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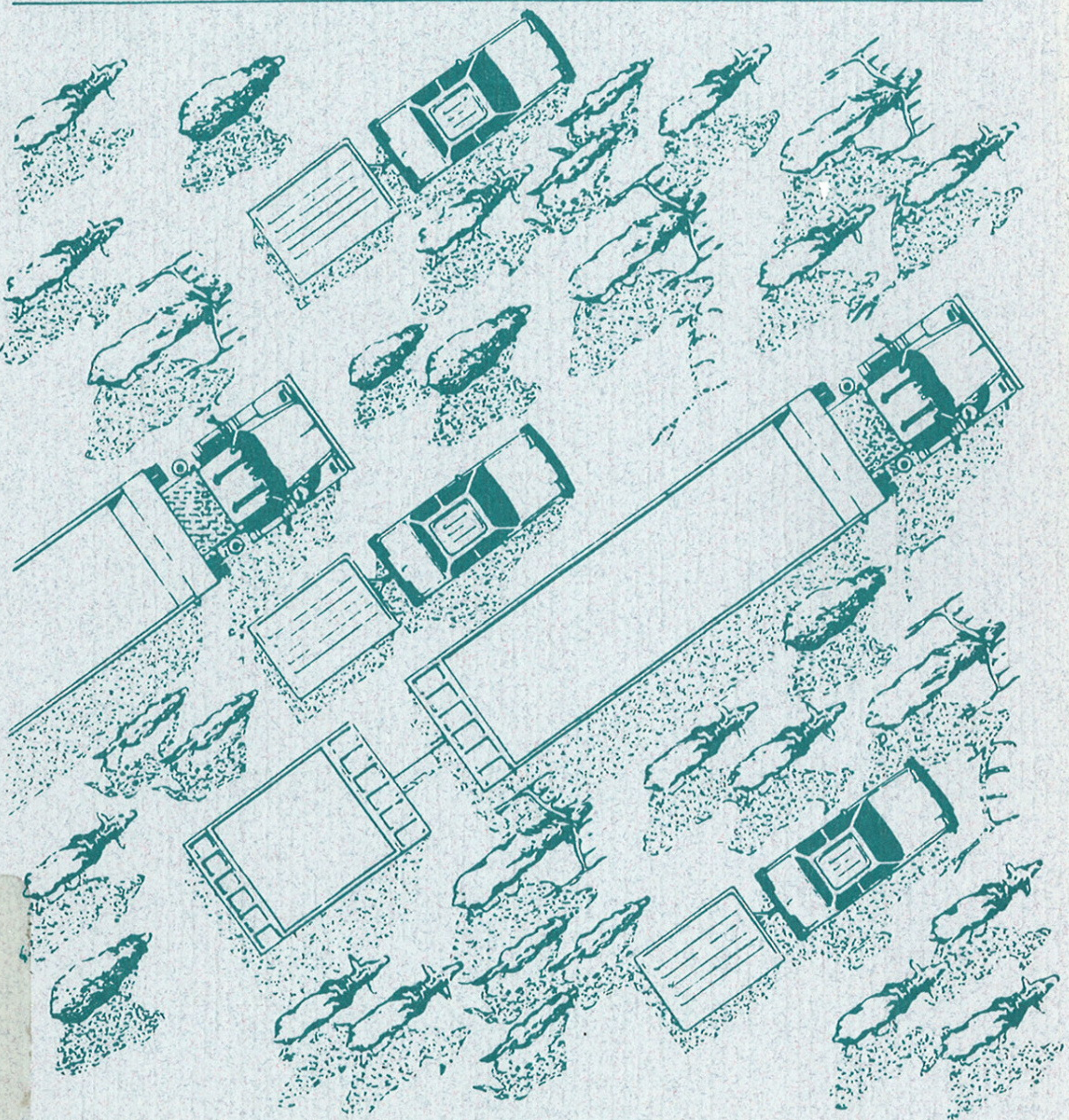
WILDLIFE MORTALITY on the KOOTENAY PARKWAY

KOOTENAY NATIONAL PARK



by: D.M. Poll, Project Biologist

Canada

WILDLIFE MORTALITY ON THE KOOTENAY PARKWAY

KOOTENAY NATIONAL PARK

Final Report

by

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Environment Canada
Canadian Parks Service

Kootenay National Park
Radium Hot Springs, B.C.

March 1989

EXECUTIVE SUMMARY

In response to Canadian Park Service concerns regarding existing and potential impacts to wildlife populations in Kootenay National Park from collisions with vehicles on the Kootenay Parkway, a study was initiated in April, 1987 to investigate and evaluate those factors of wildlife habitat, Parkway design and maintenance, and traffic volume and composition thought to influence wildlife-vehicle collisions on the Parkway.

Over the ten year period, 1978 to 1987, a total of 471 large mammals are known to have been killed by vehicles on the Kootenay Parkway; 46.5% were elk, 24.2% were white-tailed deer, and 12.7% were mule deer. The mean annual kill-rate of ungulates over the ten year period was 0.5 animals/km/yr; the highest kill-rate for elk (0.5/km/yr) occurred between McLeod Meadows and Dolly Varden Creek and for white-tailed deer (0.6/km/yr) between Dolly Varden Creek and Kootenay Pond.

The results of this study confirm conclusions of studies done elsewhere, that ungulate-vehicle collisions are not random, but aggregated in space and time. The greatest collision frequencies corresponded to the locations and periods (seasonal and diurnal) of heaviest ungulate use of the Parkway corridor and right-of-way and not necessarily to periods of greatest traffic volume.

Traffic volume was a factor, however, when high volumes corresponded to the critical periods of ungulate use. For instance, a peak in ungulate-vehicle accidents occurred on Fridays corresponding to a higher than average evening traffic volume composed primarily of passenger and recreational vehicles traveling between Alberta and the Columbia Valley.

The proportion of large trucks in the traffic mix was greatest on weekdays during early morning, coincident with the period of highest ungulate-vehicle mortality with the exception of Fridays as noted above. This observation, coupled with the low incidence of accident reports corresponding to known Parkway-wildlife mortalities, suggests that large trucks may be responsible for a disproportionate number of wildlife-vehicle accidents on the Parkway.

The primary factors separating ungulate-vehicle collision sites from non-collision sites were related more to Parkway right-of-way characteristics than to right-of-way habitat value or ungulate use on a site-specific basis. The potential of a section of Parkway being a kill-site increased with a) reduced visibility as influenced by ditch depth, shrub encroachment and the presence of guiderails, b) reduced forest cover adjacent the right-of-way, and c) increased proximity to disturbed areas such as borrow pits and man-made grasslands. The influence of the latter factor is compounded where disturbed sites are located near each other on opposite sides of the Parkway, increasing the frequency of ungulate crossings. In addition, Parkway maintenance practices such as the use of sodium chloride as a deicing agent, the mowing of roadside vegetation in late summer and the winging-back of snowbanks in late winter were found to attract ungulates to the traffic surface.

An assessment of the impact of Parkway mortality on large mammal populations was complicated by a lack of knowledge, in many cases, of the status and dynamics of these populations within the park and the effects of habitat change as a result of forest succession. Current levels of Parkway-elk mortality are considered contributory, along with habitat loss and natural mortality, to the observed decline in the park population. Moose have undergone a dramatic decline in the park over the past 40 years, largely in response to changing habitat conditions, however, current levels of Parkway mortality may be contributing to their continued decline. Mortality rates of the remaining large mammal species routinely involved in vehicle collisions on the Parkway, do not appear to be negatively impacting these populations at present, however, for many species, not enough population information exists to make an accurate assessment.

Options for mitigation of Parkway-related wildlife mortality are discussed in relation to their potential effectiveness in reducing wildlife-vehicle collisions, cost-effectiveness and aesthetic implications. A mitigation strategy is proposed involving the testing of Swareflex Wildlife Reflectors, a public awareness program, Parkway design and maintenance modifications, traffic controls and a wildlife habitat modification/improvement program.

ACKNOWLEDGMENTS

The success of this project is in large measure a result of the support and encouragement received, through all facets of the study, from the staff of Kootenay National Park and Western Regional Office (WRO) in Calgary.

Particular thanks are extended to Don Macmillan, Chief, Natural Resource Conservation, WRO, Fred Bamber, Superintendent, Kootenay National Park and Peter Whyte, Chief Park Warden, Kootenay National Park for their cooperation and support throughout the project and comments on the draft manuscript; to the Kootenay Warden Service, in particular Brian Sheehan for his administrative assistance, field support and friendship, and Steve McNaughton, for his companionship and skillful assistance with field work and data analysis.

I am especially grateful to Bette Beswick and Gail Harrison, Natural History Research, WRO for their comprehensive review of the draft manuscript and encouragement throughout the project. Thanks also to Alan Masters, Regional Forester for his invaluable advice and assistance with statistical analyses and to Patricia Benson and Percy Weibe, Natural Resource Conservation, WRO for their encouragement and comments on the draft manuscript.

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1.0 INTRODUCTION

Increasing traffic volumes and wildlife-vehicle collisions on the Kootenay Parkway (Banff-Windermere Highway, Highway 93) between 1970 and 1980 prompted resource management and public safety concerns in the Kootenay National Park (KNP) (Sheehan and Peers 1979, Sheehan 1982, Damas and Smith 1982). Sheehan (1982) reported a 325% increase in Parkway-wildlife mortality between 1974 and 1981; traffic volume on the Parkway increased 16% over the same period. In a review of wildlife mortalities in national park transportation corridors, Damas and Smith (1982) considered the level of Parkway related wildlife mortality in Kootenay to be approaching the point where it could have significant impact on park ungulate populations. The authors recommended that, close monitoring should continue, in view of the potential for increased conflict between wildlife and vehicles as Parkway traffic volumes increased.

In recognition of the need for more specific information on the relationship of ungulates to the Parkway corridor, efforts to document ungulate seasonal distribution, abundance and habitat use in relation to the Parkway were included in the wildlife inventory portion of the Ecological Land Classification of KNP (Poll _et al_ 1984). The authors concluded that the seeded Parkway right-of-way was becoming a progressively more important source of forage, particularly for elk, as the supply of native winter range was declining as a consequence of forest succession. They recommended continued close monitoring of ungulate populations and Parkway mortality trends and the investigation of potential mitigative measures.

The issue of increasing commercial trucking on the Parkway and its potential impact on park environmental and social values was initially addressed in an Environmental Impact Assessment

(EIA) prepared by the Kootenay Warden Service (Canadian Parks Service 1980) in response to a 1980 request from Baymag Mines Co., Ltd. to haul magnesite ore over Settler's Road and the Kootenay Parkway to a processing plant in Exshaw, Alberta. The EIA identified a number of potential conflicts with Parks Canada Policy (1979) as well as aesthetic, environmental and public safety values. It concluded that the proposal could not be accepted as a long-term operation and recommended that industry and government jointly identify the long-term transportation needs of the area and develop mutually acceptable alternative routes. Permission was granted Baymag to haul ore through the park on a permit basis with restrictions on numbers of loads and daily and seasonal operating periods. Subsequent amendments to the operating permit in 1983 and 1984 allowed Baymag to increase hauling to the current level of 12 loads per day (Beswick and Harrison 1987).

Renewed concern for degradation of park values and public safety, spurred by an increasing trend in Parkway-wildlife mortality in 1985-86 and another proposal by Baymag to further increase ore hauling through the park, precipitated the preparation of an Initial Environmental Evaluation (IEE) (Beswick 1986). The major potential impacts identified by the IEE were probable increases in wildlife-highway mortality, depreciation of aesthetic values and visitor enjoyment, and reduced public safety. One of several knowledge deficiencies identified in the draft IEE related to the relationship of highway-wildlife mortality and trucking on the Parkway and the ability of the populations to withstand existing or increased levels of mortality.

The purpose of this study was to investigate the relationships between ungulates and the Parkway corridor, evaluate the factors influencing ungulate-vehicle collisions, and make recommendations for mitigation.

2.0 STUDY AREA

The 94.4 km Kootenay Parkway (Highway 93) bisects Kootenay National Park in a roughly north-south direction from the Great Divide in Vermilion Pass to Radium Hot Springs (Figure 1). For most of its length the Parkway follows the valley bottoms of the Vermilion and Kootenay rivers. About two-thirds of the corridor lies within the Montane Ecoregion, one-third lies within the Subalpine Ecoregion as defined by Achuff et al (1984).

The largest extent of Montane in the Park lies within the Kootenay River Valley. Ranging in elevation from about 1200m to 1700m a.s.l., it is characterized by glacial and fluvial landforms with vegetation types dominated by Douglas fir, white spruce, trembling aspen and shrub and grasslands. Fires, however, have been widespread in the past resulting in much of the area being dominated by seral lodgepole pine forests.

Naturally occurring herb-grass vegetation types are limited to the riverbank and floodplain areas associated with the Kootenay and lower Vermilion rivers. Man-made grasslands provide the largest extent of grassland vegetation in the Kootenay Valley predominantly in the form of the wide, seeded Parkway right-of-way and to a lesser extent as a consequence of highway construction and early human settlement and development. Shrubland vegetation types are commonly associated with fluvial landforms of the Vermilion Lakes (VL) Ecosection and are most prevalent in the upper Kootenay River and Dolly Varden Creek areas.

Much of the reason for the conflict between wildlife and vehicles in the Park, stems from the fact that the Parkway bisects valley bottomlands of the Montane Ecoregion which are

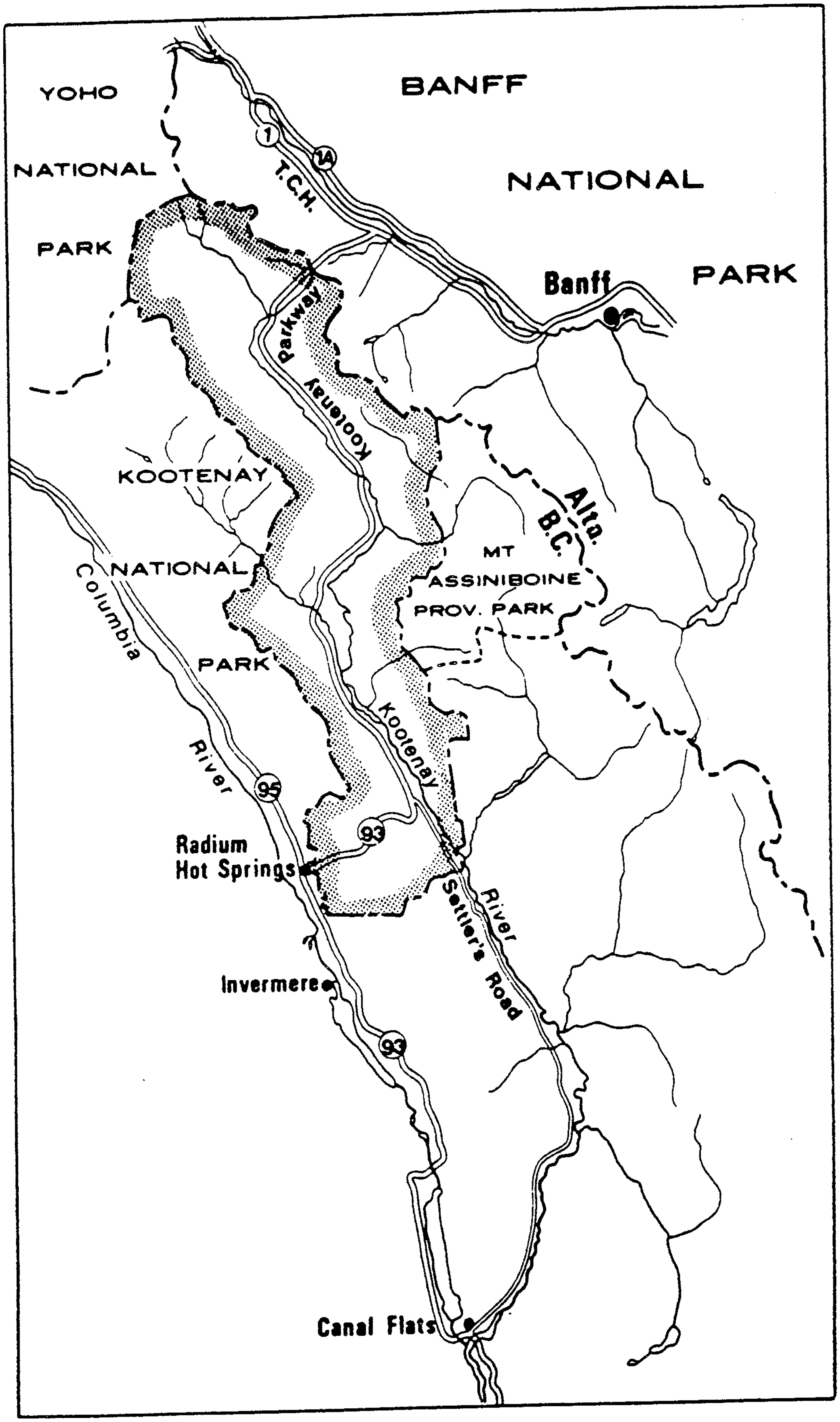

Figure 1. Regional Setting of the Kootenay Parkway.

key ungulate ranges. In particular, these Montane valley bottoms constitute the major winter range for elk (Gibbons 1978 and Poll et al 1984) and summer range for white-tailed deer (Poll et al 1984) within the Park; species which are most impacted by highway collisions (Damas and Smith 1982 and Sheehan 1986). The seeded Parkway right-of-way is an attraction for ungulates, especially elk, because of the provision of high quality forage and road salts.

3.0 METHODS

3.1 Intensive Sampling Areas

Elk and white-tailed deer highway mortality data from 1979 to 1986 were obtained from the computerized Warden Wildlife Observation files in the CanSIS (Canadian Soil Inventory System) computer system in Ottawa. The data were plotted on 1:50,000 scale Ecological Land classification maps of the Park and the distribution of kills used to select intensive sampling areas (Appendix A).

A sample of kill and non-kill or control sites was selected. Kill sites had to have a minimum of four ungulate kills during the period 1979 to 1986 within a highway length less than or equal to 500m. Control sites had to have less than 20% of the kill at kill sites over the same period of time and within the same highway length.

A total of five kill sites and five non-kill or control sites (Figure 2; Table 1) were selected along the 24km section of the Parkway between Settler's Road junction and Kootenay Crossing Warden Station.

Near the mid-point of each 500m long intensive study area a 100m X 50m macroplot was established on either side of the traffic surface with the long axis parallel to the highway

Within each macroplot four 100m long transects were established parallel to the highway; Transect 1 was placed at the mid-point between the traffic surface edge and the forest edge; Transect 2 was placed 1m out from the forest edge in the right-of-way, Transect 3, 5m inside the forest from the right-of-way forest interface; and Transect 4, 30m into the forest from Transect 3.

Table 1. Intensive sample sites located along the Kootenay Parkway, Kootenay National Park, 1987.

Site	Location	Type	UTM Ref	Ecosite*	Mortalities 1979-86 Elk	Mortalities 1979-86 w.t.deer
8701	Nixon Creek	control	NG763212	AT1	2	0
8702	Con. Cor. Rd	kill	NG759224	AT4	5	0
8703	McLeod Mead.	kill	NG745243	FR3	9	2
8704	Harkin sign	control	NG728259	AT4	1	0
8705	Crook's Mead.	control	NG698295	AT1/AT4	0	2
8706	N. Crook's Meadow	kill	NG696303	AT1	5	3
8707	Dolly Varden	kill	NG696309	AT1/VL2	2	10
8708	N. Dolly Varden	control	NG695317	AT1	0	1
8709	S. Airstrip	control	NG691338	AT1	1	0
8710	N. Airstrip	kill	NG682354	AT1/DR7	1	5

* as defined in Achuff _et at_ (1984)

3.2 Vegetation Sampling

Within each of the 20 macroplots established at 10 intensive study areas, plant cover and composition were determined using a microplot technique and the canopy coverage technique of Daubenmire (1959,1968). On the grassland transect (transect 1) of each macroplot, ten $0.5m^2$ microplots were placed at 10m intervals along the 100m line, while on the remaining three transects, $1m^2$ microplots were used at 20m intervals. The total sample size on the four transects was $20m^2$.

Plant species data was obtained from each microplot by estimating the percentage of each plot covered (foliage cover) by each plant species. Six coverage classes were used in estimating foliage cover (Table 2). Coverage was determined separately for each species overlapping the microplot, regardless of where individuals were rooted and regardless of superimposed canopies, therefore the sums of foliage cover could exceed 100 percent.

Ground condition values were also assessed in each microplot, using the same six coverage classes (Table 2). Ground condition included percentage cover of litter, rocks, bare ground and cryptogams (non-vascular plants).

Coverage of shrubs was estimated in the same manner as forbs, grasses and ground conditions. In addition, shrubs were rated for ungulate utilization according to the method used in the Wildlife Inventory of the Ecological Land Classification of Kootenay National Park (Poll et al 1984).

For analysis purposes, species or ground conditions with less than 1% cover were recorded as trace and considered to have 0.5% cover during tabulation of the data. For all other cover classes the coverage mid-point (Table 2) was used for tabulation and analysis.

Table 2. Plant foliage cover estimate values used in the Kootenay Parkway vegetation assessment, 1987. (after Daubenmire 1968)

Coverage Class	Range of coverage (%)	Coverage midpoint (%)
1	1 - 5	2.5
2	6 - 25	15.0
3	26 - 50	37.5
4	51 - 75	62.5
5	76 - 95	85.0
6	96 - 100	97.5

Right-of-way forage production, quality and utilization were assessed at each intensive study site by clipping $1m^2$ clip plots established at the 50m (mid-point) mark of Transect 1 in each macroplot. For comparison, three grassland sites adjacent to the right-of-way were sampled; a native herb-grass-lowshrub floodplain community south of McLeod Meadows campground, a man-made grassland (Poa-fescue) near plot 8710-E known locally as the "airstrip", and a man-made clearing (Fescue-Brome-Timmothy) with a fenced weather station which serves as an ungulate exclosure.

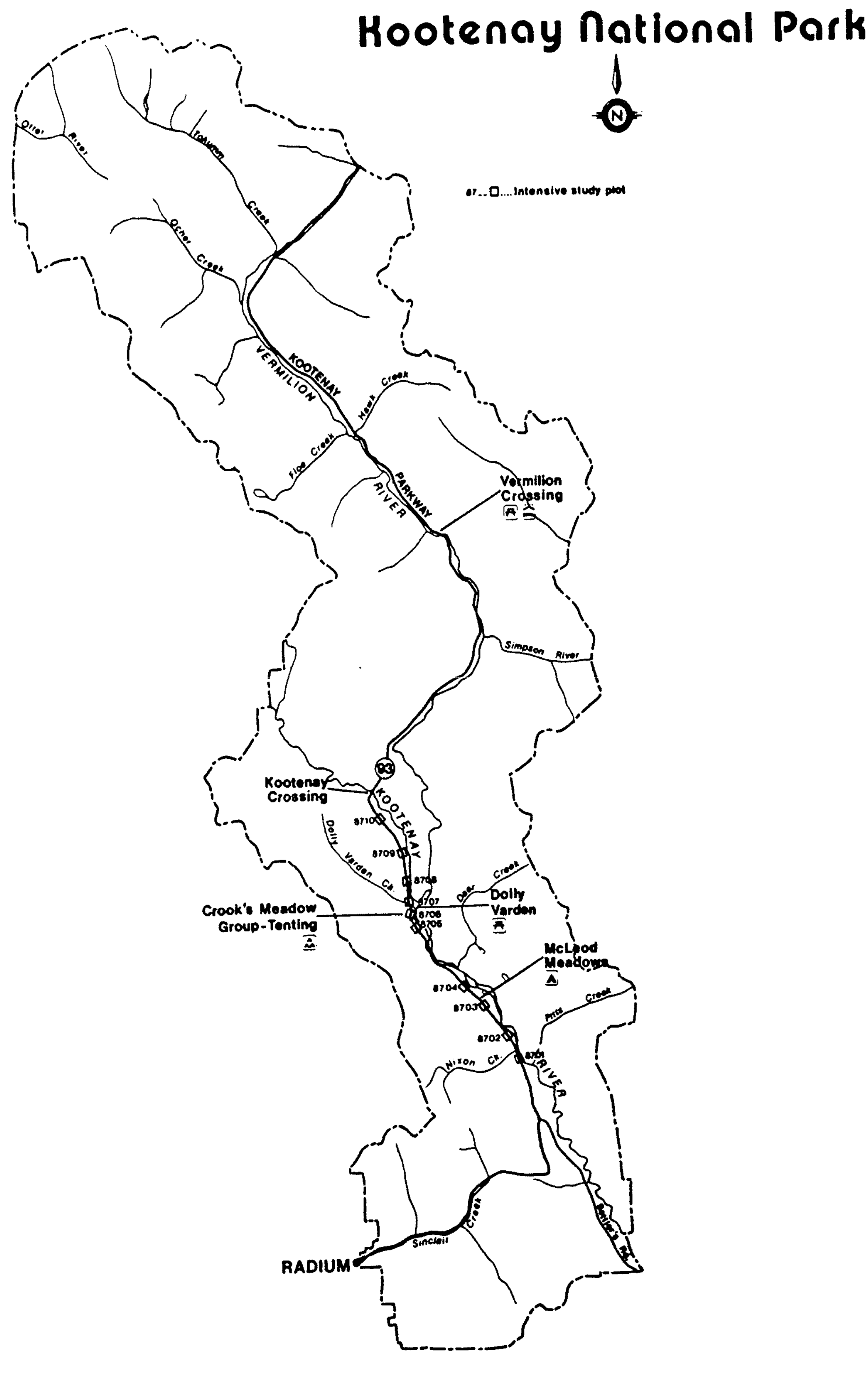

Figure 2. Study Area, Kootenay National Park.

