between disturbance categories.

	Disturbed vs Undisturbed[1]
Animal	P>|Z|
Cow elk 1	
Timeperiod 1	0.8756
Timeperiod 2	0.0486
Timeperiod 3	0.2707
Cow elk 2	
Timeperiod 1	0.0512
Timeperiod 2	0.0069
Timeperiod 3	0.0872
Cow elk 3	
Timeperiod 1	0.3408
Timeperiod 2	0.1052
Timeperiod 3	0.2113
Cow elk 4	
Timeperiod 1	0.0156
Timeperiod 2	0.0003
Timeperiod 3	0.2353
Cow elk 5	
Timeperiod 1	0.7502
Timeperiod 2	0.2404
Timeperiod 3	0.7086
Cow elk 6	
Timeperiod 1	0.0085
Timeperiod 2	0.0119
Timeperiod 3	0.1904

[1] Mann-Whitney U-test using each day's data within a timeperiod.

Table 15. Number of elk tracks observed during sampling periods from November, 1984 to March, 1985.

Sampling Date	Number of Tracks			
	elk	other ungulates	total tracks	elk (%)
November 1984	102	18	120	85.0
January 1985	145	147	292	49.6
March 1985	146	40	186	78.5
Total	393	205	598	

During the November sampling period, transects 1 and 6 had the largest number of observed elk tracks, while transect 5 had the lowest (Table 16). During the January sampling period, the number of elk tracks observed on transects 1 and 6 increased by 162 and 130 percent, respectively, while observations on transect 4 increased by 192 percent.

In March, total number of elk tracks increased from the January and November sampling periods. The number of elk tracks on transects 1 and 6 decreased by 86 and 69 percent respectively compared to January, while transect 4 decreased by 50 percent. Transects 2, and 5 had increases in the number of elk tracks observed over the November sampling period by 542 and 1700 percent respectively. Elk tracks observed on transect 3 increased 480 percent over the November period.

Table 16. Summary of the number of elk tracks observed for each transect for the November, 1984, January, 1985 and March, 1985 sampling periods.

Transect	November (1984)	January (1985)	March (1985)
1	35	57	9
2	12	0	65
3	5	8	24
4	13	25	14
5	1	8	17
6	36	47	17
Total	102	145	146

The distribution of distance of elk tracks from the pipeline right-of-way in the November sampling period was not different from the January sampling period but was significantly different from the March sampling period (K-S 2, $D_{max}=0.2753$, $P<0.05$). The distribution of elk tracks in January was significantly different from the March sampling period (K-S 2, $D_{max}=0.2792$, $P<0.05$).

The track data were grouped into the number of elk tracks occurring within 0 - 350 m and 350 - 700 m from the pipeline right-of-way for each sampling date (Table 17). If elk were responding to lower levels of human activity by moving closer to the pipeline right-of-way, then the number of elk tracks observed should be greater at closer distances to the pipeline right-of-way during January and March 1985 than November 1984.

Table 17. Summary of the number of elk tracks observed within 0 - 350 m and 350 - 700 m from the pipeline right-of-way for each sampling period.

Distance from right-of-way	November (1984)	January (1985)	March (1985)
0 - 350	58	84	53
350 - 700	44	61	93
Total	102	145	146

The distribution of elk tracks was independent of the two distance categories when November track data were compared with January data (X^2=0.024, P>0.05). When the November data was compared with the March data, the distribution of elk tracks was different between distance categories (X^2=10.27, P<0.001). It appears that the greater frequency of elk tracks at distances beyond 350 m in March contributed to this difference. A comparison of January data with March data revealed that the distribution of elk tracks was different between distance categories (X^2=13.60, P<0.001). The high number of elk tracks observed within 350 m of the pipeline right-of-way in January and the greater number observed at distances greater than 350 m in March may account for this difference.

Cover was considered an important element in determining the distribution of elk in relation to the pipeline right-of-way. Analysis of elk track data related to cover are for observations on all transects combined, within 700 m of the pipeline right-of-way. Determination of percentages of cover types on all transects combined showed that conifer accounted for 42.8, deciduous 3.0, grassland 5.4, mixed conifer/deciduous 32.1 and treed muskeg 16.7 percent.

The mixed cover type showed a steady increase in the percentage of elk tracks observed for the November, January and March sampling periods (33.3, 42.1, and 45.9 percent, respectively). The grassland cover type showed a significant change in number of elk tracks among sampling dates (K-W, $H=15.10$, $df=2$, $P<0.0005$). All other cover types showed fluctuations in the number of elk tracks observed among sampling dates but none were significant (Figure 4).

The distribution of elk tracks in the November, January and March sampling periods was dependent on cover and location ($X^2=12.076$, $P<0.007$; $X^2=35.297$, $P<0.001$; and $X^2=8.118$, $P<0.044$, respectively)[5]. Some caution must be used in interpreting the results of the January and March chi-square tests as 25 percent of the cells had expected freqeuncies of less than 5.

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[5]Data for this chi-square test are in Appendix V

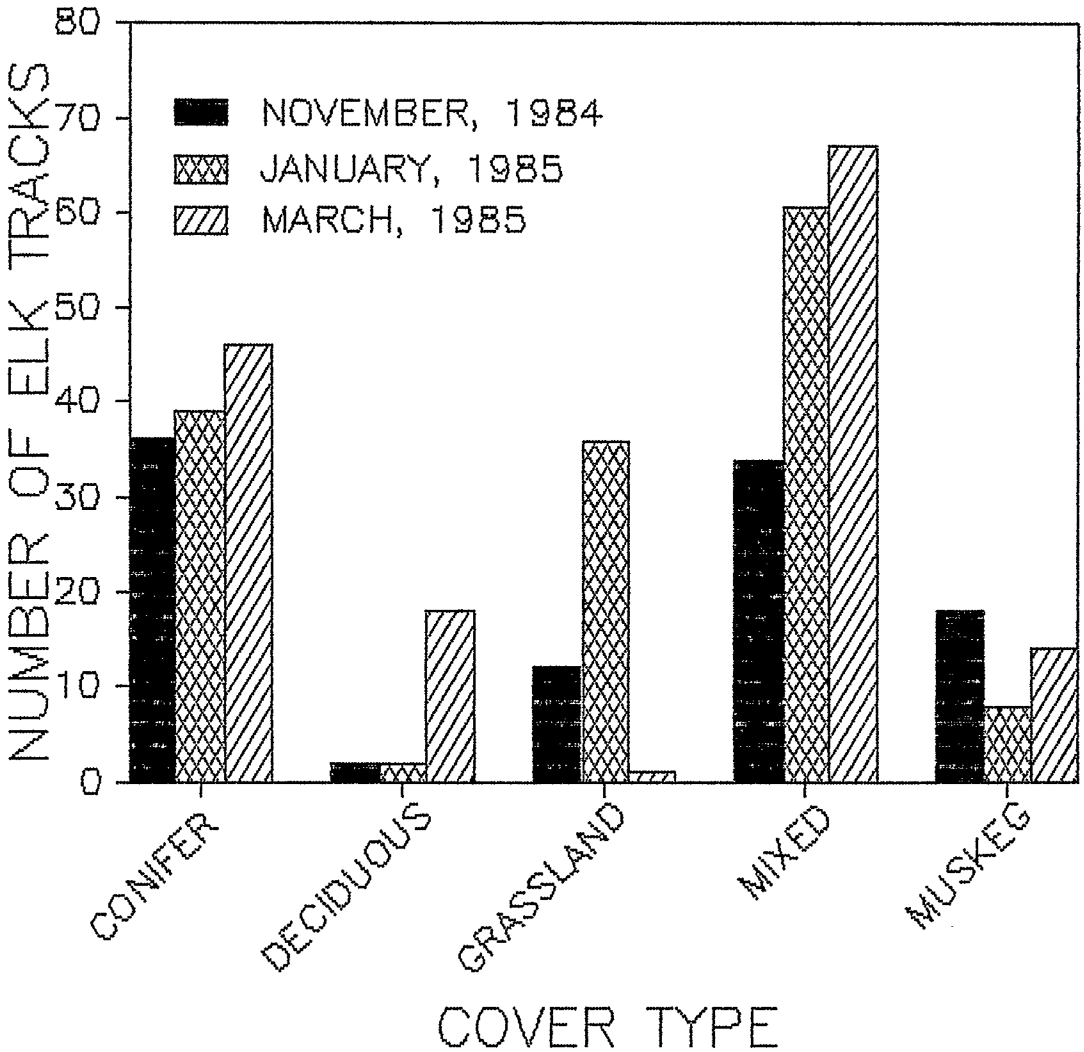

Figure 4. Total number of elk tracks observed, within 700 m of the right-of-way, by cover type for individual sampling periods.