In order to best estimate forage quality and quantity available during fall and winter, vegetation clipping was conducted in September 1987 following maturation and curing of grasses and forbs. Clipping was conducted within a $1m^2$ wooden frame. In order to avoid including the previous year's growth (litter) in the sample, clip plots were lightly raked by hand before clipping. All living vegetation within the $1m^2$ plot was clipped to within 1cm of the ground and placed in cloth bags. Grasses, forbs and shrubs were separated at the time of clipping. Samples were air-dried at room temperature (20 C) for two weeks and weighed to the nearest 0.1gm on an electronic balance. The air-dried weights were used to calculate total forage production in kilograms per hectare (kg/ha).

Forage biomass was again assessed at intensive study and off-highway sites in April 1988. One square metre plots were established next to the September 1987 clip plots and processed as described above. the difference in biomass (kg/ha) between September and April provided an indication of the forage utilization by herbivores at sample sites. The weather station exclosure plot served as a control.

Forage quality was assessed through chemical (proximate) analysis of forage samples collected in September 1987. The analyses were performed by the British Columbia Ministry of Agriculture and Food, Soil, Feed and Tissue Testing Laboratory in Kelowna and included: percent protein, fiber, calcium, phosphorus, sodium, potassium, magnesium, copper, manganese, zinc and iron.

3.3 Forage Preference and Diet Composition

The seasonal diets of elk and deer using the Parkway corridor were assessed from monthly composited fecal samples using a microhistological analysis of plant fragments in the feces (Sparks and Malecheck 1968, Hansen et al 1976). Fresh fecal samples from elk were collected monthly from September 1986 to November 1987 along the Parkway corridor. Samples of deer fecal material were collected monthly from April to November 1987, corresponding to the period of greatest deer use the Parkway corridor.

White-tailed and mule deer fecal material cannot be reliably differentiated in the field, therefore the samples collected could only be classed as "deer". White-tailed deer, however, are the more common of the two species in the corridor and therefore the diet analysis can be considered most representative of that species.

The goal was to collect a minimum of 20 individual samples from each species each month from various locations along the corridor. Owing to the seasonal nature of the use of the corridor by these ungulates, it was not always possible to meet that objective. Elk are scarce in the corridor from June to September and deer are absent from December to March and occur at much lower densities than elk at any time. A fecal sample consisted of 6-8 pellets or the equivalent from individual defecations and no animal was sampled more than once on a given occasion. Samples were kept frozen prior to shipment for analysis.

Diet analysis was conducted under contract by the Composition Analysis Laboratory, Colorado State University, Fort Collins, Co.. The frequency of occurrence of plant fragments was determined by reading 20 fields on each of 5 slides for each monthly composite sample.

3.4 Ungulate Distribution and Use of the Parkway Corridor

In order to establish an index of relative use by elk and deer of the intensive study areas, pellet group counts were conducted during April-May 1987. Counts were done on a 50m X 2m section of each 100m transect line within each macroplot for a total sample size per site of $800m^2$ ($400m^2$ on each side of the Parkway). Counts of pellets per species per line were converted into groups per hectare (gr/ha) by multiplying the total pellet groups per line by 10.

Existing information on ungulate seasonal distribution, abundance and use of the Parkway corridor (Gibbons 1978, Poll et al 1984, Sheehan 1986 and Park Warden Wildlife Files) was assembled and tabulated relative to population abundance and seasonal distribution, habitat use, crossing sites, vehicle-wildlife collision areas and mineral licks. Additional ground surveys were conducted during peak ungulate use periods in 1987 to augment the existing data base and aid in selection of intensive study areas. Ungulate pellet group densities, determined at intensive study areas, provided a measure of ungulate use in the comparison of kill and non-kill sites.

3.5 Ungulate-Vehicle Collision Site Analysis

A number of habitat and highway characteristics thought to influence the incidence of elk and deer vehicle collisions along the Parkway were measured at each intensive study site. The methodology of data collection and analysis was adapted from an analysis of deer-vehicle collision sites in Pennsylvania by Bashore et al (1985).

Characteristics (variables) considered important in evaluating ungulate-vehicle collision sites and intensive study areas along the Kootenay Parkway were:

Adjacent Habitat: in addition to ecosite and vegetation type which were recorded for each site, measured variables included: (1) Forested - the proportion (%) within 100m of the sample site and adjacent the right-of-way covered by trees > 2m tall; (2) non-forested - the proportion within 100m of the sample site covered by woody plants < 2m tall and non-woody herbaceous vegetation including grasslands; (3) barren/disturbed - proportion within 100m of the sample site devoid of vegetation or disturbed, e.g., roads, bare soil, borrow pits, water; (4) facilities - number of facilities within 100m of sample site e.g., campground, picnic site, viewpoint, bridge, residence, bungalow camps.

Parkway Characteristics: (5) traffic surface width; (6) right-of-way width on either side of the traffic surface; (7) distance to woodland or forest edge - shortest distance from highway edge at the sampling site centre to the forest edge; (8) banks - proportion of terrain, within 30m and paralleling the highway on either side, elevated more than 1m above road surface; (9) gullies - proportion of terrain, within 30m and paralleling the highway, greater than 1m below the road surface; (10) level - proportion of terrain, on either side of the highway, not classified as either bank or gully; (11) curve - presence or absence of highway curve within the 200m sample area; (12) hill - presence or absence of a change in grade of the traffic surface within the 200m sample area; (13) guardrail - proportion of sample area length (either side of highway) paralleled by concrete or metal guardrails; (14) angular visibility index - distance at which an observer standing 1m from the highway centre line could no longer see a 3cm X 1.2m orange and white range pole placed at lowest point in the right-of-way on either side of the highway; (15) shortest visibility - the least of the two angular visibility measurements taken on either side of the highway from each direction.

To determine which factor(s) of roadside vegetation cover, forage production, ungulate use (from pellet group counts), adjacent habitat and right-of-way characteristics contributed to a site being either a kill or non-kill site, a model was developed using the stepwise multiple regression (Stepwise Variable Selection) method provided by Statgraphics v2.1 computer software of Statistical Graphics Corporation, 1986, STSC Inc., Rockville, Maryland. The procedure reveals the relationship between a binary dependent variable (kill site = 1, control = 0) and independent variables of categorical or interval scale.

4.0 RESULTS

4.1 Ungulate Use of the Parkway Corridor

4.1.1 Seasonal Distribution

Ungulate seasonal distribution and habitat use in Kootenay has been described previously (Cowan 1943, Munro and Cowan 1944, Gibbons and Baker 1976, Gibbons 1978, and Poll et al 1984). Elk use of the Parkway corridor and seeded right-of-way is greatest in the post-rut period (October to December) and in spring (March to May). The duration of use of the grassy right-of-way, in both seasons, is primarily dependent on snow depth and crusting conditions. Winter use declines in late December to early January; the period when snow depth along the right-of-way normally exceeds 50 cm and/or crusting conditions prevent efficient foraging. The timing of spring use is dependent on the snow-melt.

Roadside use by elk is least from June to September and January to April. Key areas of elk utilization during high use periods are Nixon Creek fan, Meadow Creek fan (McLeod Meadows), Crook's Meadow - Dolly Varden Creek and Kootenay Crossing meadows. Key areas in the Vermilion Valley include Wardle Flats, Vermilion Crossing, Floe and Hawk creeks and Numa flats.

White-tailed deer use of the Parkway corridor and the Kootenay and Vermilion valleys is primarily limited to the snow-free months (May to October). A northward movement of white-tail deer from winter ranges to the south and west of the park, occurs in the Kootenay and Vermilion valleys during May and June. The largest counts of white-tailed deer along the Parkway are obtained during this period. Numbers of white-tailed deer decline sharply in early fall and in most years white-tailed deer have left the Kootenay and Vermilion valleys by late October or early November. Key white-tailed deer summer areas within the corridor are in the Settler's Road - Parkway junction area, Nixon Creek, Crook's Meadow - Dolly Varden Creek, and between the Daer Fire road and Kootenay Crossing. White-tailed deer use of the Vermilion valley is low, however, the Floe and Hawk creeks fans are of particular importance. Mule deer are less common in the corridor than either elk or white-tailed deer. Similar to white-tailed deer, however, mule deer utilize the Kootenay and Vermilion valleys only during the snow-free period; wintering primarily in the lower Sinclair Creek drainage and the Columbia Valley. Unlike white-tailed deer, mule deer are not restricted to the riparian habitats along the valley bottoms of the Kootenay and Vermilion rivers, rather preferring to summer in subalpine and alpine areas.

4.1.2 Abundance

Ungulate populations in the park have fluctuated over the years in response to range conditions and weather variables (Poll et al 1984). Early records indicate that ungulate populations reached maximum levels through the 1940's and early 1950's, most probably in response to improved range extent and condition following the major fire in the Kootenay and lower Vermilion valleys of 1926 (Cowan 1943, Munro and Cowan 1944). Several severe winters in the late 1940's and early 1950's and again in the early 1960's coupled with deteriorating conditions on overstocked ranges and progressive forest succession no doubt served to initiate declines in the park's cervid populations (Poll et al 1984). Redevelopment of the Parkway during the mid-1960's to the present standard with its wide, grassy right-of-way, coupled with relatively mild winters through the 1970's, probably dampened the declines, particularly for elk. White-tailed deer, once considered one of the most "abundant and characteristic animals of the Vermilion and Kootenay valleys" (Munro and Cowan 1944), became less numerous than mule deer (which were also declining) during the 1960's and 1970's. Over the past five years, however, white-tailed deer have again become more numerous than mule deer, at least along the Parkway corridor. Systematic road surveys of ungulates during periods of peak use of the Parkway corridor have been conducted since the late 1970's (Warden Wildlife Files, Poll et al 1984; Tables 3 and 4). Although not an absolute measure of population size, these counts provide a useful index to the relative abundance of ungulates from year to year. Elk numbers show a stable to slightly declining trend since 1979. Mule deer numbers along the corridor have remained stable at low levels while white-tailed deer numbers have increased dramatically since 1985.

Estimates of elk productivity from classified counts are shown in Table 5. Although the records are not continuous between 1979 and 1987, calf production shows a declining trend since 1982. Increased monitoring of elk productivity is indicated to verify this trend.

Similar productivity data are not available for either deer population. The lower density of deer relative to elk coupled with their dispersed and more secretive habits, makes this kind of information difficult to obtain. It appears, from survey data, that the white-tailed deer population is increasing while mule deer are stable to declining. Detailed studies, of both deer populations, are necessary to properly assess these observed trends.

4.1.3 Habitat Use

The seasonal distribution and habitat utilization of elk and white-tailed deer in relation to the Parkway corridor was determined, on an ecosite basis, during the Kootenay wildlife inventory (Poll et al 1984). Analysis of weekly roadside

Table 3. Maximum classified counts of elk along the Kootenay Parkway between 1979 and 1987.

Survey Date	Total elk	Adult female	Adult male	YOY	YOLY	Unclass.
Nov. 1979	320	155	7	55	41	62
Nov. 1980	204					
Nov. 1981	265	137	17	31	28	52
Nov. 1982	264	154	21	64	24	0
Dec. 1983	173					
May 1984	305	154	10		26	115
Oct. 1985	208	132	34	42		
May 1986	217	150	18		44	5
Oct. 1987	227	144	43	27	13	

Table 4. Maximum unduplicated counts of white-tailed and mule deer from Kootenay Parkway roadside surveys, 1981 to 1987.

Date	white-tailed deer	mule deer
May 1981	7	4
May 1982	5	0
May 1983	0	3
May 1984	2	0
May 1985	8	3
May 1986	24	2
Apr 1987	39	3

Table 5. Age/sex classification of elk from roadside surveys, Kootenay Parkway, 1979 - 1987.

Survey	Total elk	Calves/ 100 cows	Yearlings/ 100 cows	Bulls/ 100 cows
Nov. 1979	320	36	26.5	4.5
Nov.1981	265	23	20.4	12.4
Nov.1982	264	42	15.5	13.6
May 1984	305		16.9	6.5
Oct.1985	208	32	N/A	25.7
May 1986	217		29.3	12.0
Oct. 1987	227	19	9.0	29.9

surveys conducted in 1981 and 1982 showed that elk preferred alluvial fans (FR1, FR3) and glaciofluvial terraces (AT1, AT4) with spruce-aspen-lodgepole pine (paper birch)/buffaloberry/ pine grass (C44), white spruce-Douglas fir/feathermoss (C5) and lodgepole pine/buffaloberry/pine grass (C38) vegetation types. Combinations of ecosites (e.g., FR3/AT4 or AT1/FR1) were preferred over single ecosites and ecosites dominated by lodgepole pine forest were either avoided or used in proportion to their availability (Table 6). White-tailed deer preferred lodgepole pine dominated alluvial (FR1,AT1) and morainal (DR2,DR8) ecosites and combinations of alluvial (FR3/AT4) landforms with mixed wood (C44) and white spruce/buffaloberry/feathermoss (C37) closed forest types (Table 6).

A similar comparison, substituting the number of elk and white-tailed deer highway mortalities by ecosite as the "use" variable (Table 6) shows that, although mortalities are related generally to distribution, both spatially and temporally, they are not closely related to habitat (ecosite) use.

Table 6. Comparison of elk and white-tailed deer habitat selection and highway mortality by ecosite for the Kootenay Parkway corridor.

Ecosite	Predominant forest	% Avail. of ecosite cover	Electivity Index*			
			Use**		Mortality	
			elk	whit	elk	whit
AT1	lodgepole	10.0	-0.5	+0.02	-0.01	+0.62
AT4	white spruce	16.6	-0.01	-0.73	+0.28	-0.19
FR1	lodgepole	6.6	-0.10	+0.73	+0.05	-0.39
FR3	mixed wood	6.6	+0.59	-0.52	+0.30	-0.39
DR5	spruce/Doug. fir	7.1	-0.79	-0.54	+0.47	-0.42
DR6	spruce/mixed wood	2.8	-0.90	-	-1.00	-0.33
DR7	lodgepole pine	15.7	-0.61	-	-0.17	-0.47
FR3/AT4	mixed wood/spruce	8.5	+0.43	+0.42	-0.27	-0.33
FR1/AT1	lodgepole pine	2.8	+0.42	-	-1.00	-1.00
DR7/AT1	lodgepole pine	14.2	-0.06	-0.29	-0.18	+0.26
FR1/DR7	lodgepole pine	5.7	-0.06	-	-1.00	-1.00
DR2/DR6	lodgepole pine	2.8	-0.06	+0.58	-1.00	-0.33

* after Poll et al (1984); index ranges from +1 (preference) to -1 (avoidance)
** data from Poll et al (1984), p.60

Habitat and ungulate use variables (Appendix B), for all intensive study sites, were compared in a correlation matrix (Statgraphics 2.1, STSC Inc.) (Table 7). Elk use of the corridor, expressed as pellet groups/ha, was positively correlated ($p<0.05$) to total cover of roadside grasses and roadside forage production (kg/ha). Deer use of roadside habitats was positively correlated ($p<0.05$) to total forb cover. No significant correlations were obtained between ungulate trail densities at intensive study sites and measured habitat or ungulate use variables.

Table 7. Correlation coefficients(r) and significance (p) levels of elk and deer habitat use variables and habitat parameters from intensive study sites, Kootenay Parkway.

Habitat Variables	Elk pellet Dens. r	Elk pellet Dens. p	Deer Pellet Dens. r	Deer Pellet Dens. p	Trail Density r	Trail Density p
Total cover (%)						
grasses	.4556	.0435	-.3580	.1212	-.0377	.8745
forbs	-.0529	.8246	.4934	.0271	.0622	.7944
shrubs	-.3254	.1615	-.2928	.2103	-.2545	.2790
all veg.	.2621	.2643	.1086	.6485	.0042	.9860
forage prod. (kg/ha)	.4514	.0457	-.0903	.7050	-.2584	.2713
crude protein	.0538	.8217	-.1833	.4391	.0264	.9119

4.1.4 Roadside Vegetation Composition and Quality

The assessment of roadside vegetation transects at intensive study sites (Table 8) shows a grassland complex composed of an agronomic mixture of grasses dominated by red fescue (*Festuca rubra*), smooth brome (*Bromus inermis*) and Kentucky bluegrass (*Poa pratensis*). Other grasses, occurring less frequently, included Timothy (*Phleum pratense*) and wheatgrasses (*Agropyron trachycaulum*, *A. dasystachum*, *A. subsecundum*). Dominant forbs included strawberry (*Fragaria virginiana*), white clover (*Trifolium repens*), Canada thistle (*Cirsium arvense*), oxeye-daisy (*Chrysanthemum leucanthemum*), and dandelion (*Taraxacum officianale*). The most common shrub species were wild rose (*Rosa acicularis*) and white spruce (*Picea glauca*). A detailed list of plant species identified at intensive study sites is given in Appendix C.

Over all study sites, total vascular plant cover averaged 86.2%. Mean cover of grasses was 56.1%, constituting 65% of the total vascular plant cover. Mean cover of forbs and shrubs was 28.6 and 1.6%, respectively. Forbs averaged 33% of the total vascular plant cover while shrubs averaged 2%. On a dry-weight basis grasses averaged 89.7%, forbs 9.7% and shrubs 0.6% of the total biomass. Mean cover of litter, representing carry-over from previous years, was 40.4% for the 10 intensive study sites.

Forage production/utilization values calculated from sample plots clipped in September, 1987 and April, 1988 are shown in Table 9. September forage biomass, based on air-dried weights, averaged 1737.6 kg/ha over the 20 sample sites. Values ranged from 394 kg/ha on macro-plot 8709-west, south of the "Airstrip" to 3775 kg/ha on macro-plot 8703-east at McLeod Meadows. April biomass values, at intensive study sites, averaged 78.8% lower (range: 55.1 to 94.2%) than September values, providing an approximation of the amount of forage removed through grazing (Table 9). The two off-highway sites, one native grassland and one seeded, had range use values of 63 and 52%, respectively. The range exclosure (McLeod Meadows fire weather station) showed an 18% reduction in biomass between September and April, indicating utilization other than by ungulates. If this value is applied as a correction to the intensive study sites, average utilization by ungulates (primarily elk) becomes approximately 60%. Although this method of range use assessment lacks precision, it does

Table 8. Species composition, cover (%C) and frequency (%F) of roadside vegetation plots on Intensive Study Sites, Kootenay Parkway, 1987.

Cover Class	Vegetation Plot Number																			
	1W		1E		2W		2E		3W		3E		4W		4E		5W		5E	
Species	%C	%F	%C	%F	%C	%F	%C	%F	%C	%F	%C	%F	%C	%F	%C	%F	%C	%F	%C	%F
GRASSES																				
Agropyron spp.	19.3	100	6.8	30	16.2	100	16.5	100	19.3	100	1.5	100	.6	80	0	0	26.3	100	22.8	100
Bromis inermis	9.8	100	10.1	70	41.5	90	54.8	100	62	100	81.8	100	69	100	42.1	100	9.8	100	3.1	80
Festuca rubra	32.5	100	40	80	0	0	0	0	0	0	0	0	.9	60	0	0	12.1	100	.8	80
Phleum pratense	0	0	8.1	90	0	0	0	0	0	0	0	0	6.4	80	1.9	40	11.9	100	19.5	100
Poa pratensis	4.2	90	13.4	70																
FORBS																				
Achillea millefolium							.9	70							2.2	70	2.35	60		
Antennaria sp.					3.5	40	5.9	60												
Aster sp.			2.1	40									1.6	80			1.9	40	5.8	50
Chrysanthemum sp.	4	20													8.7	80			1.8	20
Cirsium arvense	5.5	70							1.5	10	10	100							4	20
Fragaria virginiana			2	30			1.4	80					3.7	80	2.2	60	12.1	60	5.3	20
Galium boreale					4.6	50			1.8	20					2	70				
Gentianella amarella			3.8	50																
Hedysarum sulphuresens																				
Melilotus officianale													1.8	20						
Rhinanthus crista-galli																				
Senecio spp.			3.6	60	2.6	70	1	80					.35	70						
Taraxacum officianale	25	100															10.9	90	4.3	70
Triflorum hybridum																	16.3	30		
T. pratense																	3.9	70		
T. repens	9.9	80			.8	70			8.3	90	1.3	100	2.2	70					2	70
Viola adunca																				
SHRUBS																				
Arctostaphylos															3.8	10				
Picea glauca																				
Pinus contorta																				
Populus tremuloides																				
Rosa acicularis															3.4	50				
Symphoricarpos alba									1.9	50	3.4	50								
Total Veg. Cover*	126.		91.9		75		84.3		98.1		100.		90.2		74.7		112.		70.2	
Total Grass Cover	73		79.5		60		72.4		82.5		84.4		77.5		45.3		60.1		46.5	
Total Forb Cover	53.7		12.4		14.9		11.5		13.7		12.5		12.1		22.3		52.1		23.7	
Total Shrub Cover	.3		0		.1		.5		1.9		3.4		.6		7.2		0		0	
Litter	34.8		37		18.6		6.1		80.5		69		47.5		31		50		55	

* because of superimposed canopies total vegetation cover can exceed 100%

Table 8. Continued

Cover Class Species	6W %C	6W %F	6E %C	6E %F	7W %C	7W %F	7E %C	7E %F	8W %C	8W %F	8E %C	8E %F	9W %C	9W %F	9E %C	9E %F	10W %C	10W %F	10E %C	10E %F
GRASSES																				
Agropyron spp.			9	50																
Bromis inermis	8.9	70	0	0	0	0	3.4	60	0	0	7.3	100	.5	60	8.7	100	21.3	100	27.3	100
Festuca rubra	5.1	70	2.5	50	25.3	100	8.5	100	50	100	35.8	100	14.8	100	42.8	100	34.3	100	2.8	100
Phleum pratense	4.4	100	12.3	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.5	70
Poa pratensis	43	100	47.8	100	0	0	0	0	0	0	3.4	100	0	0	.6	70	.6	70	8.1	100
FORBS																				
Achillea millefolium					1	60	3.4	100							2.5	90			1.6	30
Antennaria sp.																				
Aster sp.	13	40													6.2	80				
Chrysanthemum sp.					5.3	20	5.3	30			4.3	30								
Cirsium arvense	15.3	90	6.2	90															21.8	70
Fragaria virginiana					14.5	100	1.4	70	3.6	50	14	80	14.3	90	19.4	70	5.9	60		
Galium boreale															5.5	30				
Gentianella amarella																				
Hedysarum sulphuresens															1.8	20				
Melilotus officianale																				
Rhinanthus crista-galli											6.9	100								
Senecio spp.			1.5	10							4.1	40	1.1	100						
Taraxacum officianale	17.6	100															6.4	80	4.2	90
Triflorum hybridum	52.3	100					3.1	30												
T. pratense	4.8	40																		
T. repens			5.9	80			.25	50			8.8	100					1.9	50	7.7	100
Viola adunca									.4	70	5.2	70	1.1	100			.7	90		
SHRUBS																				
Arctostaphylos													1.5	10						
Picea glauca							5.3	20												
Pinus contorta									3.8	10										
Populus tremuloides																	1.6	20		
Rosa acicularis											2.2	50			1.9	40				
Symphoricarpos alba																				
Total Veg. Cover*	165.		88.9		48.8		32		59.9		94.1		44		101.		83.7		83.7	
Total Grass Cover	61.4		73.7		25.4		11.9		50.1		46.5		15.5		53.3		59.6		43.6	
Total Forb Cover	103.		14.9		23.4		14.8		6		45.4		27		46		22.2		40.1	
Total Shrub Cover	0		.3		.1		5.3		3.9		2.2		1.6		2.2		1.9		0	
Litter	50		68.8		4.8		1.7		3.6		40.3		3.4		59.5		66.5		80.8	

* because of superimposed canopies total vegetation cover can exceed 100%

illustrate the importance of this forage source to wintering ungulates.