Elk use (percent of total elk tracks) of individual cover types was in proportion to the availability of each cover type in November (X^2=3.92, P>0.43) but not in January (X^2=34.06, df=4, P<0.001) or March (X^2=23.14, df=4, P<0.001)[6].

[6]Data for this chi-square test are in Table 15 and Table 18.

An elk cover preference index was used based on the following formula:

$$\text{Cover Preference} = \frac{\%\ \text{elk presence}}{\%\ \text{availability}}$$

If elk were selecting cover independent of availability, then the level of use would be equal to its availability and the preference would be one. Elk cover preferences were calculated for each sampling period (Table 18).

Table 18. Comparison of percent expected elk use versus percent observed elk use of cover types for November, January and March track transect sampling periods and calculated cover preference indices for each cover type by sampling period.

Cover Type		November		January		March	
	%(A)[1]	%(U)[2]	CPI[3]	%(U)	CPI	%(U)	CPI
Conifer	42.8	35.3	0.82	26.2	0.62	31.5	0.73
Deciduous	3.0	2.0	0.67	1.4	0.47	12.3	4.10
Grassland	5.4	11.8	2.16	24.8	4.59	0.7	0.13
Mixed	32.1	33.3	1.04	42.1	1.31	45.9	1.43
Muskeg	16.7	17.6	1.05	5.5	0.33	9.6	0.57

[1]Percent of total area represent expected elk observation values as if elk occurred in each cover type in proportion to availability.

[2]Percent of utilization of each cover type by elk.

[3]Cover Preference Index

Elk appeared to seek out the grassland cover type during November and January sampling periods but avoided its use in the March sampling period. The conifer cover type was used by elk almost in proportion to its availability in November, while January and March preference indices indicate that elk did not seek out this cover type. Elk showed a high preference for the deciduous cover type during the March sampling period, while they appeared to avoid this cover type in November and January. The mixed cover type was used by elk in proportion to its availability in November, while elk use this cover type at levels greater than its availability in January and March. Elk use of the muskeg cover type was in proportion to its availability in November, but was avoided during the January and March sampling periods.

6.0 DISCUSSION

6.1 Human Activity along the Pipeline Right-of-way

1. The hypothesis that human activity along the pipeline right-of-way is independent of disturbance category was rejected. People and vehicle observation times were greater during the disturbed period than the undisturbed period at all locations along the right-of-way, while ATV observation time was only greater at locations C1, C2 and C7 (Table 7). The difference between categories was related to the high levels of people, vehicle and ATV activity associated with the fall hunting season. Hunters appear to spend a considerable amount of time either walking or driving along the pipeline right-of-way. The observed use of ATVs was not as high as was expected based on observations of people and vehicle activity. The Wildlife Act prohibits the use of ATVs during the hunting season prior to 1200 h, thereby contributing to the lower levels of ATV use observed. In addition, right-of-way ground conditions during the fall allowed for travel with either two or four wheel drive vehicles. Consequently, the need to use ATVs was reduced. Hunters appeared to use ATVs for accessing areas away from the pipeline right-of-way rather than actually travelling the right-of-way.

2. People, vehicle and ATV observation times were significantly different between disturbance category and activity period (Table 8) at most camera locations. Consequently, the hypothesis that people, vehicle and ATV activity is independent of activity period and disturbance category was rejected. People and vehicle observation times were generally greater for all activity periods between disturbance

categories at most camera locations. The higher levels of people and vehicle activity observed at location C1 is due impart to area being the only vehicle access point into the study area. Therefore, the greater amount of people and vehicle observation time for each activity period is not surprising.

The more accessible portions of the pipeline right-of-way (locations C1, C2, C6 and C7) were subjected to high levels of people and vehicle activity throughout the day during the hunting season. The least accessible portion of the right-of-way (location C8) received relatively low levels of people and vehicle activity, with people observation time being more in the sunset activity period and vehicle activity being greater only during the sunrise activity period. There were no differences in ATV observation time between disturbance categories for the sunrise and midday activity periods at all camera locations. This suggests that the use of ATVs by people for travelling along the right-of-way was relatively low during most of the year. As previously mentioned, the Wildlife Act prohibits their use during the hunting season prior to 1200 h. Consequently, a difference in ATV use would not be expected during the sunrise activity period. The greater amount of ATV use observed between disturbance categories during the sunset period at locations C1, C2 and C7 suggest that hunters use ATVs to access areas along and adjacent to the right-of-way.

3. The hypothesis that people, vehicle and ATV activity along the right-of-way is independent of seasons of the year was rejected. People and vehicle observation times were significantly different among seasons at all camera locations. The fall season was found to have the highest

levels of people and vehicle use compared with that of the other seasons at most locations. The spring season received the next highest level of people and vehicle activity. The higher levels of people and vehicle activity observed in the spring and fall seasons coincided with the spring bear and fall big game hunting seasons. Generally, people and vehicle activity during the fall was greater compared with other seasons at all camera locations, suggesting that hunters used the right-of-way for hunting and as an access corridor to hunt areas in the vicinity of the right-of-way.

4. No statistical comparisons could be made between locations along the pipeline right-of-way since camera exposure, field-of-view and operational period were not the same for each camera. However, some general observations can be made. Location C1 was confirmed as a major entry point into the study area and gives an idea of the number of hunters that use the right-of-way as an access corridor through the study area. The majority of human activity occurred at locations C1 and C5 accounting for 93 percent of the recorded human activity. Location C5 appeared to be a major staging area from which hunters dispersed into areas remote from the pipeline right-of-way. Location C8 received the lowest amount of human activity because it was the least accessible point along the right-of-way. This also indicates that hunters used the right-of-way as a base from which they hunted adjacent habitats rather than actually hunting along the right-of-way.

6.2 Elk Distribution

All of the radio-collared elk used in this study included the pipeline right-of-way as part of their home range. However, some animals stayed closer to the pipeline right-of-way than others. Fifty-six percent of the locations of radio-collared elk were at distances greater than 1600 m from the right-of-way. Aerial tracking of the radio-collared elk, showed some to be located as far as 12 km east of the right-of-way.

Analysis of the triangulation data showed that the distance radio-collared elk stayed from the pipeline right-of-way was highly variable for individual elk. The distance elk kept from the right-of-way between disturbed and undisturbed periods was significantly different for only three of the six elk. In addition, the comparison of the median distance between disturbed and undisturbed periods shows four of the radio-collared elk to have lower median distances in the undisturbed period. This would tend to indicate that elk were responding to high levels of human activity in the disturbed period by staying at greater distances from the right-of-way. However, a very high proportion of locations of radio-collared elk were from only two tower locations. These locations were assumed to be at the intersection of two bearings, but as previously mentioned they are actually located somewhere within an error polygon. Consequently, the radio-collared elk could be closer or farther from the right-of-way than indicated. Furthermore, the size of the triangles formed from three tower locations were highly variable both for observations within 1600 m and greater than 1600 m from the right-of-way. Since elk response appeared variable, and a high proportion of locations were from two tower locations, and the size of triangles formed from three tower locations were quite large, the hypothesis that the distances of radio-collared elk from the pipeline right-of-way are independent of the level of people, vehicle or ATV activity, was accepted. Other authors have also found highly variable responses by elk to human activity (Schultz and Bailey 1978, Ward 1976, 1984).

Comparisons between disturbed and undisturbed periods by animal and timeperiod showed inconclusive results. Four of the elk showed greater distances from the right-of-way between disturbed and undisturbed categories by timeperiod, but these differences in distance did not occur during all timeperiods. Since differences were not detected for all elk and all timeperiods, the hypothesis that the distances of elk from the pipeline right-of-way are independent of the time of day and level of people, vehicle or ATV activity was accepted.