Forage production averaged 12% higher on the east side of the Parkway (west facing) than on the west side (east facing). A similar pattern in elk use was noted; elk pellet group densities averaged 25% higher on the east side of the Parkway than on the west.

Table 9. Forage production/utilization from intensive study sites, Kootenay Parkway, 1987-88.

Sample Site #	kg/ha Apr 88	kg/ha Sept 87	Net Change	Carry-over %	Range Use %
8701-E	121	2003	-1882	6.04	93.96
8701-W	455	1966	-1511	23.14	76.86
8702-E	184	1401	-1217	13.14	86.87
8702-W	107	1017	-910	10.52	89.48
8703-E	642	3775	-3133	17.01	82.99
8703-W	554	2499	-1945	22.17	77.83
8704-E	62	398	-336	15.58	84.42
8704-W	277	1695	-1418	16.34	83.66
8705-E	703	2963	-2260	23.73	76.27
8705-W	755	3467	-2712	21.78	78.22
8706-E	840	2237	-1397	37.56	62.45
8706-W	460	3317	-2857	13.87	86.13
8707-E	91	1559	-1468	5.84	94.16
8708-E	271	1081	-810	25.07	74.93
8708-W	101	643	-542	15.71	84.29
8709-E	627	1397	-770	44.89	55.12
8709-W	109	394	-285	27.67	72.34
8710-E	699	1717	-1018	40.71	59.29
8710-W	226	988	-762	22.87	77.13
RIVER*	419	1129	-710	37.11	62.89
AIRSTRIP**	872	1828	-956	47.70	52.29
EXCLOSURE	2754	3352	-598	82.16	17.84
Means study plots 1 - 10				21.24	78.76
Means for off-highway sites				42.41	57.59
Means for range exclosure (control)				82.16	17.84

* Native grassland community along Kootenay River
** Seeded area (Fescue & Poa) adjacent Kootenay Parkway

Nutrient contents of forage samples collected in September 1987 at ten intensive study areas are summarized in Table 10. Crude protein of mixed forage samples (forbs + grasses) averaged 5.8% which is above the maintenance range for cattle (4.5%) given by Stoddart and Smith (1955) and within the maintenance range for elk (5.5 - 6.0%) given by Morgantini (1987). Mean calcium content was well above the maintenance requirements suggested for cattle (2.0%), however, mean phosphorus content was below recommended levels (0.18%)(Stoddart and Smith 1955, NRC 1957). Mean TDN (Total Digestible Nutrients) exceeded recommended maintenance requirements for wintering cattle (50%; Stoddart and Smith 1955)

4.1.5 Ungulate Diet Composition

Elk and white-tailed deer diet composition was assessed by microhistological analysis of plant fragments in fecal material collected along the Parkway corridor from September 1986 to October 1987 for elk (292 samples) and April to October 1987 for white-tailed deer (152 samples) Figures 3, 4 and Appendix D).

Elk showed a strong preference for grasses (primarily fescue and bluegrass) during fall and early winter. Grasses formed 58.7% of the September to November diet; >80% in October-November. Use of grasses decreased during the winter (36.1% December to February) and increased to 60.6 and 69.8% in March and April, respectively. The periods of heavy utilization of grasses correspond to the periods of heaviest use of the Parkway right-of-way by elk.

Browse use in 1986 increased from fall (22%) through late winter (58.4%); in February >75% of the diet was composed of woody browse species. Elk preferred willows (10.1%),

Table 10. Forage quality analysis from roadside clip plots, Kootenay Parkway, September 1987.

Plot#	Protein Dry %	Fiber %	Ca %	Ph %	Mg %	Cu ug/g	Mn ug/g	Na ug/g	K %	Zn ug/g	Fe ug/g	TDN* %
8701-W	6.8	35.4	.6	.1	.2	4.0	15	10	1.3	16	72	59
8701-E	6.0	34.8	.7	.1	.1	5.0	17	8	1.0	24	58	60
8702-W	4.8	35.4	.8	.1	.2	4.0	53	7	.7	13	70	59
8702-E	6.7	36.6	.8	.1	.1	4.0	17	15	1.2	22	84	57
8703-W	5.0	38.2	.7	.1	.1	4.0	34	9	.9	10	93	55
8703-E	5.4	38.4	.7	.1	.1	4.0	25	11	1.1	11	115	55
8704-W	4.7	36.0	.7	.1	.1	4.0	55	8	.8	9	45	58
8704-E	5.0	32.8	1	.1	.2	6.0	46	20	.7	12	331	62
8705-W	5.3	36.6	.7	.2	.1	4.0	26	9	1.1	12	121	57
8705-E	5.2	38.8	.6	.1	.1	4.0	30	10	1.1	12	53	54
8706-W	8.0	35.8	1.1	.3	.2	7.0	17	16	1.5	22	98	58
8706-E	6.0	39.6	.5	.1	.1	4.0	9	12	.9	13	54	53
8707-W	5.7	34.4	1.1	.2	.2	5.0	25	14	1.1	18	55	60
8707-E	7.4	40.0	1.4	.1	.2	6.0	31	16	1.0	12	161	53
8708-W	5.2	34.4	.9	.2	.2	6.0	15	16	.9	15	112	60
8708-E	6.6	36.4	.7	.2	.2	4.0	42	11	1.2	12	84	58
8709-W	5.8	35.8	1.2	.2	.2	6.0	44	13	1.0	18	106	58
8709-E	4.7	35.8	.8	.1	.1	5.0	37	12	.9	10	55	58
8710-W	4.5	40.0	.7	.1	.1	5.0	51	14	.8	11	114	53
8710-E	6.4	36.2	1.1	.2	.2	0.0	28	44	1.5	21	99	58
Mean	5.8	36.6	.8	.1	.1	5.1	30.9	13.8	1.0	14.7	99.0	57.3
Mean E	5.9	37.1	.8	.1	.1	5.1	27.9	15.5	1.1	14.5	109.9	56.6
Mean W	5.6	36.2	.8	.1	.1	4.9	33.5	11.6	1.0	14.4	88.6	57.7

*Total Digestible Nutrients

buffaloberry (5.4%) and raspberry (Rubus idaeus)(2.4%) in the fall, however as winter progressed conifers comprised an increasing proportion of the diet; lodgepole pine (27.1%), white spruce (5.5%), subalpine fir (4.9%) and Douglas fir (3.3%). Use of shrubs decreased in March through April 1987 and increased dramatically in May (80.7%). Shrub species remained high in the diet (>70%) throughout the summer of 1987, decreasing again in September as forage preference returned to grasses (Figure 3b).

The shift in elk diet composition from heavy use of grasses in the fall and early winter to heavy use of browse species in mid to late winter is concurrent with the onset of snow cover and increasing snow depth. As noted in the present study and by Poll et al (1984), elk use of the open habitats including the right-of-way and adjacent floodplain areas decreases rapidly in response to increasing snow depth and/or crusting conditions. Elk use of the Parkway right-of-way during the winter of 1981-82 was significantly reduced once snow depths reached 50 cm (Poll et al 1984).

A similar shift in elk diet composition from predominantly grass-sedge to predominantly browse, in response to increasing snow depth, was reported for elk in Riding Mountain National Park by Trottier and Hutchison (1980). On the eastern slopes of the Rockies, however, grasses and sedges formed the major components of elk diets throughout the winter (Morgantini 1987), reflecting greater availability of grassland habitats and lower snow depths compared to the Western and Main ranges of the Rockies.

Grasses and sedges formed the bulk of elk fall and winter diets in the Bow Valley of Banff National Park (John Woods, unpubl. data). Grasses and sedges averaged 67% of Bow Valley elk diets from October 1985 to March 1986. The shrub component was constant at approximately 30% through the same

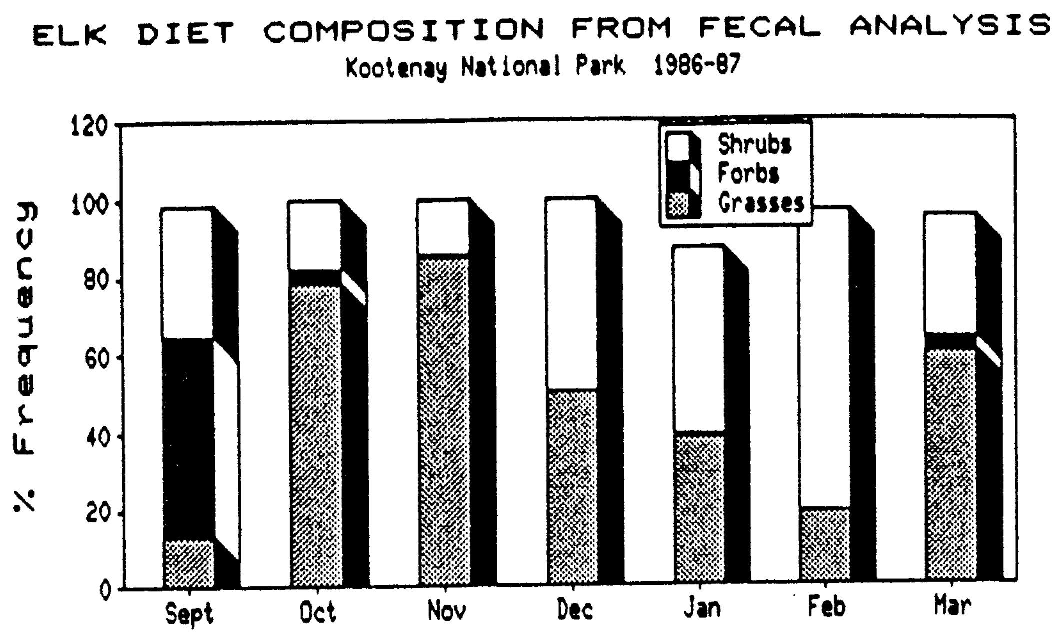

Figure 3a. Elk Diet Composition, September 1986 - March 1987.

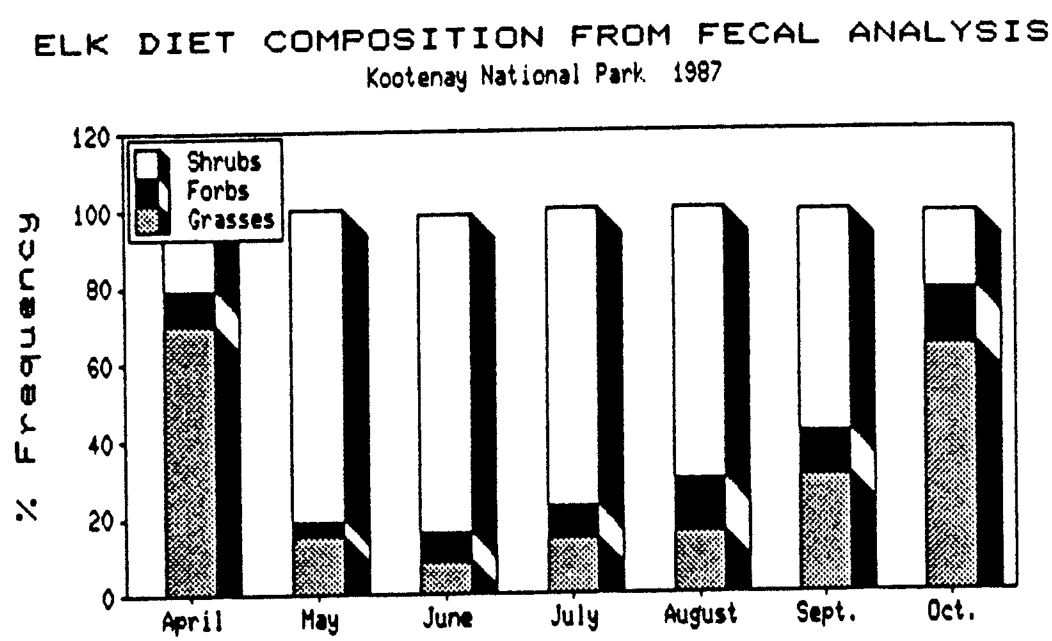

Figure 3b. Elk Diet Composition, April 1987 - October 1987.

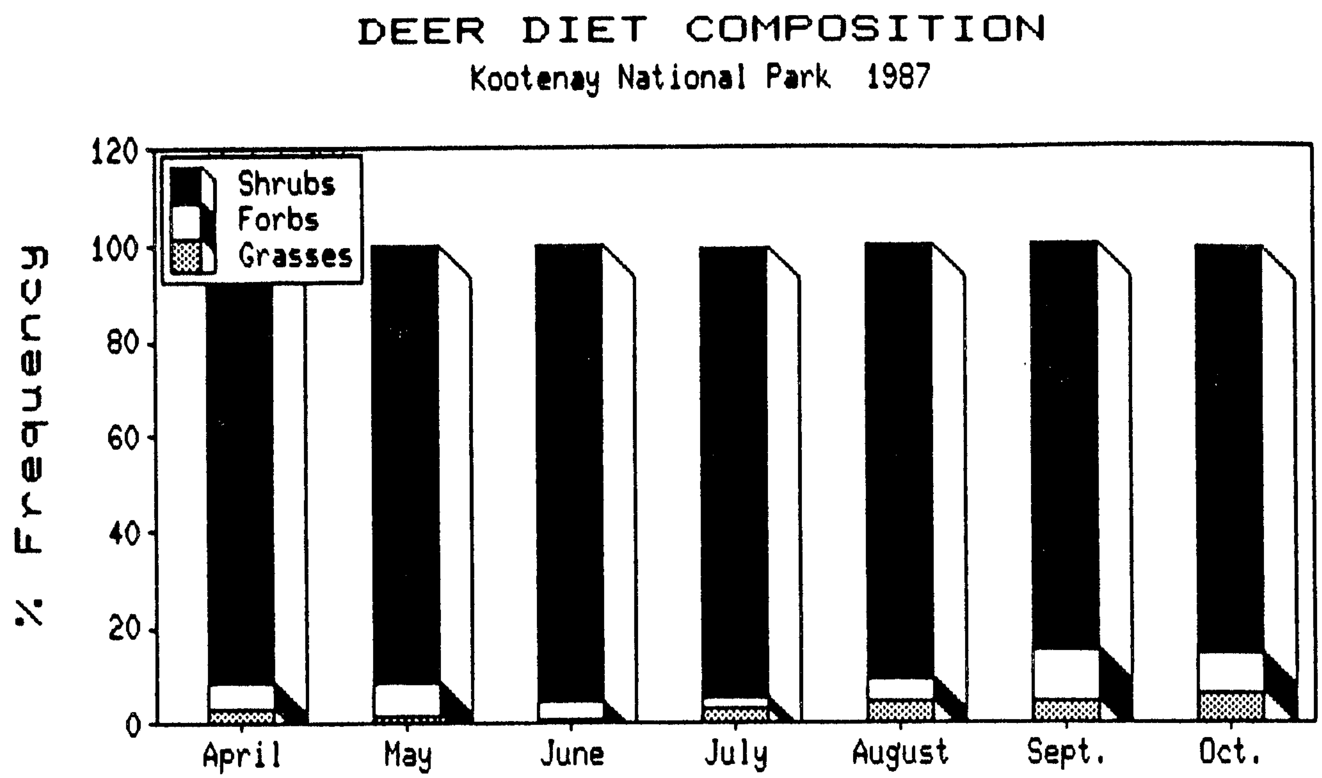

Figure 4. White-tailed Deer Diet Compostion, April - October, 1987.

period. Similar to Kootenay, lodgepole pine comprised a significant proportion (17% December to February) of elk winter diets in the Bow Valley. John Woods (pers. comm.) also reports heavy summer use of shrub species (primarily Salix sp. and Shepherdia) by elk in the Bow Valley.

White-tailed deer diets were composed primarily of shrubs throughout the April to October, 1987 period. Forbs and grasses ranked second and third in the diet, respectively (Figure 4; Appendix D). Most heavily used shrubs in the spring (April-May) were Cornus stolonifera (39.3%), Populus sp. (17.8%), Salix sp. (10.3%) and Pseudotsuga mensezii (7.9%). During summer (June-August) white-tailed deer preferred Salix sp. (53.9%), Populus sp. (20.4%), Shepherdia canadensis (5.4%) and Spiraea sp. (5.4%). In September-October white-tailed deer preferred Cornus stolonifera (29.8%), Populus sp. (25.5%) and Salix sp. (23.1%).

Forb use by white-tailed deer was highest in September (10.7%) and averaged 6.9% throughout the study period. Most prevalent forbs in the diet were Astragalus sp., Fragaria virginiana, and Equisetum sp.. Grasses accounted for an average of 3.7% of the diet over the April to October period; highest use of grasses was in October (6.5%). Preferred grass-like species included Festuca, Poa and Carex.

4.2 Wildlife-Vehicle Accidents

A total of 471 large mammals are known to have been killed by vehicles on the Kootenay Parkway between January 1, 1978 and December 31, 1987 (Table 11; B. Sheehan, Kootenay Warden Service). For this ten year period three ungulate species accounted for 83.4% of the total mortalities; elk - 46.5%, white-tailed deer - 24.2%, and mule deer - 12.7%. An additional 37 animals are suspected mortalities from accident reports where no dead animals were found.

The contribution of each of these species to the annual kill is illustrated in Figure 5. The proportion of elk in the annual kill has declined steadily from an average of 60% during the early 1980's to about 30% in 1987. The trend in white-tailed deer mortality is the reverse; from a low in 1983 of 10% of the total kill, the proportion of white-tailed deer increased to 40% in 1987, exceeding elk in the total Parkway kill. This trend closely parallels observed trends in population levels of these two species over the same time period.

In addition to the park wildlife mortality records, searches were made of both RCMP (Radium Detachment) and British Columbia Motor Vehicle Department (B.C.M.V.D., Invermere, B.C.) accident statistics involving wildlife on Highway 93 (Kootenay Parkway) within the park. Comparisons with park records, for the period 1982 to 1987, revealed a total of 46 additional wildlife related accidents not accounted for in park records (Table 11). Unfortunately, these statistics do not provide details as to the nature of the accident or the species involved. A proportion of these accidents may not result in a wildlife fatality, however, the worst-case scenario is that the annual wildlife-highway mortality averages 18% higher than observed which equates to an average of eight or nine additional fatalities each year.

The search of RCMP and B.C.M.V.D. accident statistics revealed a total of 110 accidents involving wildlife within the park for the period 1982 to 1987. The total known wildlife kill on the Parkway for that period was 292 animals. Sixty-four of the RCMP-BCMVD reports could be equated with known mortalities from park records, leaving 46 additional accident records, bringing the total for the period to 338. Comparing total

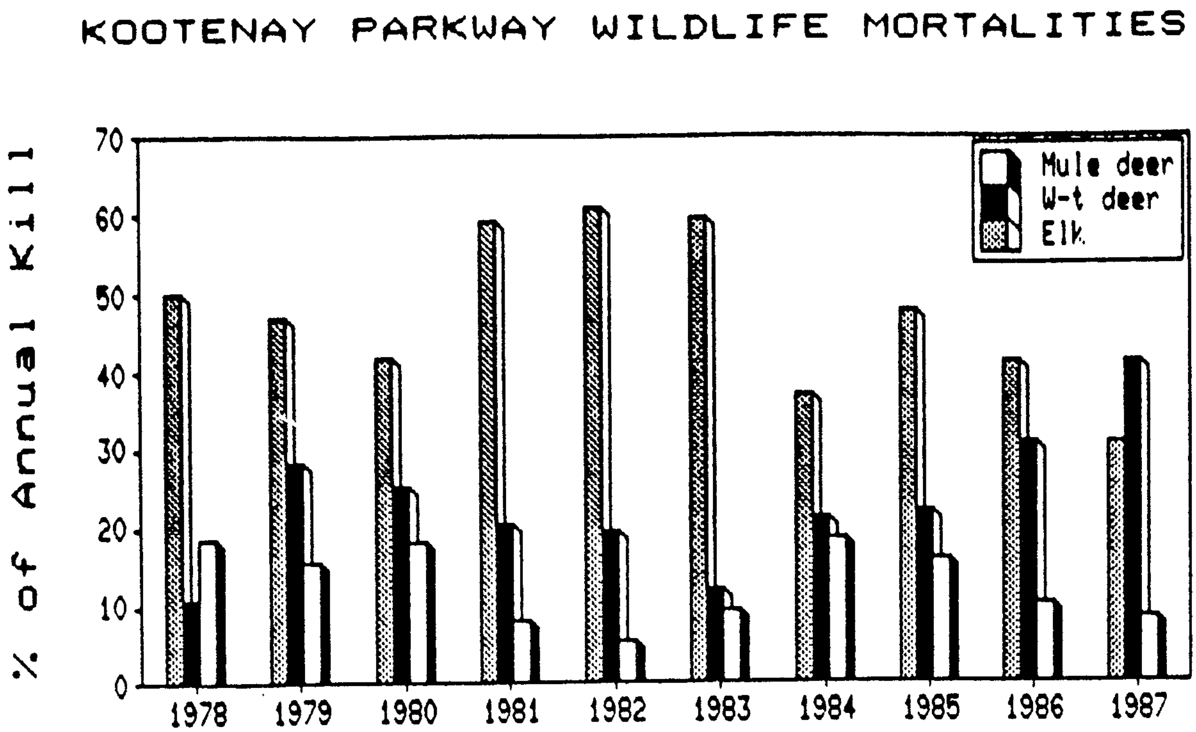

Figure 5. Kootenay Parkway Ungulate Mortality, 1978-1987.