Analysis of the track data showed that the distribution of elk tracks was not different between the November and January sampling periods but was different between November and March, and January and March. If elk were responding to lower levels of human activity along the pipeline right-of-way in January and March then the distribution of elk tracks would be expected to be different compared to the November sampling period. Since only November to March comparisons were different, elk distribution was probably being influenced by other factors besides human activity along the right-of-way. Consequently, the hypothesis that the distribution of elk tracks in relation to the pipeline right-of-way between sampling periods is not different was accepted. Further analysis of the track data revealed that cover type was likely an important element in determining the distribution of elk tracks. During the November sampling period all cover types were used in proportion to their availability. Habitat preference indices ranged from 0.67 for deciduous cover to 2.16 for grassland. With the high levels of human activity observed in November, cover types providing escape cover such as conifer and treed muskeg would be expected to show higher levels of use (Lyon et al 1985, Ward 1984 Redgate 1978). Other factors such as snow depth, air temperature, wind and predators may also be contributing to elk use of conifer and treed muskeg cover types (Burbridge and Neff 1976). The conifer and treed muskeg cover types were used almost in proportion to its availability. During the January period elk preferences for the conifer and muskeg cover types were lower than November preferences suggesting that elk maybe responding to lower levels of human activity by using escape cover less frequently. Also, the extremely high cover preference index (4.59) for the grassland cover type suggests elk were more willing to use open habitat types in the absence of human activity, although other factors may also be involved. The very low cover preference (0.13) for the grassland cover type in March, 1985 was a response by elk to a change in snow conditions. Chinook weather during February melted the snow surface causing a hard crust, strong enough to support the weight of the author (83 kg), to form. This crust may have made feeding difficult, resulting in elk abandoning this cover type for more easily accessible forage.

Other studies have found highly variable responses by elk (Lyon 1979, Perry and Overly 1976, Schultz and Bailey 1978, Thomas 1979, Ward

1976 and 1984, Ward et al. 1980) to people and vehicle activity on roads and adjacent habitats within important elk range. In these studies elk response to human activity has been shown to be influenced by cover, snow and the type of human activity. In this study, it seems that human activity may have influenced elk use of different cover types (Table 18). With the high levels of human activity observed during the fall, elk preferred to use cover types providing escape. In the absence of human activity (January, 1985), elk use of habitat types that provided escape cover decreased (Table 18).

6.3 Elk Activity along the Pipeline Right-of-Way

Elk activity observed along the pipeline right-of-way was not equal at all locations. At locations C1 and C2 elk activity was low during most times of the year. Highest levels of elk activity were recorded at locations C7 and C8. At all locations along the right-of-way elk activity was lowest in the disturbed (fall) period compared with the undisturbed period (winter, spring and summer combined).

The hypothesis that elk use of the pipeline right-of-way is independent of disturbance category was rejected. Observation time of elk use of the pipeline right-of-way was less at locations C6, C7 and C8 during the disturbed period compared with the undisturbed period. Elk may be responding to increased levels of human activity along the pipeline right-of-way by abandoning or limiting their use of the right-of-way. Other authors have also found that elk abandon habitats when human activity increases (Batcheler 1968, Hershey and Leege 1976, Marcum 1975, Morgantini 1979, Morgantini and Hudson 1979, 1985, Perry and Overly 1976).

Elk activity was lower in the sunrise activity period at locations C7 and C8 during the disturbed period compared with the undisturbed category. Consequently, the hypothesis that elk use of the pipeline right-of-way is independent of activity period and disturbance category was rejected. Elk responded to increased human activity during the disturbed category by decreasing their use of the right-of-way during the sunrise activity period. Increased human activity during the sunrise activity period has the potential to interrupt the diurnal activity pattern of elk. Elk normally feed in early morning, rest during midday, feed just prior to sunset and rest during the night (Altmann 1952, Collins et al. 1978, Craighead et al. 1973); increased human activity during the sunrise period as observed in this study may force animals to reduce their feeding activity, resulting in lower energy intake. The potential reduction of food intake could have detrimental effects on the health of individual animals and, over a long period, affect the health of the elk population in the study area. This would be particularly true if there was a shortage of other cover types that would allow the individuals to maintain their energy intake. The amount of elk activity observed in the sunset period was similar between disturbed and undisturbed categories, perhaps this is a result of a change in the feeding pattern of elk, so that they now feed after sunset, regardless of the time of year or the level of human activity.

The hypothesis that elk use of the pipeline right-of-way is independent of seasons of the year was rejected. Generally, the right-of-way received the greatest amount of elk use during the spring season, although exceptions were observed at locations C2 and C8. The higher levels of elk use in the spring is probably related to the new growth of grass on the right-of-way. The lower levels of elk use of the right-of-way observed during the fall may be related to the higher levels of human activity in this period.

6.4 Effects of Human Activity on Elk

1. The data indicate that the radio-collared elk did not respond to increased human activity along the pipeline right-of-way by moving farther away. Human activity appeared to influence the level of elk activity observed within various cover types, but other factors may have also been influencing elk activity. The distribution of elk was not significantly different between disturbance categories and evaluation of the track data showed that the distribution of elk tracks was not different between a period of high human activity (November, 1984) and low human activity (January, 1985). It appears from the data that elk in this area can accept human activity, by using cover types which provided security, while still allowing access to food sources. In November, 1984 the most preferred cover type was grassland, while the mixed and treed muskeg cover types were used in proportion to their availability. In the absence of human activity (January, 1985) elk no longer needed the security offered by the conifer and treed muskeg cover types and their use of them decreased, while use of the grassland cover type increased dramatically.

As the winter season progressed the mixed cover type became increasingly more important to elk. In January and March, preference for this cover type by elk increased by 25.9 and 37.5 percent over the November preference value. This increase in preference was probably weather and habitat related. This cover type may offer; thermal protection during cold days and nights; protection against body heat loss from winds; available forage (Houston 1982, Nelson and Leege 1982)

Crusting of snow can be an important factor in determining elk use of different cover types, especially in Alberta, where late season chinook winds cause snow melt and crusted snow on open grasslands. Chinook winds in February caused a crust to form on snow in the grassland cover type, resulting in elk abandoning this area (CPI 0.13) for more readily accessible forage. Elk showed a high preference for the deciduous cover type in March, 1985, while the next preferred cover type was the mixed. The preference for these cover types in March may be related to the modify effect of this cover type on climatic conditions. These cover types should offer protection for the animal from winds, while lessening the effect of snow melt and crusting caused by chinook winds. Overall, these cover types may reduce the daily metabolic maintenance costs for elk, resulting in a preference for it by elk. The increased elk use of these cover types may also be related to a shift in food preferences at that time of year.

2. Human activity, depending upon the season and location, limits use of the right-of-way by elk. The data indicate that elk use the right-of-way as a feeding area, suggesting that it may be an important although unnatural component of local elk habitat. The data also indicate that elk show a preference for grassland cover types at particular times of the year. In the study area, grasslands comprise

only 98.1 ha, of which the pipeline right-of-way accounts for 34.5 percent. This further emphasizes importance of the right-of-way as a component of elk habitat in the area. The pipeline right-of-way provides a unique and potentially high-quality feeding area for elk. During the rut, bull elk use up a large portion of their fat reserves since they reduce food intake during this time of the year (Houston 1982). Areas such as the pipeline right-of-way may provide important forage on which physically drained bull elk can feed to replenish fat reserves prior to the onset of winter. Increased human activity, in the form of hunting may cause elk to abandon the right-of-way as a feeding area for other areas. Disturbance by humans, particularly hunters, has caused range abandonment in sheep (*Ovis dalli stonei*) (Geist 1971), and also within other populations of elk (Hershey and Leege 1976, Marcum 1975, Morgantini 1979). How detrimental this abandonment would be to the elk population in the study area is purely speculation since there are no data on the amount or quality of other foraging areas. Presumably other sources of forage would be available to the elk during this period. Since human activity is seasonal and primarily confined to the fall season, then the vegetation along the right-of-way would be available to the elk during other seasons of the year. Elk use of the right-of-way was generally highest in the spring suggesting that it is more important to them during this season compared to the fall. Therefore, the consequences of human activity on elk use of the right-of-way in the fall may be unimportant to the overall health of the elk population in the area.