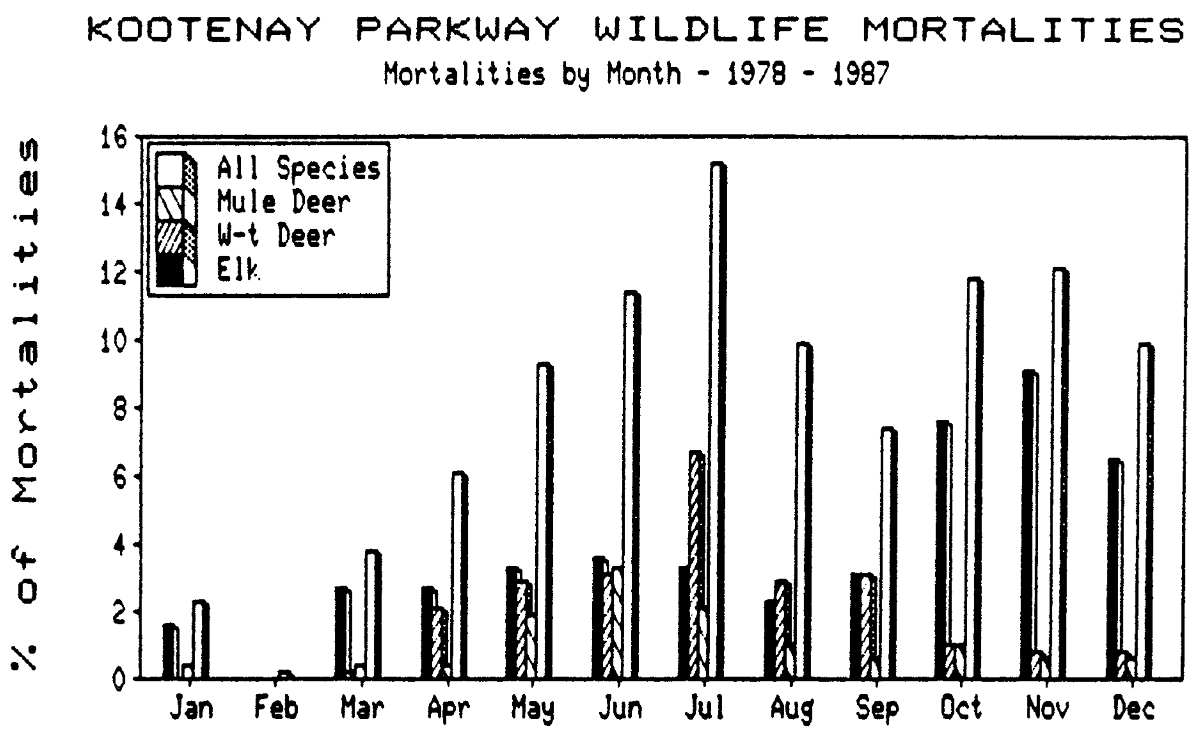

Figure 6. Kootenay Parkway Ungulate Mortality by month, 1978-1987.

accidents involving wildlife to accident reports, shows that only 32.5% of accidents were reported to either the RCMP or BCMVD.

4.2.1 Distribution of Parkway Wildlife Mortalities

Mean monthly wildlife mortality on the Parkway between 1978 and 1987 was 3.9 animals/month. Higher than average mortality occurred from May to August (5.4 animals/month; 44.9% of the annual kill) and October to December (5.3 animals/month; 34.0% of the annual kill). Peak monthly mortality occurred in July (7.2 animals/month; 15.4% of the annual kill) (Figure 6).

White-tailed deer, mule deer and elk, respectively, comprised the majority (80.6%) of highway kills during the May to August period, while elk formed the majority (68.8%) of kills from October to December (Table 12). Peaks in mortality of individual species corresponded closely to the periods of greatest use of the Parkway corridor by those species.

During the 10 year period 1978 to 1987, over the 94.4km length of the Parkway, wildlife kills from vehicle accidents averaged 0.5 animals/km/yr; the mean elk kill rate was 0.23/km/yr and white-tailed deer 0.12/km/yr (Table 11). Wildlife kills on the Parkway were not uniform, but showed a clumped distribution (Appendix A). The highest kill-rate of elk (0.5/km/yr) occurred in the nine kilometre section of the Parkway between McLeod Meadows and Dolly Varden Creek, while the highest white-tailed deer kill-rate (0.6/km/yr) was in the Dolly Varden Creek to Kootenay Pond section (Table 1 and Appendix A). The highest combined kill-rate of 0.8 animals /km/yr occurred between McLeod Meadows to Dolly Varden Creek.

For the period 1982 to 1987, in which accurate records were available, the greatest percentage of elk and white-tailed

Table 11. Total known wildlife mortalities on the Kootenay Parkway from park records (1978-1987).

SPECIES	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	TOTAL	%	MEAN
ELK	19	15	25	29	22	25	14	24	28	18	219	46	21.9
MULE DEER	7	5	11	4	2	4	7	8	7	5	60	13	6
WHITE-TAILED DEER	4	9	15	10	7	5	8	11	21	24	114	24	11.4
MOOSE	3	1	1	2	0	1	2	4	3	4	21	4	2.1
BIGHORN SHEEP	4	1	4	2	2	3	1	2	4	1	24	5	2.4
BLACK BEAR	1	0	1	0	3	0	3	0	1	2	11	2	1.1
COYOTE	0	1	3	2	0	4	3	1	4	4	22	5	2.2
YEAR TOTALS	38	32	60	49	36	42	38	50	68	58	471	100	47.1
Elk/km*	.2021	.1596	.2660	.3085	.2340	.2660	.1489	.2553	.2979	.1915	2.330		.2330
WHIT/km*	.0426	.0957	.1596	.1064	.0745	.0532	.0851	.1170	.2234	.2553	1.213		.1213
Total/km*	.4043	.3404	.6383	.5213	.3830	.4468	.4043	.5319	.7234	.6170	5.011		.5011

* based on a total Parkway length of 94.4km

Table 12. Monthly proportion of wildlife species in total kill on the Kootenay Parkway (1978-1987).

SPECIES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	% of TOTAL KILL
Elk	1.69	0	2.76	2.76	3.39	3.60	3.39	2.33	3.18	7.64	9.12	6.58	46.49
White-tailed Deer	0	0	.212	2.12	2.97	3.18	6.79	2.97	3.18	1.06	.849	.849	24.20
Mule Deer	.424	0	.424	.424	1.91	3.39	2.12	1.06	.636	1.06	.636	.636	12.73
Moose	.212	0	0	0	0	.212	1.48	.636	0	.424	.424	1.06	4.458
Bighorn Sheep	0	0	.424	.424	.212	.424	0	1.27	.212	.849	.636	.636	5.095
Black Bear	0	0	0	0	.636	.212	.849	.636	0	0	0	0	2.335
Coyote	0	.212	0	.424	.212	.424	.636	1.06	.212	.849	.424	.212	4.670
All Species	2.33	.212	3.82	6.15	9.34	11.4	15.2	9.97	7.43	11.8	12.1	9.97	100

Table 13. Age-sex classification of Kootenay Parkway wildlife mortalities (1982-1987).

Species	Age/Sex Classification*							
	Ad F	Ad M	YOLY F	YOLY M	YOY F	YOY M	UNK YOY	UNK
Number of Animals								
ELK	71	24	4	3	14	7	5	18
MULE DEER	14	9	0	1	3	0	1	5
W.T. DEER	29	25	3	5	4	3	4	4
MOOSE	6	7	0	0	1	0	0	0
SHEEP	8	2	0	0	0	2	1	0
COYOTE	5	2	1	0	0	0	2	6
BLACK BEAR	3	3	0	0	0	1	0	3
TOTALS	136	72	8	9	22	13	13	36
Percent in Sex/Age Class								
ELK	48	16	2	2	9	4	3	12
MULE DEER	42	27	0	3	9	0	3	15
W.T. DEER	37	32	3	6	5	3	5	5
MOOSE	42	50	0	0	7	0	0	0
SHEEP	61	15	0	0	0	15	7	0
COYOTE	31	12	6	0	0	0	12	37
BLACK BEAR	30	30	0	0	0	10	0	30
TOTALS	44	23	2	2	7	4	4	11

*Ad F = Adult Female; Ad M = Adult Male; YOLY = Young of Last Year; YOY = Young of Year

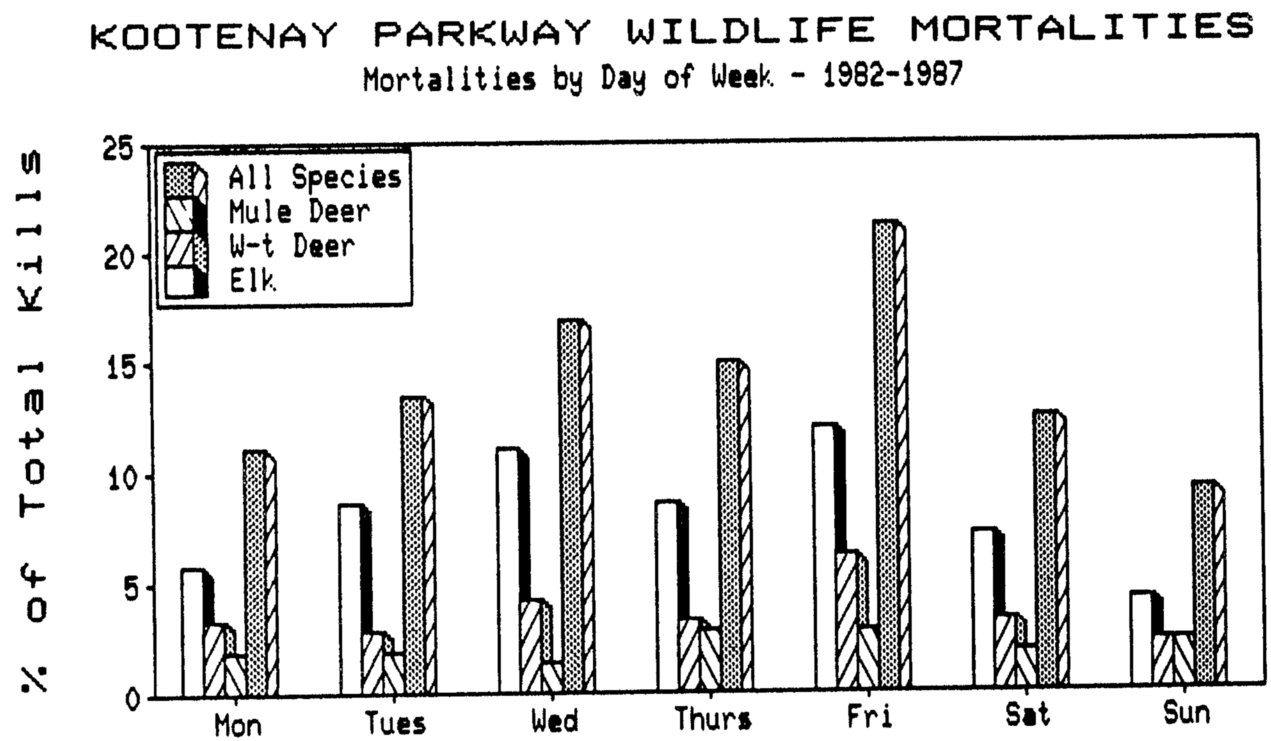

Figure 7. Kootenay Parkway Ungulate Mortality by Day of Week.

deer mortalities occurred on Wednesdays and Fridays (Figure 7). The weekly pattern of mule deer mortality was somewhat different with peaks occurring on Thursdays and Fridays (Figure 7). This variation in pattern is more likely a function of the small sample size for mule deer rather than a difference in mule deer use of the Parkway corridor. For all species combined, weekday mortality exceeded weekends, with the exception of Mondays.

For the majority of Kootenay Parkway wildlife mortalities, a specific time of death is not known. During 1987, however, a concerted effort was made to establish an accurate time of death. Of the 58 known wildlife mortalities on the Parkway during 1987, time of death, within a six hour block, was established in 43 cases. Figure 8 shows the distribution of kills in six hour blocks; 44.2% occurred between 0600 and 1200 hrs and 27.9% occurred between 1800 and 2400 hrs. In the midnight to noon period, 77% of accidents occurred between 0400 and 0900 hrs, while in the noon to midnight period, 73% occurred between 1800 and 2300 hrs.

Between 1982 and 1987 nearly twice as many females as males were killed on the Parkway. Of 260 known age/sex wildlife mortality records, 63.8% were females and 36.2% were males. Species specific sex and age classifications of highway-wildlife mortalities are shown in Table 13.

Ignoring age class and unclassified animals, the sex ratios of the major species involved in vehicle collisions for the period 1982 to 1987 were:

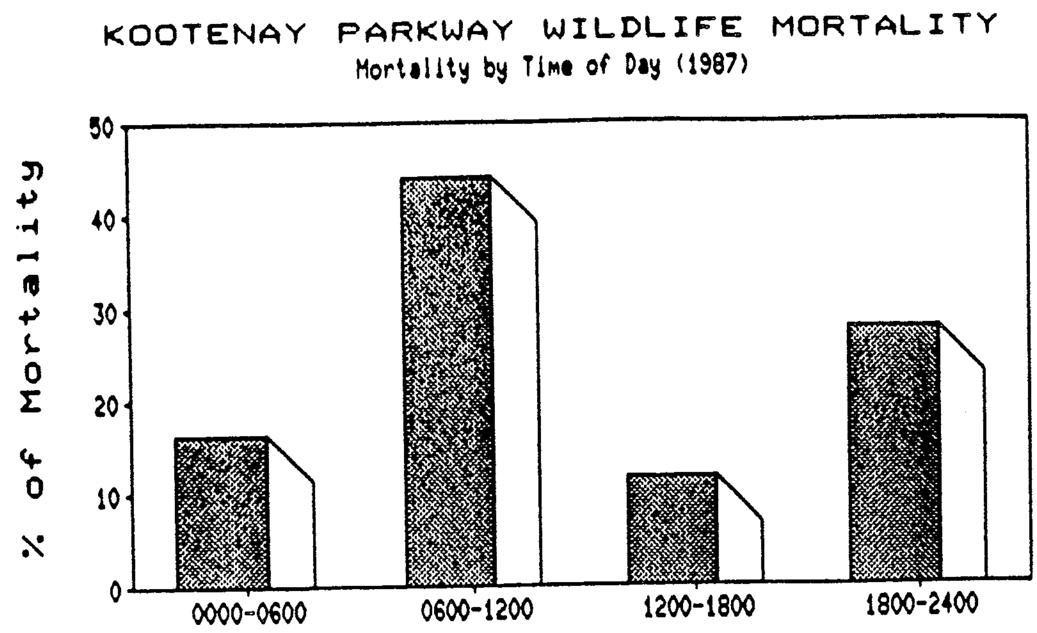

Figure 8. Kootenay Parkway Ungulate Mortality by Time of Day.

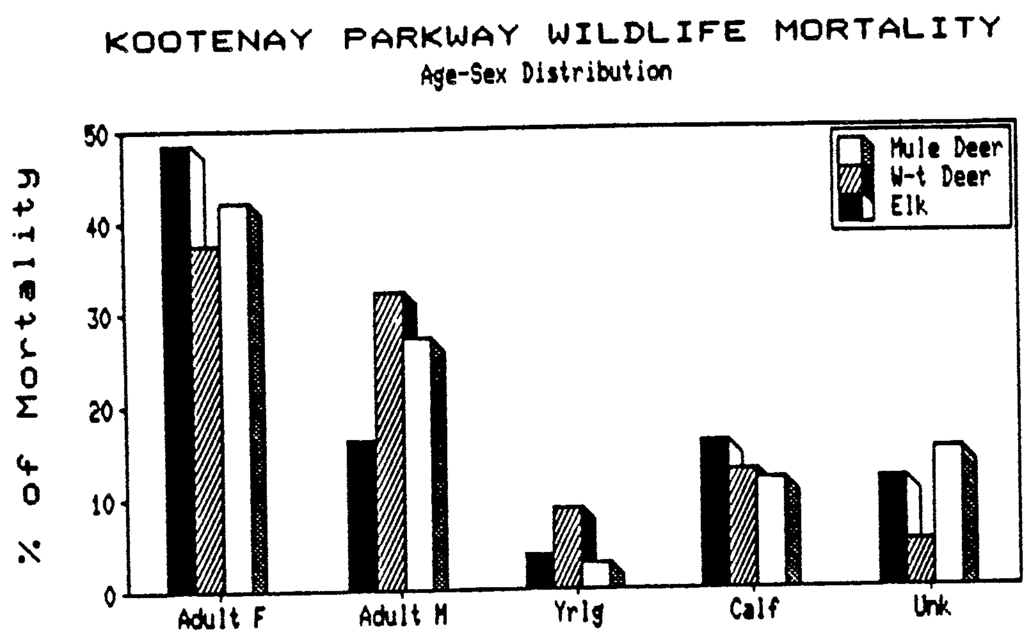

Figure 9. Age-Sex Distribution of Parkway Ungulate Mortality.

Elk and mule deer females were killed at nearly twice the frequency of males, while white-tailed deer mortalities showed an almost even sex ratio.

Age-specific sex ratios for elk, white-tailed and mule deer highway mortalities (Figure 9) show that, for all species combined, adult females average 42% of the total kill, adult males 25%, yearlings 5% (2% female, 3% male) and young-of-year 14%(10% female, 4% male). Elk mortalities had the highest representation of calves (18%), and adult females (49%) and the lowest representation of adult males (16%).

4.2.2 Vehicle Type

For more than 50% of Parkway-wildlife mortalities the type of vehicle involved is not known (Figure 10). Passenger vehicles which include cars, vans and half-ton trucks of less than 700 cm wheelbase, were involved in 32.3% of accidents while transports, including medium to large trucks, buses and motorhomes with a wheelbase length of greater than 700 cm, were involved in 17.2% of wildlife collisions.

Of the three ungulate species involved in over 80% of highway-wildlife collisions, elk had the highest percentage of known vehicle type (Figure 10). Of 143 collisions involving elk, between 1982 and 1987, 25.9% were with transport class vehicles, 37.7% were with passenger class vehicles and 36.4% were with unknown vehicles. By contrast, about 70% of collisions involving mule and white-tailed deer were with unknown vehicles. This suggests that vehicles hitting elk are more likely to either sustain sufficient damage to require reporting or be incapacitated and require towing.

The Radium RCMP (pers. comm.) indicated that more than 90% of the accidents involving wildlife reported to them are by

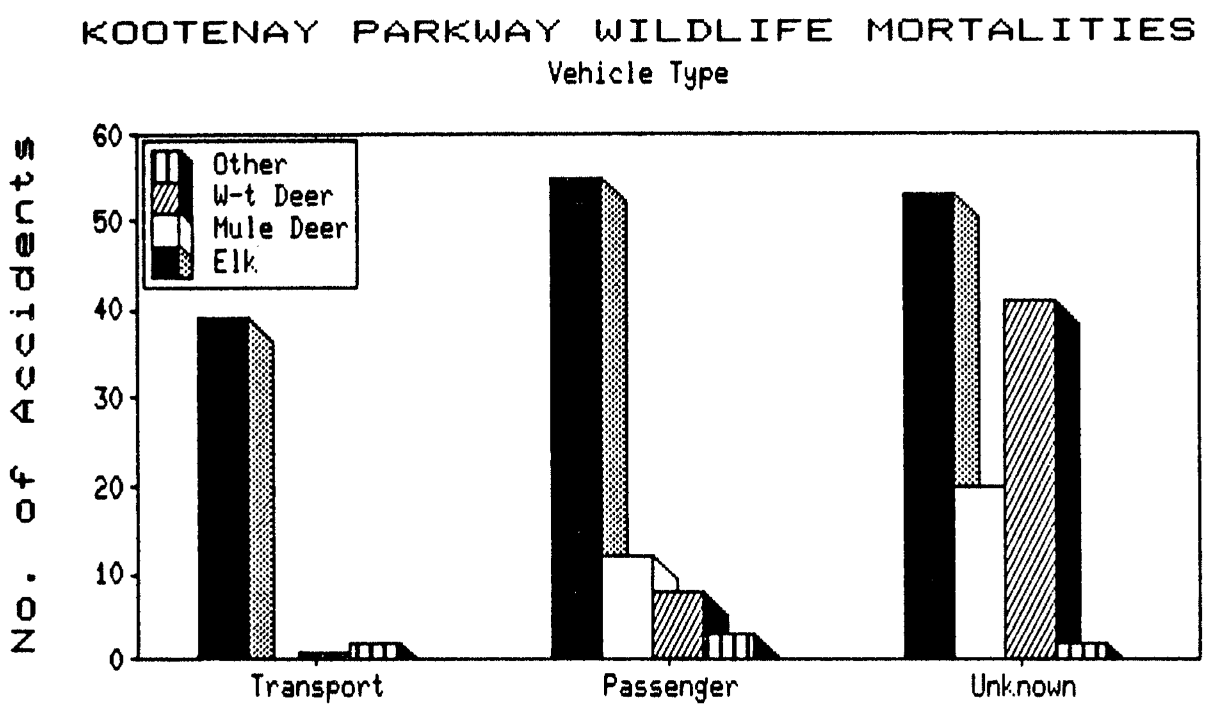

Figure 10. Kootenay Parkway Ungulate Mortality - Vehicle Type.

private, passenger vehicle owners. Very few wildlife related accidents are reported by commercial truckers unless the damage is significant.

4.2.3 Kill Site Assessment

In addition to the ten intensive study sites (5 kill and 5 control) habitat and highway characteristics were assessed at 24 known kill locations (18 deer, 4 elk and 2 moose). The analysis of habitat variables thought to influence mortality, is presented in Section 4.2. Analysis of highway characteristics at kill sites revealed that 65% of kill sites were on or within 100m of a curve; 42% were on or within 100m of a change in highway grade (hill); and 23% had guiderails within a portion of the 200m wide site. In comparison, 20% of control sites were on or near a curve; 40% were on or near a hill; and none had guiderails in a portion of the site.

The right-of-way at the majority of kill sites (71%) was comprised of some combination of "gully" and "level" topography. Only 29% of sites had some proportion defined as "bank". Seventy-one percent of sites had >50% level topography, while 58% had >50% of the area more than 1m below the traffic surface (gully). Only 8% of sites had >50% of the area more than 1m above the traffic surface (bank). All control sites had >50% level topography and 80% had >50% gully topography. No control sites had a portion of right-of-way classed as bank.

The proportion of forested to non-forested area adjacent to the right-of-way did not differ between kill-sites (89% forested) and controls (91% forested). The proximity to man-disturbed sites (i.e., borrow pits, man-made grassland or park facilities) did differ between kill and control sites: 79% of kill sites were within 100m of a man-disturbed area

(55% borrow pits, 21% man-made grassland, 17% park facilities); 24% of kill sites were within 100m of natural forest openings such as the river floodplain or a creek. Only 40% of control sites were near man-disturbed areas; 20% near borrow pits and 20% near man-made grassland.

Neither right-of-way width (mean = 62.2m) nor distance to nearest forest cover (mean = 28.4m) varied significantly among kill sites examined or between kill and control sites. Shortest visibility measurements averaged 256.4m at kill sites compared to 424.8m at the five control sites.

A multiple regression model (Stepwise Variable Selection, Statgraphics 2.1) was developed using nine of the 15 Parkway right-of-way variables, measured at the ten intensive study sites, thought to most influence the probability of Parkway wildlife kills. The nine variables (shortest visibility, banks, gullies, % forested, disturbed, facilities, guiderail, curve and hill), their coefficients and critical t-values are shown in Table 14. Four variables (shortest visibility, gullies, forested, and disturbed) had negative coefficients, decreasing the probability of a site being a kill site. Five variables (banks, facilities, guiderails, curve and hill) had positive coefficients increasing the likelihood of a site being a kill site.

Seven habitat and two ungulate use variables measured at intensive study sites (total vegetation cover, total grass, forb and shrub cover, litter, forage production, forage protein, elk and deer pellet groups/ha) were tested in a stepwise multiple regression model to determine their importance as predictors of highway kill sites. Each intensive study site (dependent variable) was identified as either a kill (1) or non-kill/control (0) site (see Section 3.0).

Table 14. Coefficients, standard error and significance levels(P=0.05, df=10) for the nine-variable model, Kootenay Parkway wildlife mortality, 1979 to 1987.

Variables	Coeff.	S.E.	t-value	sig. level
shortest visibility	-0.00173	0.000302	-5.737	0.0003
banks	0.00808	0.004149	1.948	0.0800
gullies	-0.0040	0.001358	-2.945	0.0147
forested	-0.04709	0.009002	-5.231	0.0004
disturbed	-0.00486	0.001258	-3.867	0.0031
facilities	0.00482	0.001188	4.059	0.0023
guiderail	0.02172	0.005039	4.311	0.0015
curve	0.00388	0.001463	2.653	0.0242
hill	0.01427	0.002122	6.725	0.0001
constant	2.29271	0.430371	5.327	0.0003

None of the nine variables tested had coefficients significantly different ($P<0.05$) from zero, suggesting that measured habitat quality and availability or ungulate use does not significantly influence the probability of a given location being a kill site. As reported previously, high correlations between the coefficients for elk and deer use variables and certain habitat variables were observed. Removal of the elk and deer use variables, however, resulted in a poorer model.

The analysis of variance for the full regressions (nine variable and seven variable models) are given in Table 15. The ratio of the mean square due to regression to the deviations mean square (F-ratio) for both models resulted in non-significant F values ($p<0.05$; 2 and 17 d.f.). The null hypothesis is, therefore, not rejected; the habitat and ungulate use variables are not reliable predictors of highway kill sites.

Table 15. Analysis of variance for the full regression of the nine and seven variable ungulate habitat/use models, Kootenay Parkway Wildlife Mortality Study, 1987.

	Sum of Squares	D.F.	Mean Square	F-ratio	P-value
Nine Variable Model					
Regression	1.3913	4	0.3478	1.4458	0.2675
Error	3.6087	15	0.2406		
R-squared = 0.278					
Standard Error = 0.4905					
Seven Variable Model					
Regression	0.7475	2	0.3738	1.4942	0.2525
Error	4.2525	17	0.2501		
R-squared = 0.1495					
Standard Error = 0.5001					

4.3 Parkway Traffic Analysis

The pattern of daily traffic volume along the Kootenay Parkway during 1987, as measured at the Great Divide, is shown in Figure 11 (Brunell 1988). Throughout the year, traffic volume averaged 1643 vehicles per day (A.A.D.T.); 10% higher than the 1982-1984 average of 1488 vehicles per day. Summer Average Daily Traffic (S.A.D.T.) during 1987 was 3333, an increase of 3% over the 1981-84 average. Winter Average Daily Traffic (W.A.D.T.) during 1987 (905 vehicles per day) was 20% higher than the 1981-1984 average of 752 vehicles per day. Peak traffic volumes corresponded to weekends, statutory holidays and the July - August period (Brunell 1985).

On a weekly basis during summer, traffic volume exceeded S.A.D.T. on Fridays, Sundays and holidays (Figure 11). Volumes equaled S.A.D.T. on Mondays and Saturdays and were average from Tuesday to Thursday. Hourly volumes over the summer months peaked between 1100 hrs. and 1700 hrs. daily (Figure 12). Minimum volumes occurred between 2300 hrs. and 0700 hrs.

In 1986 a classifying counter was installed on the Parkway, north of the Settler's Road junction (Doug Chambers, WRO pers. comm.). Samples of two-way classified traffic data for 1987 were selected corresponding to periods of high wildlife mortality: July 6 to August 2, 1987 and November 16 to December 6, 1987.

Vehicles were grouped into four classes based on wheelbase length; 0 - 500 cm (passenger vehicles), 500 - 700 cm (light trucks and vans), 700 - 1300 cm (medium sized trucks, cars with trailers, campers, motorhomes), and 1300 - 3500 cm (semi-trailer trucks, buses). Hourly traffic volumes, for each vehicle class, were summed for four time blocks: midnight - 0600 hrs, 0700 - 1200 hrs, 1300 - 1800 hrs, and 1900 - 2400 hrs..

During July 1987 the distribution of traffic volume within each time block by day of the week at Settler's Road (Figure 14) was similar to the pattern shown in Figure 12, measured at the Great Divide. For all days, total traffic volume was greatest during the 1300-1800 hrs. period, while minimum volumes occurred from midnight to 0600 hrs. for all days. With the exception of Fridays, volumes during the 0700-1200 hrs. period were higher than evening volumes (1900-2400 hrs.).

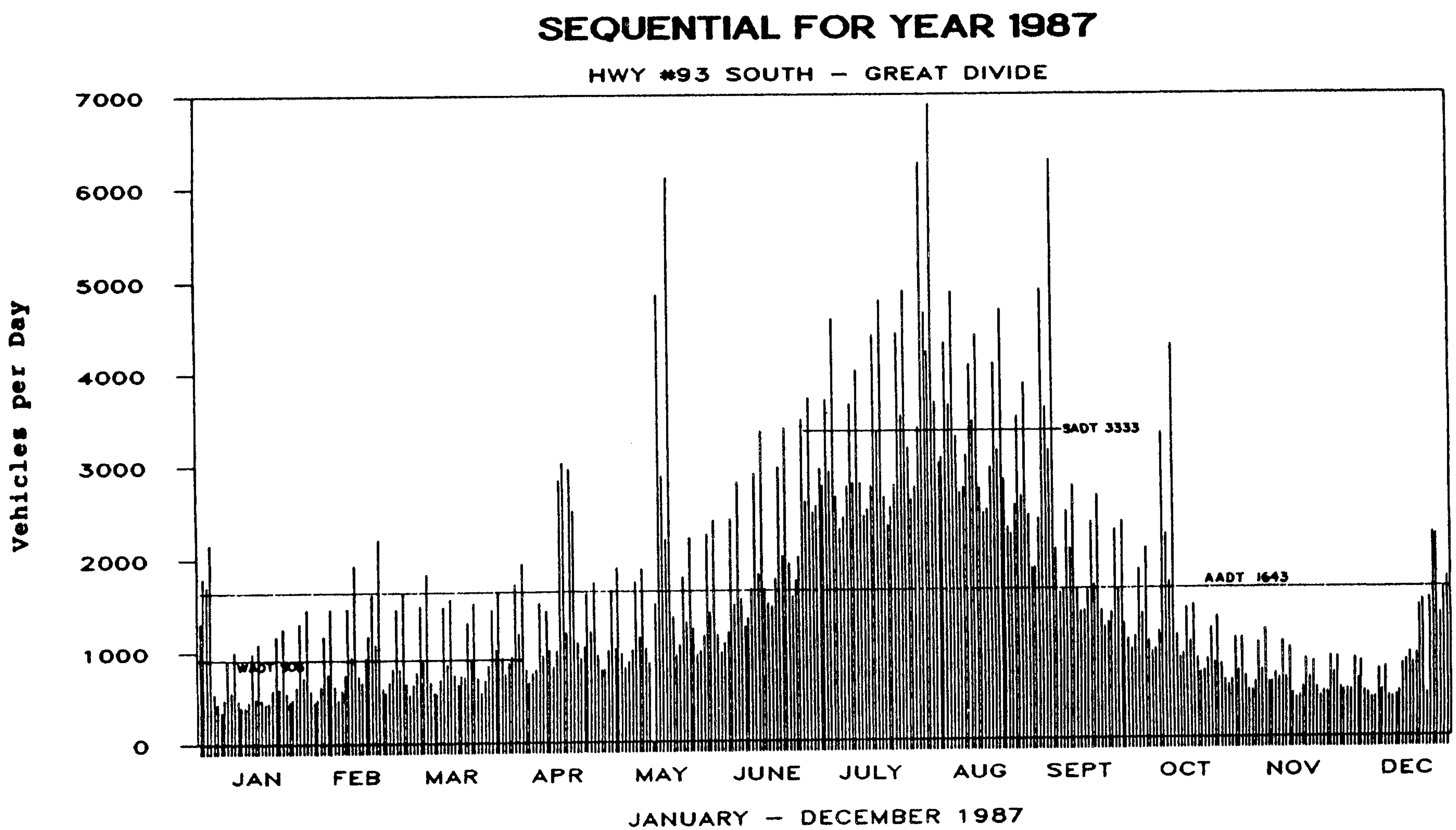

Figure 11. Sequential Traffic Volume, Kootenay Parkway at Great Divide, 1987 (from Brunell, 1988).

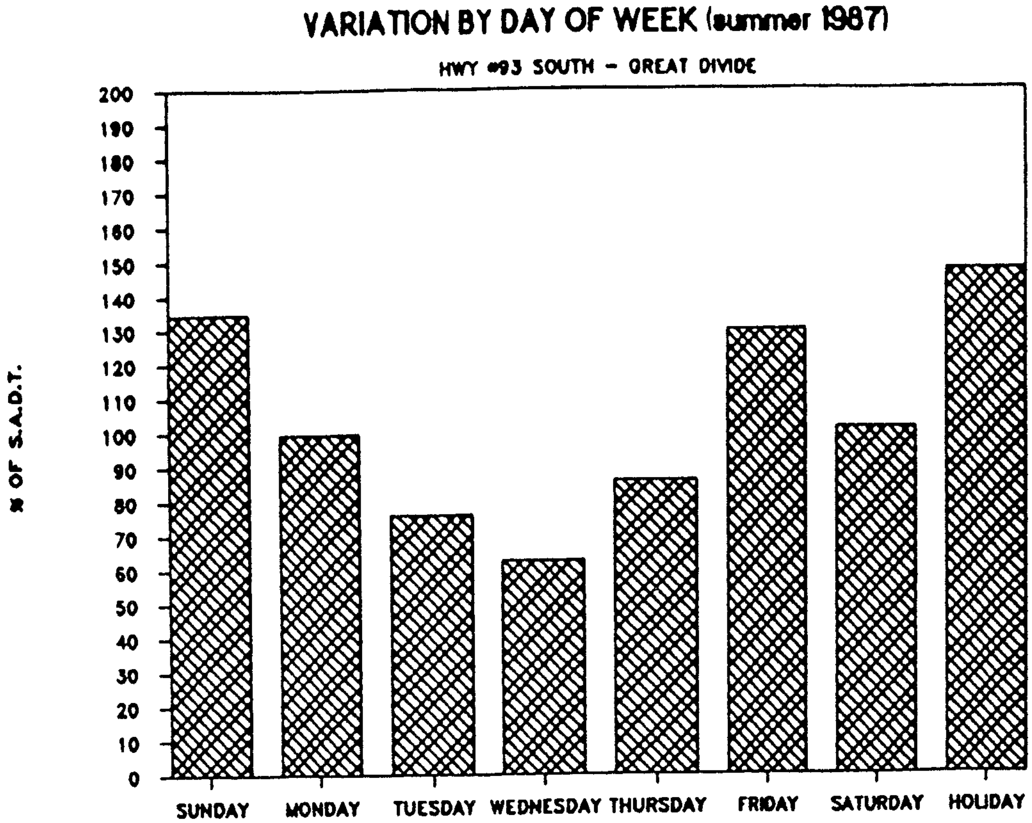

Figure 12. Kootenay Parkway Traffic Volume Variation by Day of Week, Great Divide, 1987 (from Brunell, 1988).

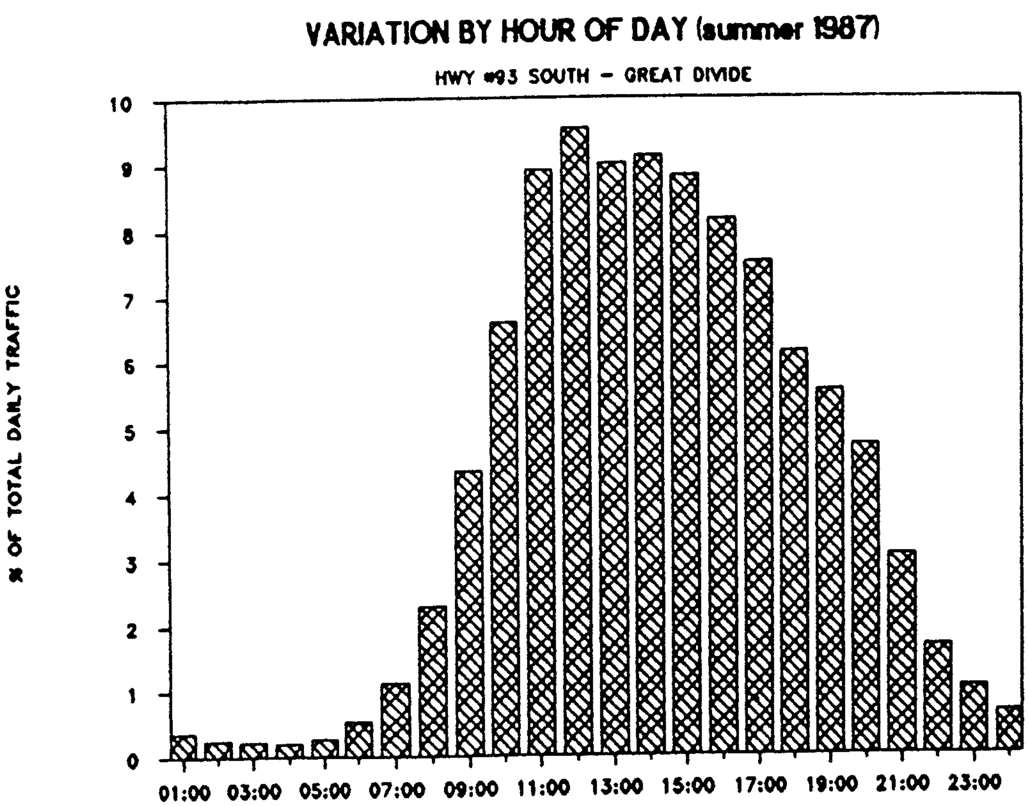

Figure 13. Kootenay Parkway Traffic Volume Variation by Hour of the Day, Great Divide, 1987 (from Brunell, 1988).

Evening volumes averaged about 16% of total volume for all days except Friday when the evening volume increased to approximately 30% of total volume.

The passenger vehicle component (0 - 500 cm wheelbase) of Parkway traffic during July 1987 peaked on Friday, Saturday and Sunday. (Figure 15). During weekdays, the proportion of passenger vehicles in the traffic mix averaged 52.8% with the lowest proportion (41%) occurring in the midnight-0600 time period. On weekends, however, the proportion of passenger vehicles was greatest during the midnight-0600 hrs. time period (67.8%). By contrast, the proportion of large trucks (1300-3500 cm wheelbase) in the July traffic mix was highest during mid-week in the midnight-0600 hrs period (Figure 16). Large trucks averaged 167 per day on weekdays and 66 per day on weekends during July.

Parkway traffic volume distribution during November - December 1987, was almost identical to that of July (Figure 17), however, the total volume was reduced by approximately 70%. The proportion of large trucks in the traffic mix increased relative to the passenger vehicles (Figures 18 and 19): large trucks averaged 6.5% of the Parkway traffic volume on weekdays (Monday to Thursday) during July, and 25.8% of the total weekday traffic in November-December. Over all days, trucks averaged 5% of the total traffic volume in July and 13% in November-December. The number of large trucks per day averaged 126 on weekdays and 53 on weekends during November-December 1987.

On an hourly basis, large trucks averaged 48% of total traffic in the midnight-0600 hrs. block on weekdays in November and 61.9% and 35.5%, respectively, on Fridays and Saturdays. For the equivalent period in July, large trucks averaged 37.1% on weekdays and 23.0 and 2.1%, respectively, on Fridays and Saturdays. The proportion of large trucks in the traffic mix also increased in the 0600-1200 hrs. time period from July to November-December; the July weekday mean was 6.7% while the November mean was 34.3%.

The remaining two vehicle size classes (500-700 cm and 700-1300 cm wheelbase length), representing half-ton trucks, vans and recreational vehicles, averaged 20.6% and 10.5%, respectively, of the traffic volume during July. The proportion of both classes decreased in the traffic mix in November-December to 14.1% and 4.2%, respectively.

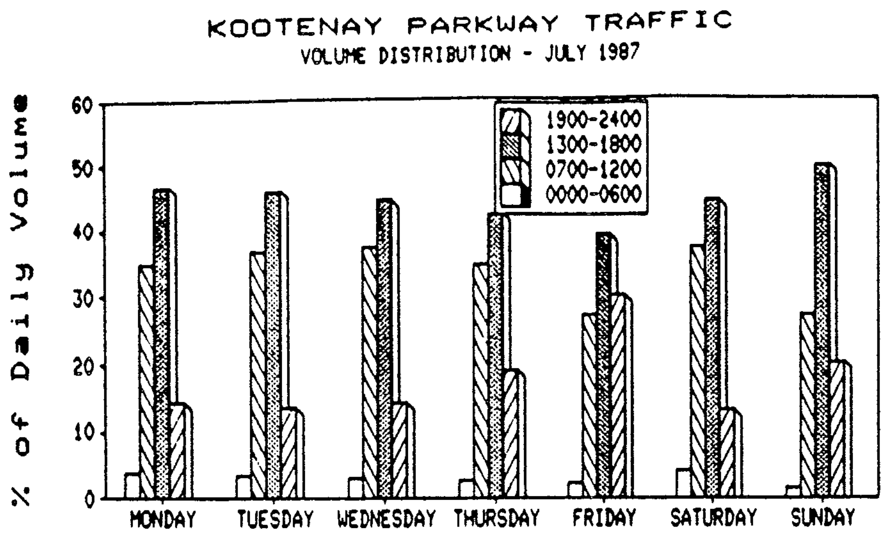

Figure 14. Kootenay Parkway Traffic, North of Settler's Road, July 1987 - All Traffic.

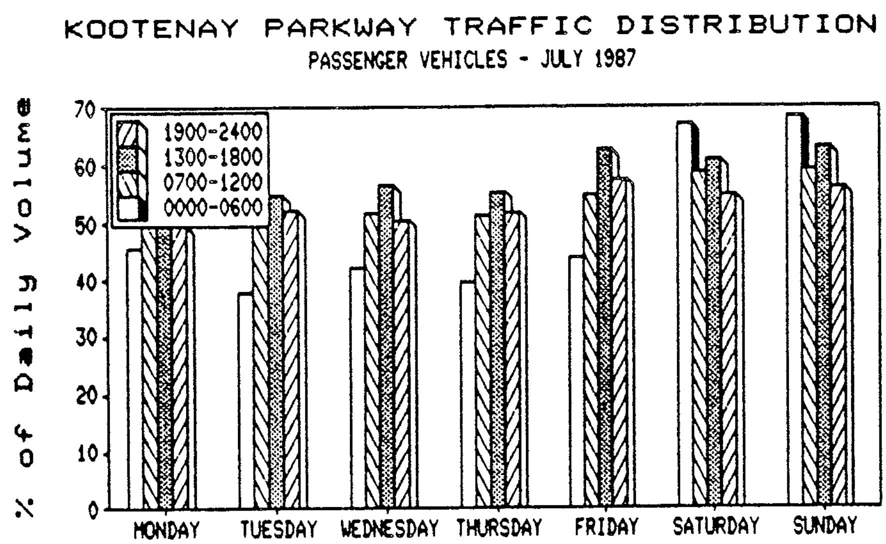

Figure 15. Kootenay Parkway Traffic, North of Settler's Road, July 1987 - Passenger Vehicles.

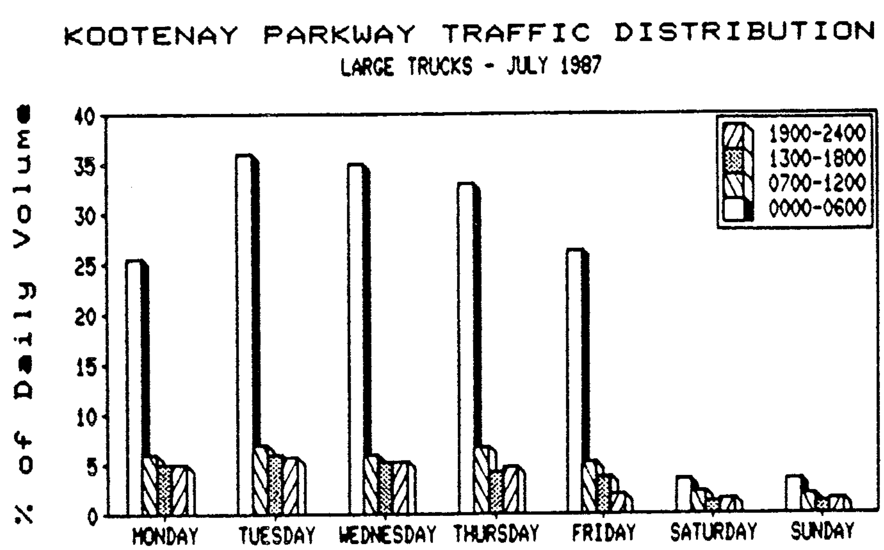

Figure 16. Kootenay Parkway Traffic, North of Settler's Road, July 1987 - Large Trucks.

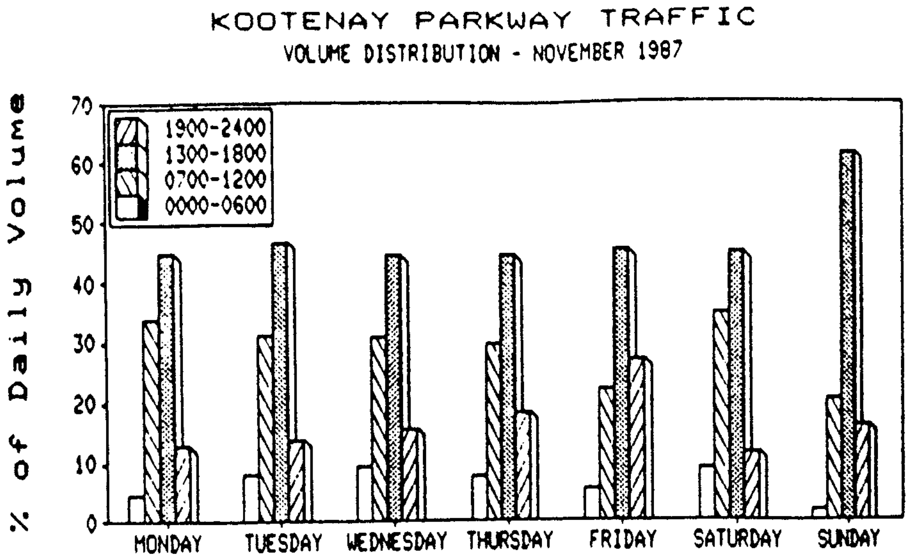

Figure 17. Kootenay Parkway Traffic, North of Settler's Road, November 1987 - All Traffic.

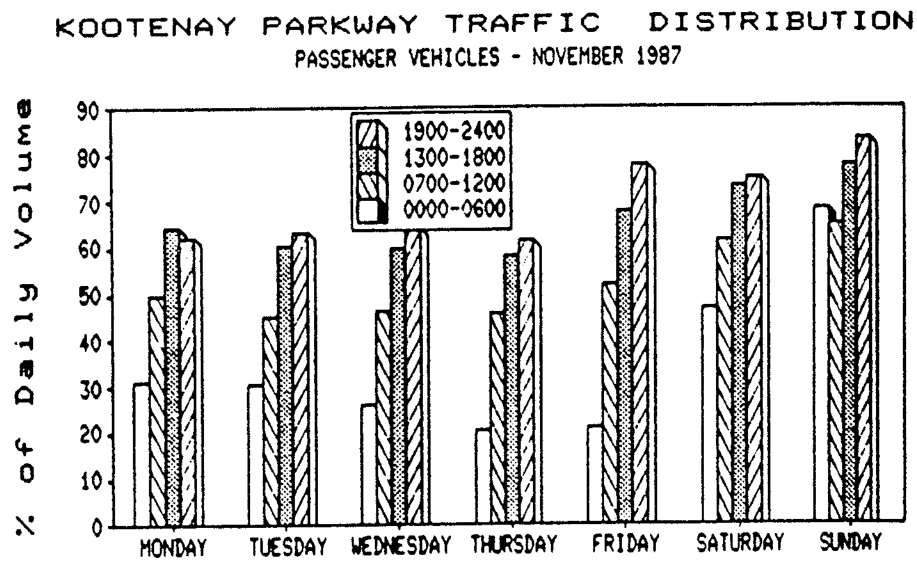

Figure 18. Kootenay Parkway Traffic, North of Settler's Road, November 1987 - Passenger Vehicles.