For cow elk to provide energy resources to ensure healthy development of the fetus, energy costs in excess of those required for maintenance must be minimized (Geist 1978a). Any activity by pregnant cow elk beyond the metabolic rates required for maintenance can potentially cause the animal to bankrupt its energy reserves. This is particularly true during the gestation period, as energy costs increase until parturition (Geist 1978b, Houston 1982). Therefore, any activity caused by man which requires the cow elk to move from or abandon favorable habitats has the potential to affect the health of a population.

The high levels of hunter activity observed during this study has the potential to cause changes in the local elk population. Hunting has the potential to interrupt the mating process thereby reducing the number of pregnant cow elk. Elk may be forced into less productive habitat types, have lower birth rates, and reduced calf survival. These effects may not manifest themselves immediately but might appear several years later resulting in local elk population being reduced. Results of Yarmoloy et al (in press) for mule deer and Batchelor (1968) for red deer support these ideas.

The extremely high levels of human activity along the pipeline right-of-way observed in this study emphasize a major problem in successful wildlife management, which is the control of public access and use of the network of trails (seismic and pipeline rights-of-way) created as a result of oil and gas exploration and field development. Improved access and the subsequent increased hunter activity resulting in higher harvest has been found to be the main reason for declines and sometimes elimination of local ungulate populations (Pendergast and Bindernagel 1977, Lynch 1973, Bergerud et al 1984, Leege 1976, Thiessen 1976, Hershey and Leege 1976). Compulsory registration of elk killed within the WMU F328 indicates that elk harvest has more than doubled since 1980. This level of kill may be too high considering there is no accurate information on the number of elk from which to base decisions on allowable kill necessary to maintain or increase the elk population within this WMU.

To maximize the value of the right-of-way to elk, control of vehicle access and subsequently the level of people activity in the area would appear too be of benefit. Access control may reduce the potential for localized over harvest, while reducing the potential for excessive disturbance of elk during the fall period. Several methods exist for potentially controlling human use of the right-of-way. Physically blocking the right-of-way with a gate or other barrier would reduce the amount of 2 or 4 wheel drive travel thereby reducing the level of human activity along. However, there is still the problem of ATV travel, this is presently restricted to some degree by the Wildlife Act during the hunting season. Regulations restricting the use of ATVs to designated trails would further reduce human activity. These regulations are now in place in some areas of the Province (eg. Kananaskis Country). Most oil and gas companies require ground access for operation and maintenance of the facilities. Consequently, making the right-of-way totally impassible for vehicle travel is not practical. Therefore, regulations may be required that allow companies to legally restrict public use of their rights-of-way. During the hunting season, the number of hunters using this particular WMU could be controlled through the use of a limited license draw system, whereby the number of hunting licenses available for each species would be strictly controlled.

Three methods were used to evaluate what elk were doing in response to human activity along the pipeline right-of-way. The ground triangulation of radio-collared elk was the least effective and the most costly to use. This technique has many difficulties associated with it, the most serious of which is that the animals move outside the effective area of signal reception. The use of time-lapse photography to monitor both elk and human activity along the right-of-way has merit. Costs of the field equipment are not that expensive. However, equipment modification can be costly both in time and labor. The system can provide large amounts of data with minimal costs associated with field time and labor. Special care must be taken to ensure proper operation of the equipment and that all data gathered will be comparable. This system is not suitable for gathering data on the distribution of animals relative to a man-made feature such as a pipeline right-of-way. The system is also limited to use during daylight hours. The transect method was the cheapest to use and provided very useful data. Animal use and activity can be recorded without having to actually observe the animals. The limitation of this technique for the purpose of this study was that snow was required in order to observe ungulate tracks. Ideally tracks should be recorded within a specified timeperiod after a new snowfall. As with all techniques, care must be taken when developing the sampling design. Particular attention should be paid to spacing of the transects, method of recording information, cover type, distance, frequency of sampling, and man-made artifacts that may influence animal distributions and movements. The transect method is probably the most versatile of techniques available for gathering information on habitat use by ungulate species.

7.0 CONCLUSIONS

Within the limits of the data presented here:

1. Human activity is primarily confined to the fall hunting season compared with other times of the year.
2. The pipeline right-of-way is used by hunters as access to the study area and serves as staging area from which hunters disperse into adjacent areas to hunt.
3. Elk distributions in relation to the pipeline right-of-way are not greatly affected by human activity along the right-of-way.
4. Elk appear to use the pipeline right-of-way primarily as a feeding area.
5. Elk use of the pipeline right-of-way is seasonal and may be affected by recreational activity depending on the season.
6. Elk exhibited a preference for the grassland cover type except when snow conditions precluded its use. This suggests that the pipeline right-of-way may be an important component of elk habitat in the study area.

The challenge to the wildlife manager will be to arrive at a balance between providing secure habitat for elk and hunting opportunities for Alberta sportsmen. This right-of-way, along with others, provide excellent opportunities to develop high quality feeding areas for elk and other ungulate species. This can only be achieved if measures are taken both by industry and government to control the use of rights-of-way as access corridors by the public. With the continued pressure for more oil and gas development, habitat security for elk and other ungulates will become more important as the number of access roads, seismic lines and rights-of-way increase.

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9.0 APPENDICES

Appendix I

STUDY AREA

1.0 Geology

Major Formation: Paskapoo formation underlies the study area, with outcrops along the Brazeau and Nordegg rivers.

Surficial Deposits: Glacial in origin deposited during the late Wisconsin advance (Dutchak n.d.).

2.0 Physiography

Physiographic Region: Western Alberta Plains

Sub-Regions:

a) Wolf Lake Upland:
- -occurs west of 1050 m elevation.
- -relief ranges from 10-60 m
- -soils are luvisolic and brunisolic in the well drained upland areas, while organic soils occur in poorly drained depressions and ground water discharge areas.

b) Brazeau Plain:
- -elevation ranges from 850 to 1050 m.
- -relief ranges between 2 to 5 m.
- -characterized by level to gently rolling topography.
- -surficial materials are glaciolacustrine clays, silts and sands, and some fluvial sands and gravels.

Ecosections:

a) Morainal Ecosection:
- -composed of gently rolling till of Cordilleran and Continental origin.
- -silt and fine textured veneers are common.
- -soils are well drained brunsolic and podzolic gray luvisols.
- -forest cover:- lodgepole pine, lodgepole pine/aspen and aspen dominated communities.
- -understory:- blueberry (*Vaccinium myrtiloides*), cowberry, bunchberry, pinegrass (*Calamagrostis rubescens*), rose, alder and peavine (*Lathyrus* sp.).

b) Aeolian Ecosection:
- -composed of undulating terrain ranging from 2-5%.
- -topography consists of medium to fine grained sands of post glacial origin.
- -organic components comprise up to 30% of ecosection.
- -soils are brunisols, while wet depressional areas are gleysols degrading to terric mesisols.

-forest cover:- lodgepole pine predominant coniferous species, while aspen poplar is codominant in areas with higher soil content.
- black spruce and tamarack are found in the organic areas.

-understory:- bearberry, blueberry and pinegrass.

3.0 Climate

-Summer precipitation ranges from 40 - 42.5 cm.
-Winter precipitation ranges from 20 - 30 cm but generally increases with elevation.
-Continuous snow cover generally lasts from mid-December to mid-April, but during this study the area was snow covered from late October until mid-April for 1984 and 1985.
-Summer temperatures are considered cool, while winter temperatures are considered moderate.

Appendix II. Camera operating dates; 1=operating, 0= not operating.