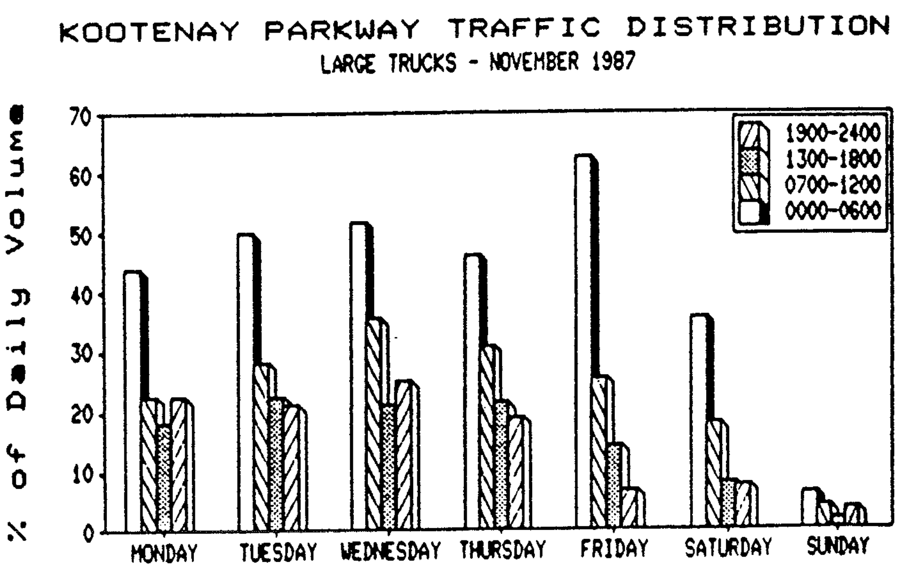

Figure 19. Kootenay Parkway Traffic, North of Settler's Road, November 1987 - Large Trucks.

5.0 DISCUSSION

5.1 Impact of Highway Mortality on Kootenay Wildlife

Although more than 80% of the annual kill on the Kootenay Parkway involves only three species - elk, white-tailed deer and mule deer, most of the park's large mammals are affected by collisions with motor vehicles. Four other large mammals (moose, bighorn sheep, black bears and coyotes) routinely form the remaining 20% of the annual kill. Mean kill-rates of these species, however, represents less than three animals per year per species.

The ten year mean kill-rate of 2.4 bighorn sheep per year represents less than 3% of the population based on 1987 census figures which place the Radium bighorn band at 80-100 animals (Kootenay Warden Service records). Even though sheep frequent the Parkway corridor and traffic surface in the Sinclair Canyon area (Poll et al 1984, Stelfox et al 1985), the incidence of highway mortality is low. This apparent anomaly, of high use and low kill-rate, is thought to be a function of:

1. Use of the area by sheep, including foraging on the roadside and licking of the traffic surface, occurs almost exclusively during daylight hours, when visibility is at its maximum;

2. The heaviest use of the Canyon area and Parkway corridor by sheep occurs in spring, fall and winter; a time of reduced visitor use and traffic volumes; and

3. The steep grade and curves associated with the Parkway through the Canyon serve to significantly reduce traffic speed, improving the ability of motorists and sheep to avoid collisions.

Recruitment in the Radium band (lambs surviving to one year of age) has been in the range of 30 to 40% annually for the past seven years (Stelfox et al 1985, Kootenay Warden Service records) exceeding the approximately 20% required for population maintenance. The mortality from vehicle collisions is, therefore, not considered a significant impact at this time.

The moose-vehicle accident rate averaged 2.1 animals/year over the past 10 years. Since 1985, however, the rate has increased to 3.7 moose/year. Poll et al (1984) indicated that, although once abundant in the park, moose numbers have declined since the 1940's in response to shrinking habitat caused by progressive forest succession. The authors estimated that there were probably fewer than 75 moose in the park in 1983.

Although there is little empirical data upon which to base a moose population estimate, the species is not abundant, particularly along the Parkway corridor. The majority of moose observations in the corridor are associated with mineral licks north of the Settler's Road junction in the lower Kootenay Valley and near Simpson's Monument in the lower Vermilion Valley. Interestingly, highway mortalities of moose have not been associated with the use of these licks, perhaps because there is no suitable habitat opposite them to attract moose across the Parkway.

The majority of vehicle-moose accidents over the past 10 years, have occurred in the Vermilion Valley; the Continental Divide - Stanley Glacier, Numa - Floe creeks and Vermilion Crossing areas being important kill locations. These areas are all associated with highly important ecosites for moose such as AL3, BV2, HC1 and CA2 (Poll et al 1984). Moose activity along the Parkway in the Kootenay Valley is relatively low with the exception of the lick area mentioned above. Pellet group counts conducted at intensive study areas during 1987 recorded only two moose pellet groups in 8000 m^2 of transects.

Based on a population estimate of 75 moose, the mean annual highway kill-rate of 2.1 animals (1978-1987) represents approximately 3% of the population. The increased mortality since 1985, however, represents almost 5% of the population. This may represent a significant mortality factor, however, not enough is known of moose population dynamics or habitat conditions within the park to accurately assess the impact.

Black bears appear to be attracted to the Parkway right-of-way during the spring and early summer (May-June) in search of green vegetation. Raine and Kansas (1987) indicated that dandelions, grasses and horsetails made up 87.3% by volume of the May-June diet of black bears in Banff National Park. The Kootenay Parkway right-of-way provides an early, abundant supply of these forages. Although this attraction creates management concerns from both a visitor and bear population perspective, the current rate of bear-vehicle accidents on the Parkway (1.1 bears/yr) is not a major problem.

While virtually nothing is known of coyote population dynamics within the park, they do frequent the Parkway corridor seasonally in response to food availability; Columbian ground-squirrels and meadow voles in summer and ungulates, as carrion and prey, during fall and winter (Poll et al 1984). The 10 year (1978-1987) mean kill-rate of coyotes on the Parkway was 2.2 animals/year. This is probably not significant, however little empirical population data is available on which to base a quantitative evaluation of the impact. The higher mean kill-rate of coyotes since 1983 (3.2/year) compared to the previous five year period (1.2/year) suggests that this species may be increasing in the park.

Of the three ungulate species (elk, white-tailed deer and mule deer) accounting for over 80% of the annual Parkway wildlife mortality, mule and white-tailed deer population dynamics are least well understood. Deer population sizes within the park are not known, however trends in relative abundance from roadside surveys and highway mortality records over the past 10 years suggest that mule deer numbers in the Kootenay Valley are relatively stable, but low compared to white-tailed deer.

The trend in the white-tailed deer population appears to be upward. The number of white-tailed deer killed annually on the Parkway has increased by a factor of five since 1983 as have the numbers of animals observed during roadside surveys. Indications are that this species is expanding rapidly in the park despite the increasing Parkway kill-rate. While this increasing accident rate represents a public safety concern, not enough is known about either deer population to adequately assess the impact to these species.

Elk, which have accounted for almost 50% of the total Parkway-related wildlife mortality over the past 10 years, are the species most vulnerable to vehicle collisions and the most impacted as a population. The reasons for this vulnerability relate to the elk's innate foraging and migratory habits, as well as the physical alignment, design and use of the Parkway. The Parkway corridor not only bisects the traditional elk winter range in the Kootenay Valley, but crosses seasonal migratory routes between this range and higher elevation summer ranges. The wide, grassy right-of-way provides high quality and quantity forage which is declining in availability elsewhere on the winter range.

Seasonal elk diet composition analysis shows that grasses, predominantly red fescue and <u>Poa</u> sp., comprise over 80% of the the fall diet. These species are more abundant on the Parkway right-of-way than anywhere in the park. The number of elk wintering in the Kootenay Valley has declined since 1979, based on annual roadside surveys. Composition counts over this period show a declining trend in productivity. Fall calf:cow ratios between 1979 and 1982 averaged 33.7 calves/100 cows while ratios from 1983 to 1987 averaged 25.3 calves/100 cows. By comparison, calf:cow ratios in the Bow Valley of Banff National Park for October-November 1985 and 1986 were 57 and 43 calves/100 cows, respectively (Woods 1987).

From studies of 37 telemetred elk in the Bow Valley during 1986, Woods (1987) calculated an annual mortality rate for elk (from all causes) of 18%. Annual productivity, therefore, must exceed 18% for population maintenance. Other studies have shown that annual production values ranging from 15 to 20% are necessary for maintenance of elk populations (Murie 1951, Flook 1970, Kimball and Wolf 1974). Calculations of productivity in the Kootenay elk population, expressed as the ratio of the number of calves in the fall to the number of animals > 1yr. of age, show that in 1985 production was 25% while in 1987 it was only 14%. It is apparent that recruitment in the Kootenay elk population is currently at or below maintenance requirements and the population trend is downward. Current levels of Parkway mortality are contributing to this trend and any additional mortality will have serious implications for the continued survival of this population within the park.

5.2 Factors Influencing Parkway Ungulate Mortality

5.2.1 Ungulate Activity

It has been widely established that ungulate-vehicle collisions are not random, but rather show predictable patterns in time and space (Bellis and Graves 1971, Ward *et al* 1980, Damas and Smith 1982, Bashore *et al* 1985). Seasonal peaks in mortality are related to seasonal migratory (Flygare 1979, Ward *et al* 1980), foraging (Puglisi *et al* 1974) and rutting behaviours (Puglisi et al 1974). The diurnal pattern of mortality peaks in the dust/dawn periods relates to daily selection of vegetation types by ungulates as a function of seasonal foraging and thermo-regulatory requirements as well as insect and/or human disturbance avoidance (Morgantini 1979) Morgantini suggested that avoidance of human activities may be the most important factor in determining the use of cover by hunted elk populations. He also indicated that proximity to roads influenced the daily use pattern of open grassland habitat by elk. Where near a road, elk activity in open habitats was restricted to the period between evening and early morning. This daily pattern of use of open grassland was not observed on an adjacent area not influenced by a road. Ward et al (1980) reported that elk preferred to stay a minimum of 400m from heavy traffic, particularly during the daylight hours while mule deer were less sensitive preferring to be a minimum of 91m from heavy traffic.

Similar patterns of daily activity were observed for elk and deer along the Kootenay Parkway. Elk and deer were seldom observed on the right-of-way during daylight hours. Heaviest use of the open right-of-way occurred in the evening and early morning. Elk were observed, however, using open habitats away from the corridor during daylight hours. The heavier day time traffic volume may have a deterrent effect, however, elk seem little affected by moving traffic after sunset.

Most studies of ungulate-vehicle collisions agree that kills are aggregated. Puglisi (1974) reported that 28.3% of the deer accident locations along a Pennsylvania interstate accounted for 57.2% of all the accidents. In Banff National Park, between 1966 and 1987, 64% of the elk-vehicle accidents occurred within 33% of the Trans-Canada Highway length through the park (R. Kunelius, pers. comm.). Bashore et al (1985) found that, although deer kill sites tended to be aggregated, sites within wooded areas were longer than in non-wooded areas and in many wooded areas no distinct concentrations could be discerned.

In Kootenay, 62.6% of the accidents with elk have occurred in 38.3% of the Parkway length, while 80.6% of the white-tailed deer accidents have occurred in 28.7% of the Parkway length. Within these high kill zones, specific locations of deer kills tend to be less distinct than those for elk.

5.2.2 Parkway Characteristics

Analysis of ungulate kill and non-kill (control) sites along the Parkway indicates that physical characteristics of the Parkway and corridor are better predictors of kill sites than are habitat and ungulate use characteristics. No significant relationships were observed in multiple regression models developed to test the influence of ungulate habitat and use variables on the probability of a site being a highway kill-site. This suggests that habitat and ungulate use is relatively uniform throughout the study area and kill-sites are determined by physical characteristics of the Parkway itself. Correlation analysis of habitat and use variables from all sites combined did show that elk choose right-of-way areas with the highest total cover of grasses and the highest overall productivity, whereas deer tend to choose sites with the highest cover of forbs.

The findings of the Parkway characteristics model indicate that the probability of ungulate-vehicle collisions increases where: 1) visibility is reduced through either right-of-way or roadway design features; 2) the proportion of forested area adjacent the right-of-way is reduced; and 3) disturbed areas (borrow pits, man-made grasslands) are within 100m or less.

These findings are consistent with those of Bashore et al (1985) who studied deer-kill sites along two-lane highways in Pennsylvania. They found that variables such as density of residences and commercial buildings, posted speed limit, distance to woodland and highway fencing, factors not applicable to Kootenay, influenced the probability of areas being deer-kill sites. However, they did find a similar negative relationship between shortest visibility and kill-site probability as in this study and suggested that drivers will avoid hitting deer if they are seen in advance. In addition, they found that as adjacent habitat became less wooded, the probability of a site being a kill-site increased. They concluded that drivers should be most cautious when approaching a woodland-field interface near the highway as deer tend to forage in these locations.

This conclusion is supported by the present study findings in the relationship of the forested and disturbed variables to Parkway kill-site probability. The disturbed variable included man-made forest openings produced by borrow pits and clearings for former facilities. The proximity of these artificial openings positively influenced kill-site location in the model and is supported by field observations that deer and elk utilize these openings for foraging and resting. The influence of these features on kill-site location is particularly acute at locations such as McLeod Meadows, Crook's Meadow-Dolly Varden, Kootenay Crossing, Vermilion Crossing and the Hawk-Floe creeks area, where disturbed sites occur on opposite sides of the Parkway. Ungulate movements between these sites increases the frequency of Parkway crossings.

Bashore et al (1985) measured an additional variable called in-line visibility; the distance at which an observer 1m from the highway centre line could no longer see a 2m-high optical density board placed at the pavement edge. This variable, unlike shortest visibility, was positively related to kill-site probability as well as to speed limit. The authors suggested that when drivers can see a considerable distance along the highway, they tend to travel at higher speed and may strike a deer crossing from a blind spot. This finding may hold true for a number of kill-site locations on the Parkway which occur on long, straight stretches with seemingly good visibility (e.g., McLeod Meadows and north of Dolly Varden picnic site).

The negative relationship of roadside facilities to kill-site location is supported by the findings of Bashore et al (1985) who found that increasing density of residences and commercial buildings decreased the kill-site probability because of habitat loss and increased human disturbance. This relationship along the Kootenay Parkway is surprising, however, as the level of development and human activity is low compared to the Pennsylvania situation and several key ungulate kill-sites are associated with roadside facilities (McLeod Meadows, Dolly Varden, Kootenay and Vermilion Crossing). The finding from analysis of 24 additional Parkway kill-sites that 54% were within 100m of a roadside facility further clouds the relationship and suggests that facilities have a positive influence on kill-site location. Further testing of this relationship is required before conclusions can be drawn regarding the actual influence of roadside facilities on kill-site location.

5.2.3 Traffic Volume and Composition

The relationship of ungulate-vehicle accidents and traffic volume is not straightforward. On an annual basis, the period of highest total wildlife kill on the Parkway corresponded to the period of highest total traffic volume. On a species specific and seasonal basis,however, periods of highest mortality occurred when individual species made greatest use of the right-of-way, irrespective of traffic volume. In fact, on a daily basis, highest mortality occurred during early morning and evening when ungulates were most active on the right-of-way, but traffic volumes were lowest. This relationship holds for all days of the week except Fridays, where a higher than average evening traffic volume, composed primarily of passenger vehicles, corresponded to the highest weekly ungulate kill. This suggests that there is a direct relationship between ungulate kill-rate and traffic volume, but only during periods of high ungulate use of the right-of-way. Increases if traffic volume, therefore, may only result in increases in ungulate mortality when they occur during periods of high ungulate activity, i.e., early morning and evening.

As with traffic volume, the composition of Parkway traffic also varied on a daily, weekly and seasonal basis. The proportion of large trucks in the traffic mix was greatest during weekdays in the early morning, corresponding to the period of highest ungulate mortality with the exception of Friday evenings as noted above. This configuration was more pronounced in November-December than in July as passenger and recreational vehicle traffic decreases dramatically after September. This observation as well as the low incidence of accident reports compared to known ungulate kills suggests that large trucks may be a significant factor in the Parkway ungulate kill.

5.2.4 Parkway Maintenance

In the course of this investigation it became apparent that several highway maintenance practices in Kootenay have an influence on ungulate-highway mortality. These observations are not, however unique to Kootenay, having been reported in other studies and reviews of ungulate-vehicle accidents (Flygare 1979, Damas and Smith 1982, Fraser and Thomas 1982). One of the most significant of these factors is the relationship of deicing salts (predominantly sodium chloride) and ungulate-highway mortality. The attraction of ungulates to natural and artificial sources of sodium has been extensively reviewed by Weeks (1978), Damas and Smith (1982) and Fraser and Thomas (1982) who conclude that sodium (Na) is a major constituent of most mineral licks and is the principal attractant for ungulates. Damas and Smith state that "....most research supports the view of Weeks (1978) that Na is the universal attractant in the general use of mineral licks by herbivores". Analysis of lick and control samples from Kootenay showed Na to be present, in various concentrations, in all samples (Sheehan 1987). In all cases, however, Na levels were higher in samples from licks than in non-lick controls. Sodium was the only element found to be consistently higher in licks compared to controls.

Fraser and Thomas (1982) reported a positive relationship between moose-vehicle accidents and the proximity to heavily used salt water pools adjacent Ontario highways. No such relationship to licks was apparent for ungulate-vehicle accidents along the Kootenay Parkway. The observed attraction of ungulates to deicing salts in Kootenay relates to its direct application to the Parkway surface rather than to the use of roadside mineral licks. Although no quantitative data is available, numerous observations (Warden Wildlife Records) have been made of ungulates (bighorn sheep and elk) licking the traffic surface following application of deicing materials (mixtures of NaCl and abrasives or NaCl and CaCl) to the Parkway.

The writer directly observed the attraction of elk to deicing salt (NaCl) applied to the Parkway on November 17, 1988. Large numbers of elk (120+) were observed on the right-of-way and traffic surface, many licking the pavement, within hours of the application of a NaCl-abrasive mixture in the McLeod Meadows area. This concentration of elk, lasting for three or four days, contributed directly to three elk-vehicle accidents.

Not only wildlife-vehicle accidents have been attributed to the use of NaCl as a deicing agent. Other environmental costs include corrosion of vehicles, damage to highway structures and roadside vegetation, and contamination of water supplies (Fraser and Thomas, 1982, Banks 1988). Reviews of alternate deicing compounds point to calcium chloride (CaCl) as a viable alternative, having fewer environmental implications and less attractiveness for ungulates (Damas and Smith 1982, Fraser and Thomas 1982). It also has a broader range of operating temperatures than does NaCl. Calcium chloride is, however, three to six times more expensive than NaCl and has the same corrosive properties. Fraser and Thomas (1982) suggested that the higher cost of CaCl might be offset by more efficient use and lower application rates. It has also been suggested that the cost of using conventional road salt (NaCl) is much higher than simply the cost of purchasing and application because of the cost of damage to structures, vehicles, roadside vegetation and ground water supplies (Banks 1988).

The most recent alternatives to NaCl as a deicing agent include chemicals such as sodium formate and calcium magnesium acetate (CMA) (Banks 1988). Neither compound contains chloride, which promotes corrosion and CMA does not contain sodium which eliminates the salinity threat to roadside soil, vegetation and water. The major disadvantage of these alternatives is their cost; 20 to 30 times more than sodium chloride.

While the search continues for an environmentally and structurally safe as well as cost effective alternative to

NaCl as a deicing agent, the mass of evidence against NaCl is such that its use, especially in a national park, should be discontinued. If our "bare pavement" policy is to be maintained, then the most viable alternative to NaCl, from an environmental and economic viewpoint, is still CaCl.

Two other maintenance practices routinely applied to the Kootenay Parkway, "winging-back" of snowbanks at the roadside in late winter-early spring and mowing of Parkway edges in late summer, have implications for ungulate-vehicle collisions. The practice of ploughing back the snowbanks at the Parkway margin encourages meltwater to run into the ditches rather than onto the road surface and also improves sight distances for drivers. This practice, however, exposes up to a 1m wide strip of vegetation adjacent to the traffic surface, which greens-up more rapidly than the surrounding, snow-covered vegetation. This early source of green vegetation is highly attractive to elk, and places them in a high risk situation for collisions with vehicles. Refraining from ploughing the road edges, especially in the Kootenay and lower Vermilion valleys is the best solution to the problem. If, however, Parkway safety and maintenance concerns require its continuation, then it is suggested that a layer (15-20cm thick) of snow be left covering the roadside vegetation so that green-up is delayed to more closely coincide with the remainder of the corridor.

Mowing of the roadside, which is aimed at improving sight distance and reducing snow accumulation, produces a similar response in the vegetation as does early snow removal, by stimulating growth. Actively growing vegetation is higher in protein and other nutrients and more palatable to ungulates, therefore, at a time when the right-of-way vegetation has set seed and begun to cure, mowing promotes growth and attracts ungulates to a high risk area. If mowing is essential it should be done as late as possible in the season so that new growth is discouraged and be restricted to as narrow a band as possible, preferably to only the tall forbs which tend to grow at the pavement-gravel interface.

5.3 Mitigation Options

The selection of options for a mitigation strategy for the Kootenay Parkway must consider not only the factors which influence the timing, location and frequency of accidents but also the potential ecological, aesthetic, public safety and economic implications of the various options.

Extensive reviews of mitigation options have been conducted by Flygare (1979) and Damas and Smith (1982). In general, approaches to mitigation take three forms: a) restricting or preventing animal access to rights-of-way either through active or passive restraint; b) changing highway design features and maintenance practices to reduce right-of-way attractiveness to wildlife and/or improve driver's abilities to avoid collisions; and c) improving driver awareness.

5.3.1 Fencing

Restrictive fencing is generally considered the best method of preventing wildlife access to highway rights-of-way (Harrison *et al* 1980, Ward *et al* 1980, Damas and Smith 1982, and Woods 1987). While highly effective, if properly installed and maintained, restrictive fencing options have a high initial and long-term maintenance cost as well as serious negative aesthetic implications in a national park setting. As was determined through the recent park management planning exercise (Canadian Park Service 1988), a major visitor activity in Kootenay is driving for pleasure, the popularity of which is based on the existence of natural landscapes of high scenic quality and visible wildlife along the Parkway corridor. Reducing visual quality and the opportunity to see wildlife along the corridor would impact visitor satisfaction.

The decision to install continuous fencing and underpasses during Phase I and II twinning of the Trans-Canada Highway in Banff National Park was largely based on the concern for public safety and wildlife populations resulting from unacceptably high ungulate-vehicle accident rates (FEARO 1979). Ungulate kill-rates on this section of the TCH were in excess of 2.2 animals/km/year, prior to fencing (Sopuck and Jakimchuk 1988). Reed et al (1982) recommended highway kill-rates of 3.8 - 5.0 deer/km/year as minimum values for implementing the least costly partial fencing option and rates of 11.3 - 15.0 deer/km/year for the full fencing with underpasses option for highways in Colorado.

Sopuck and Jakimchuk (1988) in their review of mitigation options for Phase III of the Banff TCH twinning project suggest that the lower ungulate-vehicle collision rate (1.5 animals/km/year) in Phase III compared to Phases I and II may not warrant full fencing and recommend that alternative mitigation measures be explored.

Mortality rates of ungulates from vehicle collisions on the Kootenay Parkway are well below the rates recorded on Phases I and II of the TCH in Banff. The mortality rate in the highest kill sections of the Parkway averaged 0.8 animals/km/year between 1979 and 1987. Based on the general guidelines established for the TCH twinning project and by Reed et al (1982), the current rate of ungulate-vehicle mortality in Kootenay does not justify a Parkway fencing program.

5.3.2 Reflectors

A lower cost and more aesthetic alternative to the fencing option may be found in the use of roadside reflectors. Several designs of reflective devices have been developed (Van de Ree and Stratolite mirrors and Swareflex Wildlife Reflectors) all of which operate on the principle that a series of devices mounted at specified intervals along a highway will reflect the headlights of approaching vehicles onto the roadside creating an "optical fence" which deters an animal from crossing the highway at that moment. Reviews of early tests of these devices concluded that the Van de Ree and Statolite mirrors were ineffective in reducing vehicle collisions with deer or related species and that results with the newer, less rigorously tested, Swareflex reflector were inconclusive (Flygare 1979, Damas and Smith 1982). Although many of the early tests of Swareflex indicated reductions in deer-vehicle collisions, most were non-statistical "before and after" comparisons that were subject to annual variations in weather, animal distribution and abundance, and traffic patterns (Schafer et al 1985).

Schafer et al (1985) used an alternating present-absent study design in a test of Swareflex reflectors between February, 1981 and April, 1984 near Spokane, Washington. Reflectors in each of four test sections were alternately covered and uncovered at one-week intervals throughout the test period. Of 58 deer killed at night in the test sections during the study period, 90% were killed while the reflectors were covered and 10% while the reflectors were uncovered. The difference was statistically significant ($p<.005$).

J. Strieter of Strieter Corporation (North American distributor for Swareflex Wildlife Reflectors, pers. comm. August, 1988) indicated that many of the early inconclusive or negative tests of Swareflex reflectors were due to improper installation and/or poor pre-installation accident records. He further indicated that the technology related to the installation of the reflectors has improved substantially and is contributing to improved success.

Installation of Swareflex reflectors in Alberta by Alberta Transportation (N. Allan, pers. comm.) and Alberta Fish and Wildlife Division (D. Radford, Regional Director, Lethbridge, pers. comm.) has met with good success and more installations are planned. The British Columbia Ministry of Highways also reports good success with Swareflex for both deer and elk at installations in the Cranbrook area (B.C. Ministry of Highways, Cranbrook office, pers. comm.) None of these sources reported any severe difficulties with maintenance or vandalism of reflector installations.

Although the mounting body of evidence suggests that, if properly installed, Swareflex reflectors can significantly reduce night time vehicle collisions with deer, their potential effectiveness in reducing elk-vehicle collisions is largely unknown. A six-month test of Swareflex reflectors along a 0.8km section of the Trans-Canada Highway in Banff National Park during 1978 was considered ineffective in reducing elk-vehicle collisions (Flygare 1979). Improvements in reflector design and installation since 1978 make the reflector potentially more effective for elk and justify additional testing. The Kootenay Parkway presents an ideal situation for testing the effectiveness of Swareflex reflectors on elk.

5.3.3 Sound

The use of sound has often been proposed as a method of preventing wildlife from entering transportation corridors. Ultrasonic sound (>20KHz) has been most often been recommended as it is inaudible to humans and represents and uncommon occurrence in nature. Damas and Smith (1982) reported that the upper hearing limit of most large mammals does not exceed that of humans (16KHz to 20KHz) and therefore they are unable to detect ultrasonic frequencies.

Several "Ultrasonic Warning Devices", designed to be mounted on vehicles, are currently on the market. Manufacturers contend that at speeds of 50 kph the devices emit sound in the frequency range of 16 KHz to 20 KHz which will repel wildlife. This frequency range is not ultrasonic and would be audible to some humans (Damas and Smith 1982).

Although there is little published evidence on which to evaluate the effectiveness of these warning devices, a number of commercial trucking companies are reporting success in reducing collisions with wildlife (B-A Consulting Group 1988). A preliminary study of the effectiveness of these devices was conducted by Child and Foubister (1986). The results were inconclusive indicating that the devices were marginally effective in increasing the flight response of moose, but may be useful in reducing the incidence of drivers taking action to avoid moose. No conclusion could be reached about the effectiveness of the device for deer (Child and Foubister 1986).

Further documentation of the effectiveness of these devices is necessary, however, preliminary indications are that they may have potential in reducing wildlife-vehicle accidents.

5.3.4 Driver Awareness

One of the key components in a wildlife-vehicle accident is the driver and his/her perception and reaction time. Damas and Smith (1982) suggest that driver perception delay, in relation to wildlife-vehicle collisions, can be substantial because an animal on the roadway is not a "normal" driving hazard. They concluded that collisions with wildlife could be reduced if drivers a) were aware of the unpredictable behaviour of animals and b) concentrated on the early detection of animals.

A multi-media public information program aimed at improving driver awareness of the problem of wildlife-vehicle collisions, the unpredictable behaviour of wildlife and the skills associated with early detection of animals could reduce wildlife collisions. A program would have to be directed not only at the park user, but also the through travelers, both recreational and commercial.

Terra Nova National Park chose a public awareness approach to reducing moose-vehicle accidents in the park (Hardy 1984). The program employed moose silhouettes, patterned after those developed in Yoho National Park, as well as buttons and bumper stickers, marketed by the park cooperating association. The program has been successful in increasing public awareness, however more information on moose population dynamics and traffic patterns is needed before a critical evaluation of the program's effect on moose-vehicle accidents can be done (J. Reynolds, TNNP, pers. comm.).

Early detection of wildlife along the Parkway is critical to improving driver perception time and ultimately a driver's ability to avoid an accident. Traditional, static, wildlife warning signs (leaping deer) although widely used, are generally considered ineffective (Damas and Smith 1982). The elk silhouette sign, developed in Yoho National Park, and currently being used in several other mountain national parks and in the Province of Alberta, appears to have a greater impact on driver awareness. A critical evaluation, however, of the effect of the design on driver awareness and wildlife-vehicle collisions has yet to be conducted and as drivers become more familiar with these signs and their use more prevalent, driver habituation may become a problem.

The key to effective signing for increasing driver awareness and perception time is mobility and timeliness. A driver's ability to scan the roadside for animals improves the chances of detecting an animal, but requires considerable concentration and cannot be maintained for long periods. It is important, therefore, that warning signs be located near the area where and at the time when the highest probability exists of animals being on the road. Experiments with lighted warning signs, both manually activated (Pojar et al 1971) and remotely activated (Ward et al 1980) have proven successful in increasing driver awareness. Damas and Smith (1982) concluded that increased awareness may be more important in avoiding collisions with wildlife than a reduction in posted speed limit. They calculated that at 90 kph, a reduction in perception time of one second decreases the total stopping distance by 25 metres which is equivalent to a speed reduction of 10 kph.

Highway signing is a very cost-effective method of increasing driver awareness and compliance with regulations. Highly sophisticated, mobile, lighted signs are used effectively by highway maintenance departments to alert drivers to maintenance operations. This technology should be adaptable to the problem of wildlife-highway mortality. Damas and Smith (1982) recommended further testing of the microwave detection system of Ward et al (1980) and proposed an experimental design for testing in Yoho National Park. Such a test has yet to be conducted. The experimental design could be easily adapted for testing on the Kootenay Parkway.

5.3.5 Parkway Design and Use

Visibility has been identified in this study as a key factor influencing ungulate-vehicle collisions on the Parkway. This factor is most pronounced under night time driving conditions, when the majority of accidents occur. At night, a driver's visibility is limited to the range of the vehicle's headlights. Huculak (1974) reported that, under lowbeam lighting, a driver's detection distance of an animal on the roadway was 60 metres or less and from 90 to 150 metres under highbeam lighting. In order for a driver to avoid a collision the vehicle speed would have to be in the range of 40 to 50 kph under lowbeam lighting and 70 to 100 kph under highbeam conditions. Damas and Smith (1982) concluded that speed control of 60 kph or less would be required to achieve a high degree of success in reducing wildlife-vehicle collisions. To impose a blanket night time speed reduction on the Parkway to 60 kph would be impractical and costly to enforce. Speed reductions associated with an "early warning" signing system or to certain critical periods of the year would be more feasible. If a functional speed reduction of 10 kph can be achieved through improved driver perception time through signing and public awareness programs, then a night time speed reduction from the current 90 kph to 70 kph might be feasible.

Visibility of animals along the Parkway right-of-way is also influenced by factors, either singly or in combination, such as: shrub encroachment, ditch depth and guiderails. Contrary to the conclusion of Damas and Smith (1982) that right-of-way clearing only improves visibility during the day, this investigator concludes that the presence of shrubs (>0.5 m in height), particularly at curves, does influence visibility, even at night. The problem becomes more acute where the ditches are greater than one metre below the traffic surface and guiderails are present. The visibility index at kill-sites examined with all three of these factors present was always zero. The influence of ditch depth on animal visibility is most pronounced for deer, owing to their smaller size compared to elk.

The improvement of roadside visibility, particularly at known high-kill locations along the Parkway, could significantly reduce the incidence of ungulate-vehicle collisions by increasing a driver's ability to detect animals on the right-of-way. Reducing the steepness of sideslopes, clearing of shrubs from the right-of-way and removing guiderails would improve visibility of the right-of-way and reduce the element of surprise for drivers and ungulates.

The fact that wildlife, particularly ungulates, show a predictable seasonal and diurnal pattern in use of the Parkway right-of-way suggests an additional mitigation option in the form of vehicle operating restrictions. One such restriction, as discussed above, is the implementation of a night time speed limit reduction which could be imposed seasonally during those periods when ungulates most actively use the right-of-way; June-July for deer and October-November for elk. To be effective, a night time speed limit reduction to at least 70 kph is necessary and could be augmented with an "early warning" signing system to achieve a functional speed reduction to 60 kph in areas where the hazard is greatest.

Given that the majority of ungulate-vehicle accidents on the Parkway occur in the early morning and evening periods, it is reasonable to suggest that traffic control efforts be directed at reducing traffic volume during these periods. An alternate strategy to imposing a speed limit reduction could be to restrict vehicle operating hours to the daylight period only during the high ungulate use periods. Such a restriction, however, would be extremely difficult to enforce on a blanket basis short of physically closing the Parkway. Large trucks, however, are a major Parkway user during these critical ungulate activity periods and could be more practically restricted to operating during daylight hours on a seasonal basis. The most critical season for elk is October-November when they make intensive use of the Parkway right-of-way. Restricting truck traffic to daylight hours during October-November could reduce elk mortality on the Parkway and would have minimal conflict with other Parkway users given the reduced recreational and passenger vehicle traffic during this period. However, the economic implications of such a restriction are unknown and beyond the scope of this investigation.

5.3.5 Vegetation Management

This study has documented the seasonal importance of the Parkway right-of-way as a habitat component for elk and deer. In fact, the grassy right-of-way through the Kootenay and lower Vermilion valleys provides a critical forage resource for elk in the fall-early winter and spring. White-tailed deer make relatively less use of the grassy right-of-way, but are attracted to the "edge" habitats created by right-of-way clearing, borrow pits and park facilities.

An obvious long-term strategy for reducing ungulate-vehicle collisions is to discourage ungulate use of right-of-way and associated habitats. Restrictive fencing is the most effective method of excluding ungulates from the right-of-way, but has significant cost, aesthetic and visitor experience implications as discussed previously. Restricting ungulates from the Parkway right-of-way also has serious implications for the ungulate populations, especially elk, as suitable alternative habitat is severely limited in the Kootenay Valley. Elk winter range in the Kootenay and lower Vermilion valleys will continue to decline as forest succession progresses. Any measure to restrict or discourage elk use of the Parkway right-of-way should be accompanied by a program of habitat enhancement away from the corridor. Such a program should be coordinated with the Vegetation Management Plan (Masters 1988) so that joint wildlife habitat and vegetation management objectives can be established.

Whereas a good body of literature exists on ungulate habitat requirements and methodologies for species-specific habitat creation and enhancement (Watson et al 1980, Damas and Smith 1982, Green et al 1987, Green and Salter 1987), little information exists on methods of reducing the attractiveness of rights-of-way to ungulates. In a review of mitigation options for TCH twinning in Banff National Park, Sopuck and Jakimchuk (1988) recommend that new highway development should minimize the area of forest clearing and restoration of disturbed areas should use a sterile medium (e.g., gravel, crushed rock) and relatively unpalatable plant species such as low-lying conifers. They conclude, however, that there are relatively few unpalatable native plant species available in Banff suitable for right-of-way revegetation and that further experimentation is required.

There is even less information available on methods of reducing the attractiveness of existing planted rights-of-way. Much of the effort in this regard has centered on adapting chemical repellents, largely developed for reducing deer damage to agricultural crops, to deter ungulates from using roadside vegetation. Damas and Smith (1982) suggested two commercially available preparations had potential for deterring ungulates from roadsides, but that further testing was required. The same conclusion was reached by Sopuck and Jakimchuck (1988). Repellents may have short-term benefits in deterring ungulate use of relatively small areas, however, because of cost and the relatively short acting time, their suitability for long-term use over large areas is questionable. In addition, there is little information on the environmental implications of long-term use of these chemicals.

The potentially most effective long-term strategy for reducing the attractiveness of roadsides to ungulates lies in altering the existing roadside vegetation to a less attractive (less palatable) association. The key to this strategy is identifying suitable unpalatable native plant species. Palatability of a species, however, varies geographically, topographically and seasonally and in response to local growing conditions (nutrients, moisture, temperature, exposure, etc.). There are very few native plants that are unpalatable at all phenological stages and under all growing conditions. Some information is available on the relative palatability of a number of plant species (Fargey and Hawley 1986 and Sopuck and Jakimchuk 1988), however nothing is known of their suitability to the Kootenay situation. Site-specific experimentation is required to identify suitable non-palatable species for Kootenay and to develop the most ecologically appropriate and economically feasible method of altering right-of-way vegetation associations.

6.0 CONCLUSIONS AND RECOMMENDATIONS

This investigation has documented and evaluated those factors related to wildlife habitat, highway design and maintenance, and traffic volume and composition thought to influence wildlife-vehicle collisions on the Kootenay Parkway. In addition, where possible through analysis of existing information, an assessment of the impact of current levels of Parkway-related mortality on the primary species involved was made. Potential mitigation options were reviewed and discussed in relation to developing a mitigation strategy for reducing wildlife-vehicle accidents on the Kootenay Parkway.

The results of this study confirm conclusions of studies done elsewhere, that ungulate-vehicle collisions are not random, but aggregated in space and time. The greatest collision frequencies corresponded to the locations and periods (seasonal and diurnal) of heaviest ungulate use of the Parkway corridor and right-of-way and not necessarily to periods of greatest traffic volume. Traffic volume was a factor when high volumes corresponded to the critical periods of ungulate use. The highest weekly kill of ungulates occurred on Fridays corresponding to a higher evening traffic volume composed primarily of passenger and recreational vehicles traveling between Alberta and the Columbia Valley.

The proportion of large trucks in the traffic mix was greatest on weekdays during early morning, coincident with the period of highest ungulate-vehicle mortality. This, coupled with the low incidence of accident reports corresponding to known Parkway-wildlife mortalities, suggests that large trucks may be responsible for a disproportionate number of wildlife-vehicle accidents on the Parkway.

The primary factors separating ungulate-vehicle collision sites from non-collision sites were related to Parkway right-of-way characteristics rather than right-of-way habitat value or ungulate use. The potential of a section of Parkway being a kill-site increased with a) reduced visibility as influenced by ditch depth, shrub encroachment and the presence of guardrails, b) reduced forest cover adjacent the right-of-way, and c) increased proximity to disturbed areas such as borrow pits and man-made grasslands. The influence of the latter factor is compounded where disturbed sites are located near each other on the opposite sides of the Parkway, increasing the frequency of ungulate crossings.

Although further testing of the highway characteristics model is required, the variables identified have value in the assessment of potential wildlife-vehicle collision sites on new or existing highway alignments through forested, mountainous terrain.

Three Parkway maintenance practices were identified as contributing to the problem of wildlife-vehicle collisions in the park. The continued use of sodium chloride as a roadway deicing agent is being re-evaluated throughout North America because of its known environmental implications. Greater efforts should be directed toward finding more environmentally appropriate and cost effective alternative deicing agents and methodologies. The practice of mowing of roadside vegetation in late summer and the winging-back of snowbanks in late winter, which attract ungulates to the Parkway, should be modified or discontinued.

An assessment of the impact of Parkway mortality on large mammal populations was complicated by a lack of knowledge, in many cases, of the status and dynamics of these populations within the park and the effects of habitat change as a result of forest succession. Current levels of Parkway-elk mortality are considered contributory, along with habitat loss and natural mortality, to the observed decline in the park population. Moose have undergone a dramatic decline in the park over the past 40 years, largely in response to changing habitat conditions, however, current levels of Parkway mortality may be contributing to their continued decline. Mortality rates of the remaining large mammal species routinely involved in vehicle collisions on the Parkway, do not appear to be negatively impacting these populations at present, however, for many species, not enough population information exists to make an accurate assessment.

Current rates of Parkway-wildlife mortality in Kootenay, although representing a significant wildlife and public safety concern in the park context, are much lower than the mortality rate considered unacceptable prior to fencing on Phases I and II of the TCH twinning in Banff National Park. It is for this reason as well as the high cost and negative aesthetic implications that a restrictive fencing program is not recommended as a mitigation option for the Kootenay Parkway.

A number of alternate, more cost-effective and aesthetically appropriate mitigation options exist. The following mitigation strategy is recommended to reduce wildlife mortalities on the Kootenay Parkway:

1) The effectiveness of Swareflex Wildlife Reflectors in reducing ungulate-vehicle collisions should be tested on the Parkway. Two test sections, approximately one kilometre long, are proposed for the Crook's Meadow-Dolly Varden and the McLeod Meadows areas because of their importance as kill-sites for elk and deer. A three to five year monitoring program, utilizing the "presence-absence" technique described by Schafer _et al_ (1985) is recommended, however may prove impractical because of the low potential sample

size. A pre-installation analysis of existing wildlife mortality data should be conducted in order to design a statistically relevant experiment. If Swareflex reflectors prove effective, priorities for additional installations include: Kootenay Crossing-Kootenay Pond area; the area immediately north of the "airstrip"; the Daer fire road entrance area; the 21-mile curves area and the McKay Creek compound area.

2) A multi-media public information/education program should be developed to increase public awareness of the problem, gain public compliance with proposed mitigation measures and improve driver ability to detect wildlife on the right-of-way. Components of such a program should include:

   a) A regionally coordinated information program aimed at all highway users in those parks with highway-wildlife mortality problems;

   b) an in-park awareness program directed at all Parkway users - park visitors and through travelers, both private and commercial, employing interpretive and extension programs, public safety messages and an informational and "early-warning" signing program incorporating the elk "silhouette" and remotely activated lighted signs.

3. From a wildlife protection perspective, the institution of Parkway traffic controls in the form of a reduced night time speed limit and/or restrictions in operating times to the daylight period only for critical periods of high ungulate use of the Parkway right-of-way, would likely result in reduced

wildlife-vehicle accidents. Such restrictions, however, would have to be evaluated in relation to their potential economic and traffic safety implications.

The cooperation of the major Parkway user-groups such as commercial trucking companies, independent operators and recreationists should be sought in developing and implementing traffic control strategies for the mitigation of vehicle-wildlife conflicts on the Parkway.

4. Immediate steps should be taken to improve sight distances at a number of important wildlife-vehicle collision locations along the Parkway such as Kootenay Crossing, Dolly Varden Creek, 21-mile curves and McLeod Meadows. Visibility is impaired at these locations by combinations of shrub encroachment, guiderails and long, steep sideslopes.

5. The continued use of sodium chloride as a deicing agent on the Parkway should be reviewed and efforts directed toward finding more environmentally appropriate and cost effective alternative deicing methods. Other Parkway maintenance practices implicated in Parkway-wildlife collisions should be reviewed and replaced by more acceptable methods or eliminated altogether.

6. Objectives for long-term management of ungulate habitat within the park should be established within the framework of the vegetation management plan so that a coordinated approach to vegetation and habitat management can be developed.

7. Further investigation and experimentation is needed to develop appropriate methodologies for reducing the attractiveness of both established and newly developed highway rights-of-way.

8. Continued monitoring of elk population dynamics should be a priority as should research into the population dynamics and habitat requirements of moose, white-tailed deer and mule deer within the park. Such research is necessary not only to adequately assess the impact of Parkway-related mortality on these species, but also to develop cooperative management programs with neighboring wildlife management agencies and to establish population and habitat management objectives for the long-term survival of these species within the park.

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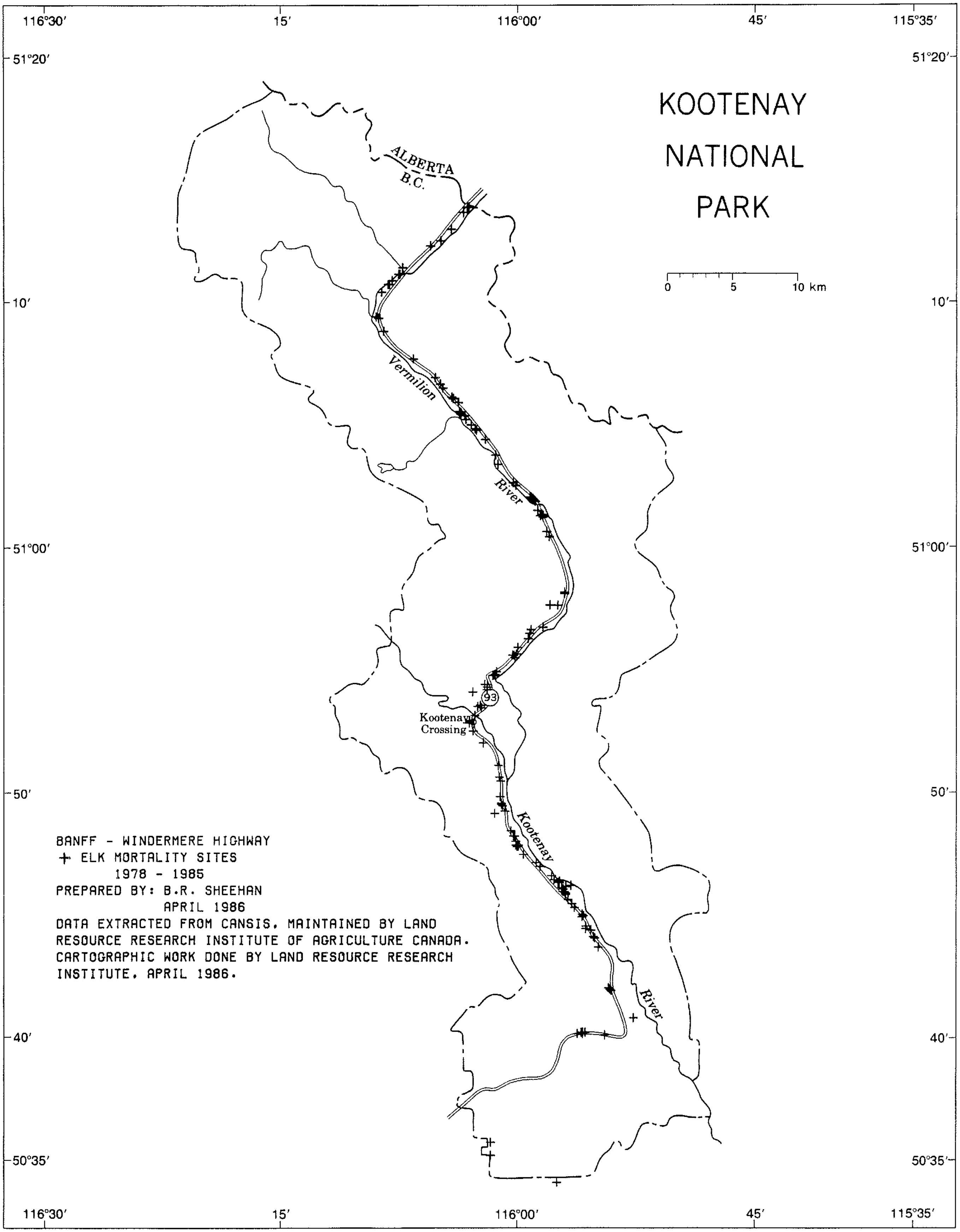
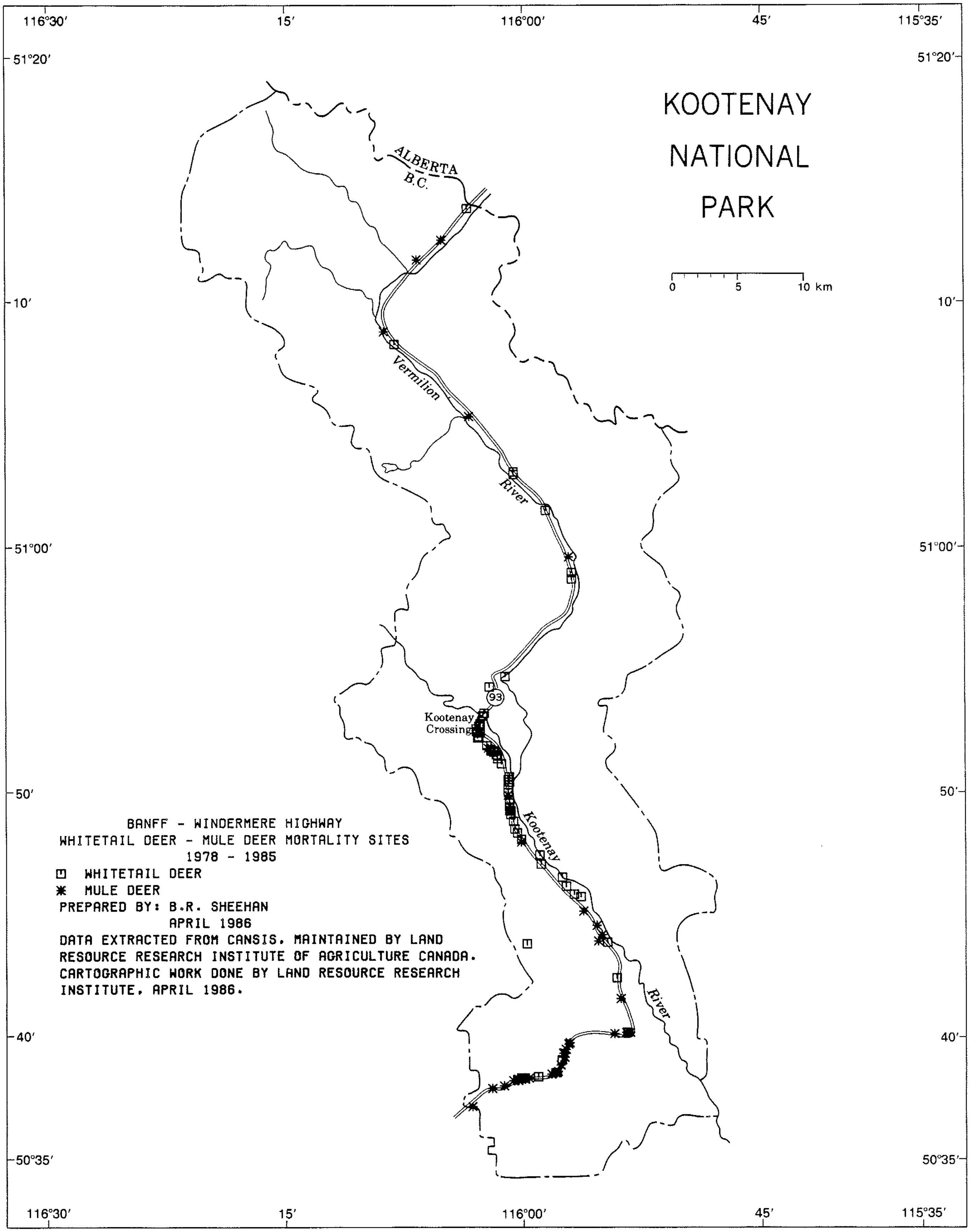
APPENDIX A:

Locations of Ungulate Mortalities on the Kootenay Parkway, 1978 - 1985



KOOTENAY
NATIONAL
PARK
0 5 10 km
116°30'
15'
116°00'
45'
115°35'
51°20'
10'
51°00'
50'
40'
50°35'
ALBERTA
B.C.
Vermilion
River
93
Kootenay Crossing
Kootenay
River
BANFF - WINDERMERE HIGHWAY
+ ELK MORTALITY SITES
1978 - 1985
PREPARED BY: B.R. SHEEHAN
APRIL 1986
DATA EXTRACTED FROM CANSIS, MAINTAINED BY LAND
RESOURCE RESEARCH INSTITUTE OF AGRICULTURE CANADA.
CARTOGRAPHIC WORK DONE BY LAND RESOURCE RESEARCH
INSTITUTE, APRIL 1986.