DAY	CAMERA1	CAMERA2	CAMERA5	CAMERA6	CAMERA7	CAMERA8
840615	1	0	0	0	0	0
840616	1	0	0	0	0	0
840617	1	0	0	0	0	0
840618	1	0	0	0	0	0
840619	1	0	0	0	0	0
840620	1	0	0	0	0	0
840621	1	0	0	0	0	0
840622	1	0	0	0	0	0
840623	1	0	0	0	0	0
840624	1	0	0	0	0	0
840625	1	0	0	0	0	0
840627	1	0	0	0	0	0
840628	1	0	0	0	0	0
840629	1	0	0	0	0	0
840630	1	0	0	0	0	0
840701	1	0	0	0	0	0
840702	1	0	0	0	0	0
840703	1	0	0	0	0	0
840711	1	0	0	0	0	0
840712	1	0	0	0	0	0
840713	1	0	0	0	0	0
840714	1	0	0	0	0	0
840715	1	0	0	0	0	0
840716	1	0	0	0	0	0
840717	1	0	0	0	0	0
840718	1	0	0	0	0	0
840719	1	0	0	0	0	0
840720	1	0	0	0	0	0
840721	1	0	0	0	0	0
840722	1	0	0	0	0	0
840801	1	0	0	0	0	0
840802	1	0	0	0	0	0
840803	1	0	0	0	0	0
840804	1	0	0	0	0	0
840805	1	0	0	0	0	0
840806	1	0	0	0	0	0
840807	1	0	0	0	0	0
840808	1	0	0	0	0	0
840809	1	0	0	0	0	0
840810	1	0	0	0	0	0
840811	1	0	0	0	0	0
840812	1	0	0	0	0	0
840813	1	0	0	0	0	0
840814	1	0	0	0	0	0
840815	1	0	0	0	0	0
840816	1	0	0	0	0	0
840817	1	0	0	0	0	0
840818	1	0	0	0	0	0
840819	1	0	0	0	0	0
840820	1	0	0	0	0	0
840821	1	0	0	0	0	0
840822	1	0	0	0	0	0
840823	1	0	0	0	0	0
840824	1	0	0	0	0	0

Appendix II continued.

DAY	CAMERA1	CAMERA2	CAMERA5	CAMERA6	CAMERA7	CAMERA8
840825	1	0	0	0	0	0
840830	1	1	0	0	0	0
840831	1	1	0	0	0	0
840901	1	1	0	0	0	0
840902	1	1	0	0	0	0
840903	1	1	0	0	0	0
840904	1	1	0	0	0	0
840905	1	1	0	0	0	0
840906	1	1	0	0	0	0
840907	1	1	0	0	0	0
840908	1	1	0	0	0	0
840909	1	1	0	0	0	0
840910	0	1	0	0	0	0
840911	0	1	0	0	0	0
840912	0	1	1	0	0	0
840913	0	1	0	0	0	0
840916	0	0	1	0	0	0
840917	0	0	1	0	0	0
840918	0	0	1	0	0	0
840919	0	0	1	0	0	0
840920	0	1	0	0	0	0
840921	0	1	0	0	0	0
840922	0	1	0	0	0	0
840923	0	1	0	0	0	0
840924	0	1	0	0	0	0
840925	0	1	0	0	0	0
840926	0	1	0	0	0	0
840927	0	1	0	0	0	0
840928	0	1	0	0	0	0
840929	0	1	1	0	0	0
840930	0	1	1	0	0	0
841001	0	1	1	0	0	0
841002	0	1	1	0	0	0
841003	0	1	1	0	0	0
841004	0	1	1	0	0	0
841005	0	0	1	0	0	0
841006	1	1	1	0	0	0
841007	1	1	1	0	0	0
841008	1	1	0	0	0	0
841009	1	1	0	0	0	0
841010	1	1	0	0	0	0
841011	1	1	0	0	0	0
841012	1	1	0	0	0	0
841013	1	1	0	0	0	0
841014	1	1	1	0	0	0
841015	1	1	1	0	0	0
841016	1	1	1	0	0	0
841017	0	0	1	0	0	0
841018	0	0	1	0	0	0
841019	0	0	1	0	0	0
841020	0	0	1	0	0	0
841027	0	0	1	0	0	0
841028	1	0	1	0	0	0
841029	1	0	1	0	0	0

Appendix II continued.

DAY	CAMERA1	CAMERA2	CAMERA5	CAMERA6	CAMERA7	CAMERA8
841030	0	0	1	0	0	0
841031	0	0	1	0	0	0
841101	1	0	1	0	0	0
841102	1	0	1	0	0	0
841103	1	0	1	1	1	0
841104	1	0	1	1	1	0
841105	1	0	1	1	1	0
841106	1	0	1	1	1	0
841107	1	0	1	1	1	0
841108	1	0	1	1	1	0
841109	1	0	1	1	1	0
841110	0	0	0	1	1	0
841111	0	0	0	1	0	0
841112	1	0	0	1	0	1
841113	1	0	0	0	0	1
841114	1	0	0	0	0	1
841115	1	0	0	0	0	1
841116	1	0	0	0	0	1
841117	1	0	0	1	0	1
841118	1	0	0	1	0	1
841119	1	0	0	1	0	1
841120	1	0	0	1	0	1
841121	1	0	0	1	0	1
841122	1	0	0	1	0	1
841123	1	0	0	1	0	1
841124	1	0	0	1	0	1
841125	1	0	0	1	0	1
841126	1	0	0	1	0	1
841127	1	0	0	1	0	1
841128	1	0	0	1	0	0
841129	0	0	0	1	0	0
841130	0	0	0	1	0	0
841201	0	0	0	1	0	1
841202	0	0	0	1	0	1
841203	0	0	0	1	0	1
841204	0	0	0	1	0	1
841205	0	0	0	1	0	1
841206	0	0	0	1	0	1
841207	0	0	0	1	0	1
841208	0	0	0	1	0	1
841209	0	0	0	1	0	1
841210	0	0	0	1	0	1
841211	0	0	0	1	0	1
841212	0	1	0	1	0	1
841213	0	1	0	1	0	1
841214	0	1	0	1	0	1
841215	0	1	0	1	0	1
841216	0	1	0	1	0	1
841217	0	1	0	1	0	1
841218	0	1	0	1	0	1
841219	0	1	0	1	0	1
841220	0	1	0	1	0	1
841221	0	1	0	0	0	1
841222	0	1	0	0	0	1

Appendix II continued.

DAY	CAMERA1	CAMERA2	CAMERA5	CAMERA6	CAMERA7	CAMERA8
841223	0	1	0	0	0	0
841224	0	1	0	0	0	0
841225	0	1	0	0	0	0
841229	0	0	0	1	0	0
841230	0	1	0	1	0	0
841231	0	1	0	0	0	0
850101	0	1	0	0	0	0
850102	0	1	0	1	0	0
850103	0	1	0	1	0	0
850104	0	1	0	1	0	0
850105	0	1	0	1	0	0
850106	0	1	0	1	0	0
850107	0	1	0	1	0	0
850108	0	1	0	0	0	0
850109	0	1	0	0	0	0
850110	0	1	0	0	0	0
850111	0	1	0	0	0	0
850112	0	1	0	0	0	0
850113	0	1	0	0	0	0
850114	0	1	0	0	0	0
850115	0	1	0	0	0	0
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850118	0	1	0	0	0	0
850119	0	1	0	1	0	1
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850123	0	0	0	1	1	1
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850129	0	0	0	0	1	1
850130	0	0	0	0	1	1
850131	0	0	0	1	1	1
850201	0	0	0	1	1	0
850202	0	0	0	1	1	0
850203	0	0	0	1	1	0
850204	0	0	0	1	1	0
850205	0	0	0	1	1	0
850206	0	0	0	0	1	0
850207	0	0	0	0	1	0
850208	0	0	0	0	1	0
850220	0	0	0	0	0	1
850221	0	0	0	0	0	1
850222	0	0	0	0	0	1
850223	0	0	0	0	0	1
850224	0	0	0	0	0	1
850225	0	0	0	0	0	1
850226	0	0	0	0	0	1
850227	0	0	0	0	0	1
850228	0	1	0	0	0	1

Appendix II continued.

DAY	CAMERA1	CAMERA2	CAMERA5	CAMERA6	CAMERA7	CAMERA8
850301	0	1	0	0	0	1
850302	0	1	0	0	0	1
850303	0	0	0	0	0	1
850304	0	0	0	0	0	1
850305	1	1	0	0	0	0
850306	1	1	0	0	0	1
850307	1	1	0	0	0	1
850308	1	1	0	0	0	1
850309	1	1	0	0	0	1
850310	1	1	0	0	0	1
850311	1	1	0	0	0	0
850312	1	0	0	0	0	0
850313	1	1	0	1	0	1
850314	1	1	0	1	0	1
850315	0	1	0	1	0	1
850316	0	1	0	1	0	1
850317	0	1	0	1	0	1
850318	0	0	0	1	0	1
850319	0	0	0	0	0	1
850320	0	0	0	0	0	1
850321	0	0	0	1	0	1
850322	0	0	0	1	0	0
850323	0	0	0	1	0	0
850324	0	0	0	1	0	0
850325	0	0	0	1	0	0
850326	0	0	0	1	0	0
850327	0	0	0	1	0	0
850329	0	0	0	1	0	1
850330	0	0	0	1	0	1
850331	1	0	0	1	0	1
850401	0	0	0	1	0	1
850402	0	0	0	1	0	1
850403	0	0	0	0	0	1
850404	0	0	0	0	0	1
850405	0	0	0	0	0	1
850406	0	0	0	0	0	1
850425	1	1	0	1	1	1
850426	1	1	0	1	1	1
850427	1	1	0	1	1	1
850428	1	1	0	1	1	1
850429	1	1	0	1	1	1
850430	1	1	0	1	1	1
850501	1	1	0	1	1	1
850502	1	1	0	1	1	1
850503	1	1	0	1	1	1
850504	1	1	0	1	1	1
850505	1	1	0	1	1	1
850506	0	1	0	1	1	1
850507	1	1	0	0	1	1
850508	1	1	0	0	1	1
850509	1	1	0	0	1	1
850510	1	1	0	1	1	1
850511	1	1	0	1	1	1
850512	1	1	0	1	1	1

Appendix II continued.

DAY	CAMERA1	CAMERA2	CAMERA5	CAMERA6	CAMERA7	CAMERA8
850513	1	1	0	1	1	1
850514	1	1	0	1	1	1
850515	1	1	0	1	1	1
850516	1	1	0	0	1	1
850517	1	1	0	0	1	1
850518	1	1	0	1	1	1
850519	1	1	0	0	1	1
850520	0	0	0	0	0	1
850522	1	1	0	1	1	1
850523	1	1	0	1	1	1
850524	1	1	0	1	1	1
850525	1	1	0	1	1	1
850526	1	1	0	1	1	1
850527	1	1	0	1	1	1
850528	1	1	0	1	1	1
850529	1	1	0	1	1	1
850530	1	1	0	1	1	1
850531	0	0	0	1	0	0
850601	1	1	0	1	1	1
850602	1	1	0	1	1	1
850603	1	1	0	1	1	1
850604	1	1	0	0	1	1
850605	1	1	0	1	1	1
850606	1	1	0	1	1	1
850607	1	1	0	1	1	1
850608	1	1	0	1	1	1
850609	1	1	0	1	1	1
850610	1	1	0	1	1	1
850611	1	1	0	1	1	1
850612	1	1	0	1	1	1
850613	1	1	0	1	1	1
850614	1	1	0	1	1	1
850615	1	1	0	1	1	1
850616	1	1	0	1	1	1
850617	1	1	0	1	1	1
850618	1	1	0	1	1	1
850619	1	1	0	1	1	1
850620	1	1	0	1	1	1
850621	1	1	0	1	1	1
850622	1	1	0	1	1	1
850623	1	1	0	1	0	1
850624	1	1	0	1	0	1
850625	1	1	0	1	0	1
850626	1	1	0	1	0	1
850627	1	1	0	1	1	1
850628	1	1	0	1	1	1
850629	1	1	0	1	1	1
850630	0	1	0	1	1	1
850701	0	1	0	1	1	1
850702	0	1	0	1	1	1
850703	0	1	0	1	1	1
850704	1	1	0	1	1	1
850705	1	1	0	1	1	1
850706	1	1	0	1	1	1

Appendix II continued.

DAY	CAMERA1	CAMERA2	CAMERA5	CAMERA6	CAMERA7	CAMERA8
850707	1	1	0	1	1	1
850708	1	1	0	1	1	1
850709	1	0	0	0	1	1
850710	1	0	0	0	0	0
850711	1	0	0	0	0	1
850712	1	0	0	0	0	1
850713	1	0	0	0	0	1
850714	1	0	0	0	0	1
850715	1	0	0	0	0	1
850716	1	1	0	1	0	1
850717	1	1	0	1	0	1
850718	0	1	0	1	0	1
850719	0	1	0	1	0	1
850720	0	1	0	1	0	1
850721	0	1	0	1	0	1
850722	0	1	0	1	0	1
850723	0	1	0	1	0	1
850724	0	1	0	1	0	1
850725	1	1	0	1	0	1
850726	1	1	0	1	1	1
850727	1	1	0	1	1	1
850728	1	1	0	1	1	1
850729	1	1	0	1	1	1
850730	1	1	0	1	1	1
850731	1	1	0	1	1	1
850801	1	1	0	1	1	1
850802	1	1	0	1	1	1
850803	1	1	0	1	1	1
850804	1	1	0	1	1	1
850805	1	1	0	1	1	1
850806	0	1	0	1	1	1
850807	0	1	0	1	1	1
850809	0	1	0	1	1	1
850810	0	1	0	1	1	1
850811	0	1	0	1	1	1
850812	0	1	0	1	1	1
850813	0	1	0	1	1	1
850814	0	1	0	1	1	1
850815	0	1	0	1	1	1
850816	0	1	0	1	1	1
850817	0	1	0	1	1	1
850818	0	1	0	1	1	1
850819	0	1	0	1	1	1
850820	0	1	0	1	1	1
850821	0	1	0	1	1	1
850822	0	1	0	1	0	1
850823	0	0	0	0	0	1
850824	0	0	0	0	0	1
850825	0	1	0	1	0	1
850826	0	1	0	1	0	1
850827	0	1	0	1	0	1
850828	0	1	0	1	0	1
850829	0	1	0	1	0	1
850830	0	1	0	1	0	1

Appendix II continued.

DAY	CAMERA1	CAMERA2	CAMERA5	CAMERA6	CAMERA7	CAMERA8
850831	0	1	0	1	0	1
850901	0	1	0	1	0	1
850902	0	1	0	1	0	1
850903	0	1	0	1	0	1
850904	0	1	0	1	0	1
850905	0	1	0	1	0	1
850906	0	1	0	1	0	1
850907	0	1	0	1	0	1
850908	0	1	0	1	0	1
850909	0	1	0	1	1	1
850910	0	1	0	1	1	1
850911	0	1	0	1	1	1
850912	0	1	0	1	1	1
850913	0	1	0	1	1	1
850914	0	1	0	1	1	1
850915	0	1	0	1	1	0
850916	0	1	0	1	1	1
850917	0	1	1	1	1	1
850918	0	1	1	1	1	1
850919	0	1	1	1	1	1
850920	0	1	1	1	1	1
850921	0	1	1	1	1	1
850922	0	1	1	1	1	1
850923	0	1	0	1	1	1
850924	0	1	0	1	1	1
850925	0	1	0	1	1	1
850926	0	1	0	1	1	1
850927	0	1	0	1	1	1
850928	0	1	0	1	1	1
850929	0	1	0	1	1	1
850930	0	1	0	1	1	1
850931	0	1	0	0	0	0
851001	0	0	0	1	1	1
851002	0	1	0	1	1	1
851003	0	1	0	1	1	1
851004	0	1	0	1	1	1
851005	0	1	0	1	1	1
851006	0	0	0	1	1	1
851007	0	1	1	1	1	1
851008	0	1	1	1	1	1
851009	0	1	1	1	1	1
851010	0	1	1	1	1	1
851011	0	1	1	1	1	1
851012	0	1	1	1	1	1
851013	0	1	1	1	1	1
851014	0	0	1	1	1	1
851015	0	0	1	1	1	1
851016	0	0	0	1	1	1
851017	0	0	0	1	1	1
851018	0	0	0	1	1	1
851019	0	0	0	1	1	0
851020	0	0	0	0	1	0
851021	0	0	0	0	1	0
851022	1	0	1	1	1	1

Appendix II continued.