116°30′
15′
116°00′
45′
115°35′
51°20′
10′
51°00′
50′
40′
50°35′
KOOTENAY
NATIONAL
PARK
0
5
10 km
ALBERTA
B.C.
Vermilion
River
93
Kootenay
Crossing
Kootenay
River
BANFF - WINDERMERE HIGHWAY
WHITETAIL DEER - MULE DEER MORTALITY SITES
1978 - 1985
WHITETAIL DEER
MULE DEER
PREPARED BY: B.R. SHEEHAN
APRIL 1986
DATA EXTRACTED FROM CANSIS, MAINTAINED BY LAND
RESOURCE RESEARCH INSTITUTE OF AGRICULTURE CANADA.
CARTOGRAPHIC WORK DONE BY LAND RESOURCE RESEARCH
INSTITUTE, APRIL 1986.

APPENDIX B:

Ungulate habitat and use variables measured at intensive study sites
Kootenay Parkway corridor, July-August, 1987.

Plot #	Location	Vegetation Analysis							Pellet Densities		Trail Density trails/ metre
		% Litter	% Grasses	% Forbs	% Shrubs	Total Cover %	Forage Production kg/ha	% Protein	Elk gr/ha	Deer gr/ha	
8701-E	Nixon Cr.	37	79.5	12.4	0	91.9	2003	6.4	178.7	12.5	.03
8701-W		34.8	73	53.7	.3	126.9	1966	4.5	71.3	3.8	.06
8702-E	Con Corp	6.1	72.4	11.5	.5	84.3	1401	4.7	110	0	.09
8702-W		18.6	60	14.9	.1	75	1017	5.8	110	7.5	.06
8703-E	McLeod Mead.	69	84.4	12.5	3.4	100.2	3775	6.6	75	0	0
8703-W		80.5	82.5	13.7	1.9	98.1	2499	5.2	65	5	.04
8704-E	Harkin	31	45.3	22.3	7.2	74.7	398	7.4	75	2.5	.09
8704-W		47.5	77.5	12.1	.6	90.2	1695	5.7	72.5	7.5	.13
8705-E	Crook's Mead.	55	46.5	23.7	0	70.2	2963	6	90	2.5	.09
8705-W		50	60.1	52.1	0	112.1	3467	8	115	5	.07
8706-E	N. Crook's Mead.	68.8	73.7	14.9	.3	88.9	2237	5.2	202.5	7.5	.07
8706-W		50	61.4	103.9	0	165.2	3317	5.3	117.5	27.5	.06
8707-E	Dolly Varden	1.7	11.9	14.8	5.3	32	1559	5	80	12.5	.03
8707-W		4.8	25.4	23.4	.1	78.8	235	4.7	52.5	25	.11
8708-E	Daer	40.3	46.5	45.4	2.2	94.1	1081	5.4	20	10	.06
8708-W		3.6	50.1	6	3.9	59.9	643	5	37.5	7.5	.06
8709-E	S. Airstrip	59.5	53.3	46	2.2	101.4	1397	6.7	20	12.5	.08
8709-W		3.4	15.5	27	1.6	44	394	4.8	12.5	7.5	.02
8710-E	N. Airstrip	80.8	43.6	40.1	0	83.7	1717	6	45	30	.1
8710-W		66.5	59.6	22.2	1.9	83.7	988	6.8	15	5	.06
Mean		40.1	56.1	28.6	1.6	86.2	1737.6	5.8	78.2	9.6	.0655
Mean East		44.9	55.7	24.3	2.1	82.1	1853.1	5.9	89.6	9	.064
Mean West		36	56.5	32.9	1	90.4	1622.1	5.6	66.9	10.1	.067

Parkway design and corridor variables measured at intensive study sites, Kootenay Parkway wildlife mortality study, 1987.

Plot #	Location	shortest visibility	% Bank	% Level	% Gully	Guard rail %	Curve (m)	Hill (m)	Forest Cover %	Shrubs < 2m %	Shrubs > 2m %	Disturbed (m)	Facility (m)
8701-E	Nixon Cr.	456	0	100	0	0	100	100	75	0	20	100	200
8701-W		518	0	0	100	0	100	100	75	0	20	100	200
8702-E	Con. Corps.	171	0	0	100	0	100	200	80	0	0	100	100
8702-W		241	0	0	100	0	100	200	80	0	0	100	100
8703-E	McLeod Mead.	104	0	100	0	0	200	100	70	0	0	100	100
8703-W		146	0	100	0	0	200	100	70	0	1	100	100
8704-E	Harkin	445	0	100	0	0	200	200	100	3	0	200	100
8704-W		518	0	100	0	0	200	200	100	5	0	200	100
8705-E	Crook's Mead.	280	0	50	50	0	200	100	80	0	0	100	100
8705-W		316	0	50	50	0	200	100	80	1	0	100	100
8706-E	N. Crook's Mead.	100	0	70	30	0	100	200	100	2	2	100	200
8706-W		112	0	60	40	0	100	200	100	0	0	100	200
8707-E	Dolly Varden	0	0	0	100	50	100	200	100	0	0	200	100
8707-W		141	0	50	50	50	100	200	100	2	5	200	100
8708-E	Daer	518	0	50	50	0	200	200	100	0	0	100	100
8708-W		518	0	50	50	0	200	200	100	0	0	100	100
8709-E	S. Airstrip	518	0	50	50	0	200	200	100	0	0	200	200
8709-W		518	0	50	50	0	200	200	100	0	0	200	200
8710-E	N. Airstrip	518	0	100	0	0	200	200	100	0	0	100	200
8710-W		518	50	0	50	0	200	200	100	2	3	100	200

APPENDIX C - LIST OF VASCULAR PLANTS

This list is based on collections made during the Kootenay Parkway Wildlife Mortality Study at intensive study sites along the Parkway corridor, Kootenay National Park, 1987. Nomenclature follows that of Packer (1983), Hitchcock and Cronquist (1973) and Achuff et al (1984).

EQUISETOPHYTA

EQUISETACEAE

Equisetum arvense L.
Equisetum fluviatile L.

PINOPHYTA

CUPRESSACAEA

Juniperus communis L.

PINACEAE

Picea glauca (Moench)Voss
Pinus contorta Loud. var latifolia Engelm.
Pseudostuga menziesii (Mirb.)Franco var. glauca (Bessn.)Franco

MAGNOLIOPHYTA

MAGNOLIATAE

BERBERIDACEAE

Berberis repens Lindl.

CAMPANULACEAE

Campanula rotundifolia L.

CAPRIFOLIACEAE

Linnaea borealis L.
Lonicera dioica L.
Lonicer involucrata (Rich.) Banks
Symphoricarpos albus (L.) Blake
Viburnum edule (Michx.) Raf.

COMPOSITAE

Achellea millefolium L.
Agoseris glauca (Pursh) Raf.
Antennaria lanata (Hook.) Greene
Antennaria nitida Greene = A. microphylla Rydb.
Antennaria racemosa Hook.
Antennaria rosea Greene
Arnica cordifolia Hook.
Aster ciliolatus Lindl.
Aster conspicuus Lindl.
Aster sibiricus L.
Chrysanthemum leucanthemum L.
Cirsium arvense (L.) Scop.
Cirsium hookerianum Nutt.
Erigeron sp.
Gaillardia aristata Pursh
Petasites palmaus (Ait.) Gray
Petasites sagittatus (Banks) Gray
Senecio indecorus Greene
Solidago Decumbens Greene = S. spathulata DC.
  var. nana (Gray) Cronq.
Solidago missouriensis Nutt.
Solidago multiradiata Ait.
Solidago nemoralis Ait.
Taraxacum officianale Weber

CORNACEAE

Cornus canadensis L.
Cornus stolonifera Michx.

CRUCIFERAE

Arabis holboellii Hornem.

ELAEAGNACEAE

Elaeagnus commutata Bernh. ex Rydb.
Shepherdia canadensis (L.) Nutt.

ERICACEAE

Arctostaphylos uva-ursi (L.) Spreng.
Ledum groenlandicum Oeder
Menziesia glabella Gray = M. ferruginea Smith
  var. glabella (Gray) Peck
Vaccinium caespitosum Michx.
Vaccinium scoparium Leiberg

GENTIANACEAE

Gentianella amarella (L.) Borner

LEGUMINOSAE

Astragalus bourgovii Gray
Astragalus dasyglottis Fisch. ex DC. = A. agrestis Dougl. ex Hook.
Astragalus miser Dougl. var. serotinus (Gray) Barneby = A. decumbens (Nutt.)Gray
Hedysarum sulphurescens Rydb.
Hedysarum boreale Nutt.
Medicago lupulina L.
Melilotus alba Desr.
Melilotus officianalis (L.) Lam.
Oxytropis campestris (L.) DC.
Oxytropis deflexa (Pall.) DC.
Trifolium hybridum L.
Trifolium pratense L.
Trifolium repens
Vicia americana Muhl.
Vicia cracca L.

ONAGRACEAE

Epilobium angustifolium L.
Epilobium latifolium L.

PYROLACEAE

Chimaphila umbellata (L.) Bart.
Moneses uniflora (L.) Gray
Pyrola asarafolia Michx.
Pyrola chlorantha Sw. = P. virens Schweig.
Pyrola secunda L. = Orthilia secunda (L.) House

RANUNCULACEAE

Actaea rubra (Ait.) Willd.
Anemone multifida Poir
Thalictrum occidentale Gray

ROSACEAE

Amelanchier alnifolia Nutt.
Dryas octopetala L. var. hookeriana (Juz.)Breit.
Fragaria virginiana Cuchesne var. glauca Wats.
Geum allepicaum Jaeq.
Potentilla fruticosa L.
Rosa acicularis Lindl.
Rubus idaeus L. = R. strigosus Michx.
Rubus parviflorus Nutt.

Rubus pedatus Smith
Rubus pubescens Raf.
Spiraea lucida Dougl. = S. betulifolia Pallas var. lucida (Dougl.) Hitchc.

RUBIACEAE

Galium boreale L.
Galium triflorum Michx.

SALICACEAE

Populus balsamifera L. spp. trichocarpa (Torr.& Gray) Brayshaw
Populus tremuloides Michx.
Salix sp.

SANTALACEAE

Geocaulon lividum (Richards.) Fern.

SAXIFRAGACEAE

Mitella nuda L.
Ribes sp.

SCROPHULARIACEAE

Castelleja miniata Dougl. ex Hook.
Pedicularis bracteosa Benth.
Rhinanthus crista-galli L.

UMBELLIFERAE

Heraclium lanatum Michx.

VIOLACEAE

Viola adunca J.E. Smith
Viola rugulosa Greene = V. canadensis L. var. rugulosa (Greene) Hitchc.

LILIATAE

CYPERACEAE

Carex sp.

GRAMINEAE

Agropyron cristatum (L.) Gaertn.
Agropyron dasystachum (Hook.) Scribn.

Agropyron trachycaulum (Link) Malte.
Agrostis stolonifera
Agrostis scabra Willd.
Bromus ciliatus L.
Bromus inermis Leyss.
Bromus tectorum L.
Calamagrostis inexpansa (Michx.) Beauv.
Calamagrostis rubescens (Buckl.)
Danthonia intermedia Vasey
Danthonia parryi Scribn.
Elymus glaucus Buckl.
Elymus innovatus Beal
Festuca ovina L.
Festuca rubra L.
Phleum pratense L.
Poa compressa L.
Poa palustris L.
Poa pratensis L.
Stipa richardsonii Link

IRIDACEAE

Sisyrinchium montanum Greene

LILIACEAE

Allium cernuum Roth
Smilacina racemosa (L.) Desf.
Smilacina stellata (L.) Desf.
Zygadenus elegans Purch.

ORCHIDACEAE

Calypso bulbosa (L.) Oakes
Listera borealis Morong
Spiranthes romanzoffiana Cham. & Schlect.

APPENDIX D:

Deer Diet Composition From Fecal Analysis, Kootenay National Park, April 1987 - September 1987

Forage Class	Genera	April Mean	May Mean	June Mean	July Mean	August Mean	Sept. Mean	Oct. Mean	Mean Apr-May	Mean June-Aug	Mean Sept-Oct
GRASSES											0
	Agropyron				.51	.84			0	.45	0
	Agrostis								0	0	0
	Bromus		.6		.84				.3	.28	0
	Danthonia								0	0	0
	Festuca	.65			.87	.76	4.16	2.59	.325	.543	3.375
	Koeleria cristat								0	0	0
	Poa		.75	.48	.37	.76	.65	2.65	.375	.537	1.65
	Stipa comata			.38				.8	0	.127	.4
	seed & glume	1.21	.75						.98	0	0
	Carex	1.15				2.34		.41	.575	.78	.205
	Eleocharis				.75				0	.25	0
	Total Grams.	3.01	2.1	.86	3.34	4.7	4.81	6.45	2.555	2.967	5.63
FORBS											
	Astragalus	1.15	.81	1.89	1.32	5.02	4.55	4.27	.98	2.743	4.41
	Castilleja						2.88	1.74	0	0	2.31
	Delphinium		.81		.39						0
	Dryas								0	0	0
	Equisetum	3.62	1.56	.48				.77	2.59	.16	.385
	Fragaria	1.17	3.65	1.35	.37		1.64	.8	2.41	.573	1.22
	legume seed						1.09		0	0	.545
	Lycopodium								0	0	0
	Lupinus								0	0	0
	Medicago (type)						.53		0	0	.265
	Vicia							.41	0	0	.205
											0
	Total Forbs	5.94	6.83	3.72	2.08	5.02	10.69	7.99	6.385	3.607	9.34
SHRUBS											0
	Abies	.52		.57			.46		.26	.19	.23
	Amelanchier							.41	0	0	.205
	Berberis								0	0	0
	Chrysothamnus	52	26.48	.48	1.66	4	5.06	54.58	39.24	2.047	29.82
	Cornus	3.02				3.53			1.51	1.177	0
	Juniper/Thuja	4.25	2.74	.48		2.67			3.495	1.05	0
	Picea	2.86	3.05		3.42	2.41	2.1	1.21	2.955	1.943	1.655
	Pinus	8.71	26.94	7.55	15.05	38.73	32.87	18.09	17.825	20.443	25.48
	Populus	14.4	1.35	.48	.52	3.08		.38	7.875	1.36	.19
	Pseudotsuga		3.69						1.845	0	0
	Rosa	1.21						.97	.605	0	.485
	Rubus ideaus	1.23	.75						.99	0	0
	Rubus sp.	1.1	19.45	75.33	61.87	24.46	37.55	8.56	10.275	53.887	23.055
	Salix		1.35	5.64	6.57	4.05	1.68	.41	.675	5.42	1.045
	Shepherdia/Eleag		5.27	4.89	4.13	7.35	3.57		2.635	5.457	1.785
	Spiraea				.84		1.21		0	.28	.605
	Symphoricarpos								0	0	0
	Total Shrubs	89.3	91.07	95.42	94.06	90.28	84.5	84.61	90.185	93.253	84.555

Elk Diet Composition From Fecal Analysis, Kootenay National Park, April 1987 - October 1987

Forage Class	Genera	April	May	June	July	August	Sept.	Oct.	Mean Apr-May	Mean June-Aug	Mean Sept-Oct
GRASSES											
	Agropyron	3.13	.5			.65			1.815	.217	0
	Agrostis		.37					1.14	.185	0	.57
	Bromus	2.76			.6	1.31	2.38		1.38	.636	1.19
	Danthonia	.49							.245	0	0
	Festuca	38.84	1.87	5.58	4.35	5.65	10.53	41.45	20.355	5.193	25.99
	Koeleria	4.27	.48						2.375	0	0
	Poa	3.58	1.34	.9	4.35	3.25	6.14	2.92	2.46	2.833	4.53
	Stipa comata	16.08	4.89		.72	3.15	7.22	11.4	10.485	1.29	9.31
	seed & glume		3.17	1.49	4.25		2.42	5.97	1.585	1.913	4.195
	Carex	.62	1.88	.91		1.21	1.16	1.01	1.25	.706	1.085
	Eleocharis		.5			.66	.6	.46	.25	.22	.53
											0
	Total Grams.	69.77	15	8.88	14.27	15.88	30.45	64.35	42.385	13.01	47.4
FORBS											
	Astragalus		.48	1.11	2.7	3.14	.6	2.32	.24	2.316	1.46
	Castilleja					3.02	2.46		0	1.006	1.23
	Dryas	5.61			1.46				2.805	.4866	0
	Equisetum	3.24	.95	3.71		3.13	5.61	11.25	2.095	2.28	8.43
	Fragaria		1.88	1.83			.55	.56	.94	.61	.555
	legume seed				1.36				0	.453	0
	Lupinus					3.14			0	1.046	0
	Medicago (type)				.72	.65			0	.456	0
	Vicia	.62	.97	.38	2.21	.68	1.96		.795	1.09	.98
									0	0	0
	Total Forbs	9.47	4.28	7.03	8.45	13.76	11.18	14.13	6.875	9.746	12.655
SHRUBS											
	Abies								0	0	0
	Berberis								0	0	0
	Chrysothamnus	.49							.245	0	0
	Cornus	8.09	2.07	.38			.55	6.68	5.08	.126	3.615
	Juniper/Thuja					.53			0	.176	0
	Picea	2.45	.42			.53	1.15		1.435	.176	.575
	Pinus	6.05	.5	.38	1.46			.56	3.275	.613	.28
	Populus				12.84	36.84	37.35	5.68	0	16.56	21.515
	Pseudotsuga	1.27	.48	4.55		.68		1.12	.875	1.743	.56
	Rosa					.66	.55		0	.22	.275
	Rubus ideaus						5.94	4.59	0	0	5.265
	Rubus sp.		2.42	1.11	3.09	5.2	2.91	.57	1.21	3.13	1.74
	Salix		2.76	35.09	38.41	16.99	5.99	.46	1.38	30.163	3.225
	Shepherdia	.49	71.59	41.54	18.58	6.45	2.33	.72	36.04	22.19	1.525
	Spiraea				2.9	2.48	.6		0	1.793	.3
	Symphoricarpos		.48						.24	0	0
									0	0	0
	Total Shrubs	18.84	80.72	83.05	77.28	70.36	57.37	20.38	49.78	76.886	38.875

Elk Diet Composition From Fecal Analysis, Kootenay National Park, September 1986 - March 1987

FORAGE CLASS Genera	September Mean	October Mean	November Mean	December Mean	January Mean	February Mean	March Mean	Sept-Nov mean	Dec-Feb mean
GRASSES									
Agropyron	.63	.81	2.12				1.47	1.18	0.0
Agrostis		1.13	1.48					0.87	0.0
Bromus			2.12		3.51	2.51	.74	.71	2.01
Festuca	2.81	21.01	51.74	10.49	1.77	.96	26.89	25.18	4.41
Poa	8.80	42.67	25.35	27.26	4.96	3.20	14.60	25.61	11.81
Stipa comata		4.43				2.42	8.14	1.48	.81
seed & glume		4.15	.73	7.82	8.70	9.85	7.33	1.63	8.79
Carex	.88	3.95	1.39	4.91	19.17		1.43	2.07	8.03
Eriophorum					.81			0.0	.27
Total Grams.	13.12	78.15	84.93	50.48	38.92	18.94	60.60	58.73	36.11
FORBS									
Astragalus		.59					.85	.19	0.0
Cetraria (type)	1.52				.81			.51	.27
Composite	.71							.24	0.0
Equisetum	.71	3.74	.68				2.38	1.71	0.0
Medicago (type)	.71							.24	0.0
Vicia	47.91							15.97	0.0
Total Forbs	51.56	4.33	.68	0	.81	0	3.23	18.86	.27
SHRUBS									
Abies	.71				12.81	1.86		.23	4.89
Berberis	.11							.04	0.0
Juniper/Thuja		.79	2.92	2.99	2.49			1.24	1.83
Picea			2.84	7.93	2.66	5.78	3.01	.95	5.46
Pinus	1.68	1.49		25.97	24.49	30.96	9.36	1.06	27.14
Pseudotsuga					5.00	4.84	1.42	0.0	3.28
Rubus ideaus	1.52	4.96	.71				2.29	2.40	0.0
Rubus sp.	1.52		.68			.84		.73	.28
Salix	16.45	8.9	5.08	9.48	9.58	12.60	5.78	10.14	10.56
Elaeagnacea	12.73	1.38	2.16	3.15	3.24	19.70	9.66	5.42	8.70
Unk bark						3.58		0.0	1.19
Total Shrubs	34.01	17.52	14.39	49.52	47.46	78.30	31.52	21.97	58.43