DAY	CAMERA1	CAMERA2	CAMERA5	CAMERA6	CAMERA7	CAMERA8
851023	1	0	1	1	1	1
851024	1	0	1	1	1	1
851025	1	0	1	1	1	1
851026	1	0	1	1	1	1
851027	1	0	1	1	1	1
851028	1	0	1	0	0	1
851029	1	0	1	0	0	1
851030	1	0	1	0	0	1
851031	1	0	1	0	0	0
851101	1	0	1	0	0	0
851102	1	0	1	0	0	0
851103	1	0	0	0	0	0
851104	1	0	0	0	0	0
851105	1	0	0	0	0	0
851106	1	0	0	0	0	0
851107	1	0	0	0	0	0
851108	1	0	0	0	0	1
851109	1	0	0	0	0	1
851110	0	0	0	0	0	1
851119	0	0	0	0	0	1
851120	0	0	0	0	0	1
851121	0	0	0	0	0	1
851122	0	0	0	0	0	1
851123	0	0	0	0	0	1
851124	0	0	0	0	0	1
851125	0	0	0	0	0	1
851126	0	0	0	0	0	1
851127	0	0	0	0	0	1
851128	0	0	0	0	0	1
851129	1	0	0	0	0	1
851130	1	0	0	0	0	1
851201	1	0	0	0	0	1
851202	1	0	0	0	0	1
851203	1	0	0	0	0	1
851204	1	0	0	0	0	1
851205	1	0	0	0	0	1
851206	1	0	0	0	0	1
851207	1	0	0	0	0	1
851208	1	0	0	0	0	1
851209	1	0	0	0	0	1
851210	1	0	0	0	0	1
851211	0	0	0	0	0	1
851212	1	0	0	0	0	1
851213	1	0	0	0	0	1
851214	1	0	0	0	0	1
851215	1	0	0	0	0	1
851216	1	0	0	0	0	1
851217	1	0	0	0	0	1
851218	1	0	0	0	0	1
851219	1	0	0	0	0	1
851220	1	0	0	0	0	1
851221	1	0	0	0	0	1
851222	1	0	0	0	0	1
851223	1	0	0	0	0	1

Appendix III.

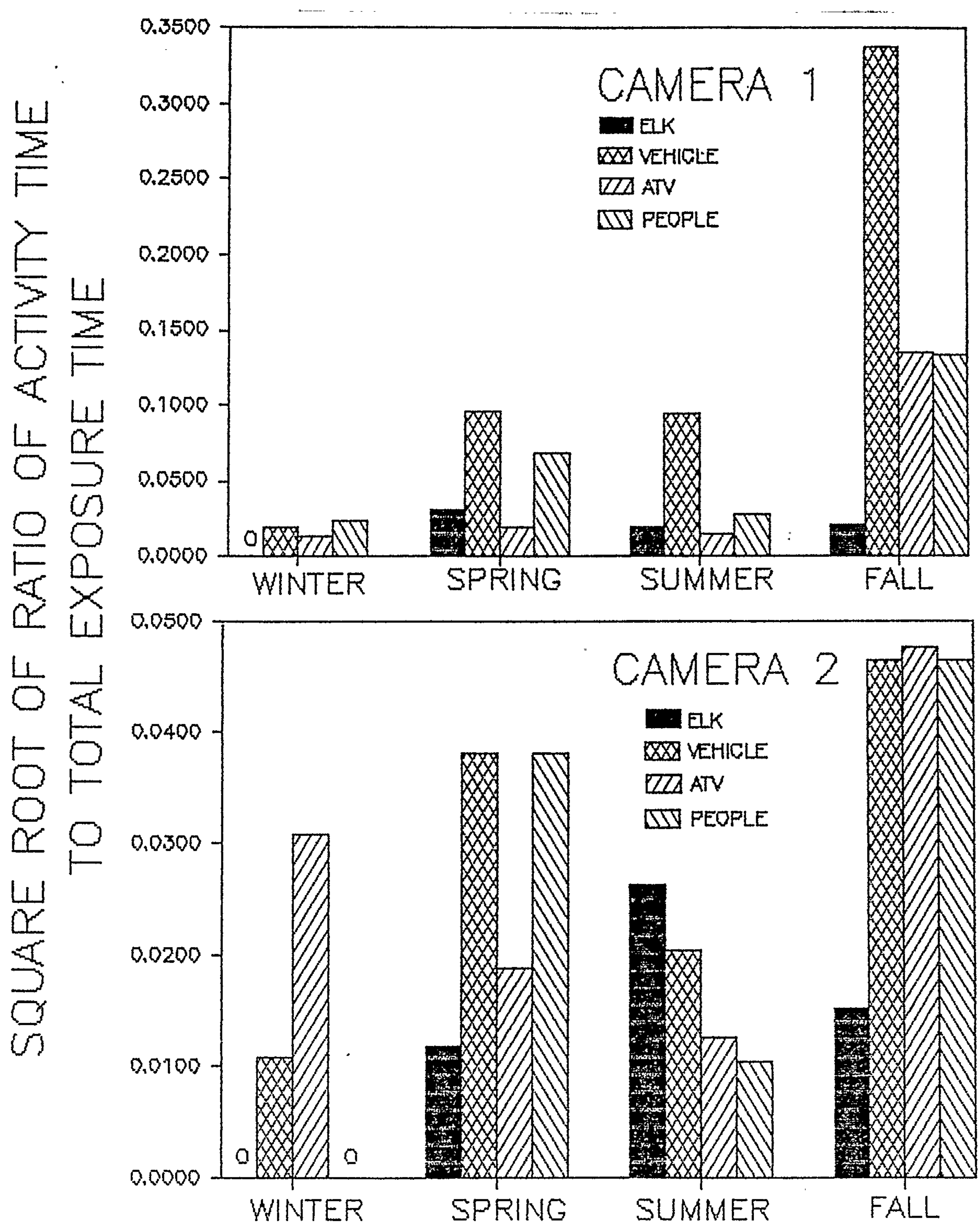

Figure IIIa. Ratio of activity time to total exposure time for each activity by season for camera locations C1 and C2.

Appendix III continued.

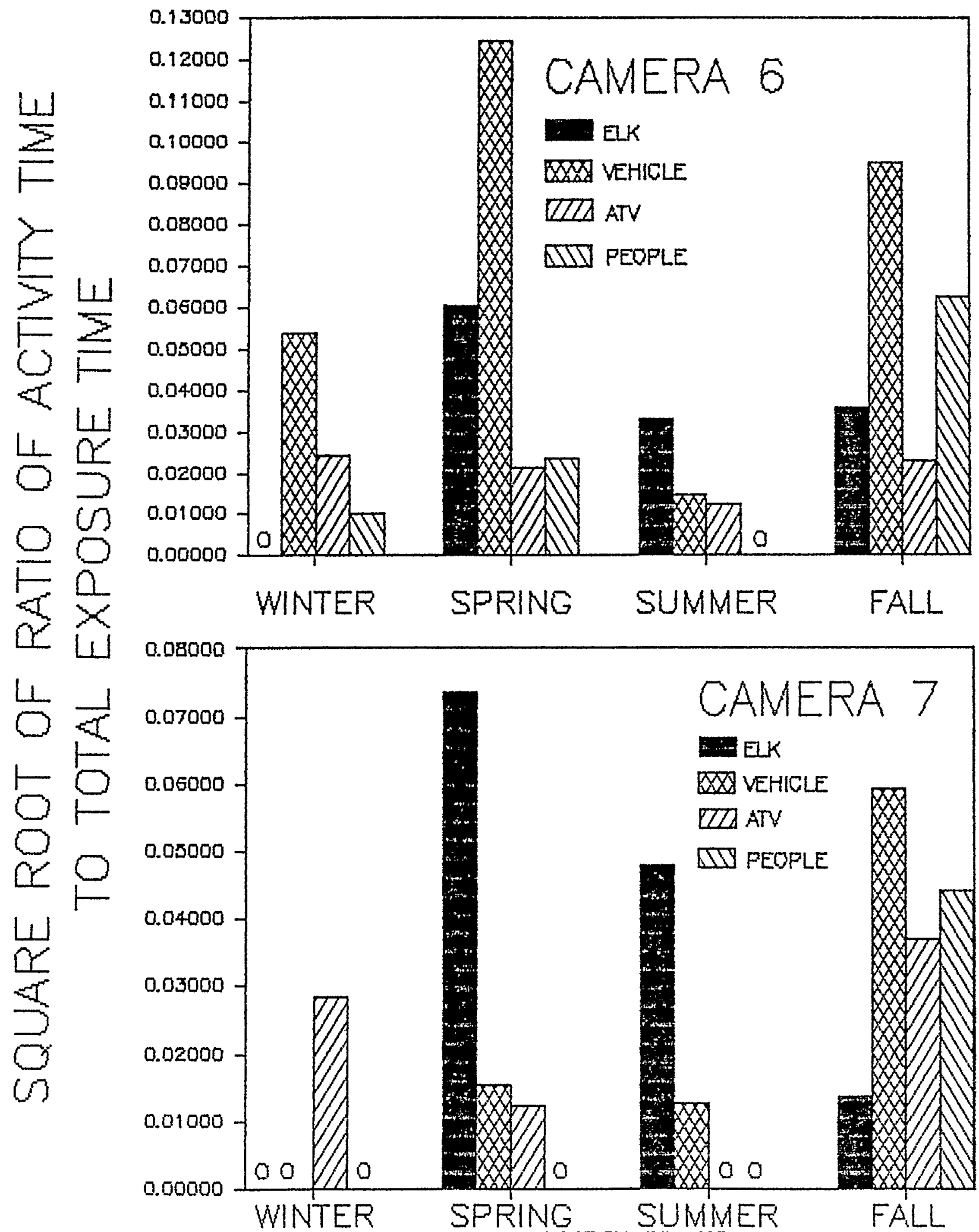

Figure IIIb. Ratio of activity time to total exposure time for each activity by season for camera locations C6 and C7.

Appendix III continued

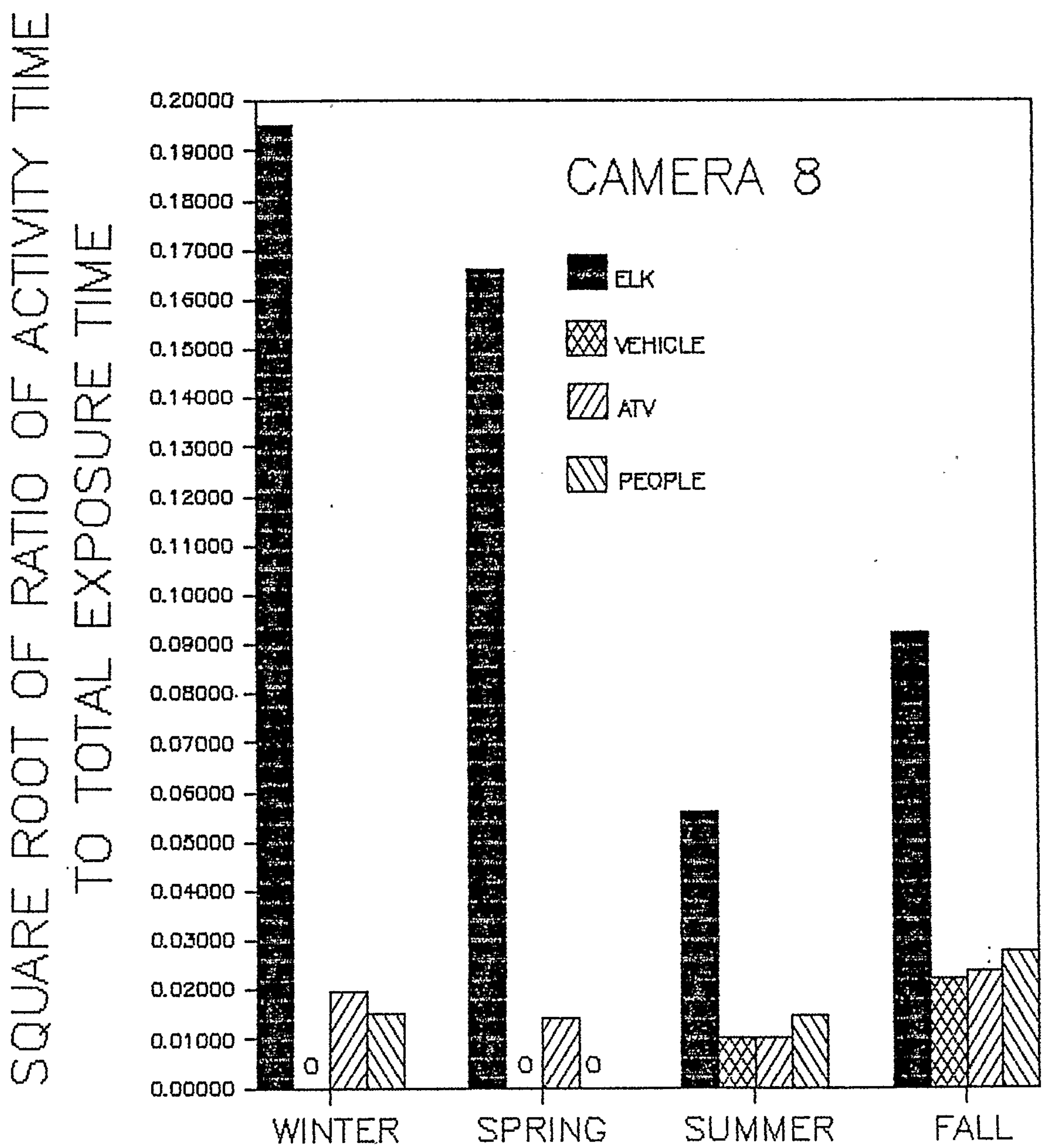

Figure IIIc. Ratio of activity time to total exposure time for each activity by season for camera location C8.

Appendix IV.

Table IVa. Summary of mean area for triangulations using three tower locations for observations of individual radio-collared elk 1600 m or less and greater than 1600 m from the pipeline right-of-way.

	Obs <= 1600 m			Obs > 1600 m		
Animal	N	Mean Area (sq.m)	S.E	N	Mean Area (sq.m)	S.E
cow elk 1	37	203410.41	55240.54	25	1028786.00	540190.32
cow elk 2	2	284446.00	237486.00	5	1199347.60	531995.91
cow elk 3	2	117628.00	17219.00	2	573698.00	143950.00
cow elk 4	16	254384.19	126414.20	24	538322.58	258494.95
cow elk 5	38	587468.68	241295.86	6	2111062.83	1246733.58
cow elk 6	0	0	0	5	1769112.60	890020.76

Appendix V.

Table Va. Summary of median distance (m) and range of distances by disturbed (September 16 - December 2, 1984) and undisturbed (December 11, 1984 - March 21, 1985) category for each radio-collared elk.

	Disturbed				Undisturbed			
	Median		Range		Median		Range	
Animal	distance	N[1]	min.	max.	distance	N	min.	max.
Cow elk 1	2516.0	(89)	98.0	10454.0	1356.0	(23)	152.0	5940.0
Cow elk 2	3575.0	(42)	54.0	16355.0	578.0	(16)	20.0	3445.0
Cow elk 3	7410.0	(24)	104.0	17430.0	9670.0	(12)	6597.0	18473.0
Cow elk 4	3247.0	(83)	329.0	12929.0	1186.0	(25)	99.0	8960.0
Cow elk 5	1090.0	(77)	94.0	5900.0	915.0	(23)	108.0	5639.0
Cow elk 6	2030.0	(31)	536.0	4906.0	6417.0	(8)	4394.0	14673.0

[1]N=Sample size

Appendix VI. Summary of track data by sampling date.

	November 1984		January 1985		March 1985	
Cover type	1[a]	2[b]	1	2	1	2
Conifer	16	20	18	20	15	31
Deciduous	*[c]	2	*	2	*	18
Grassland	12	0	36	0	1	0
Mixed	21	13	25	36	27	40
Muskeg	9	9	5	3	10	4
TOTAL	58	44	84	61	53	93

[a] 1=location 1 (0-350 m)

[b] 2=location 2 (350-700 m)

[c] * indicates cover type not represented in location category.