Forest Succession and Range Conditions
in Elk Winter Habitat
in Kootenay National Park

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A Research Proposal submitted to the
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Introduction

1.1 Background

Wildlife highway mortality is a serious problem in Canada's National Parks. This problem affects ungulate populations, lowers public safety, and results in substantial economic costs (Damas and Smith, 1982). A significant level of highway mortalities of elk, white-tailed deer, and mule deer, occur in Kootenay National Park (KNP) (Damas and Smith, 1982, Poll et al, 1984). This has prompted the Canadian Parks Service to formally identify this problem as a park resource management concern (Kootenay National Park, 1984).

Research is needed to document the factors which influence the presence of ungulates on the highway right-of-way. Park management practices, both past and present, regarding forest fire suppression and resultant vegetation changes, manipulation of natural ungulate ranges, and present highway corridor maintenance practices, have concentrated animals along the highway (Kootenay National Park, 1984). The location of the right-of-way through the middle of critical habitat and seeding of the wide roadsides with highly palatable plant species has resulted in a very attractive forage resource for ungulates in the Kootenay Valley. This attraction, combined with conflicting transportation patterns has resulted in an unnatural reduction factor for the park's ungulates. An estimated 10% of the elk and white-tailed deer populations are being removed annually along the transportation corridor (Kootenay National Park, 1984).

1.2 Problem Statement

Fire suppression has been practised in Kootenay National Park since the parks' inception in 1920. This has likely resulted in a gradual reduction of open forest and meadow habitats available for ungulates in the montane valley bottoms. Older age forest stands may, however, have undergone self-thinning resulting in the reverse situation. The extent of change in forest cover must be documented to determine whether or not elk winter range in KNP has decreased over the last several decades.

In addition to the above, an assessment must take place to provide more information on the present condition of this rangeland. Since future consideration may be given to enhancing existing ranges, or creating new ranges away from the highway, baseline information on range condition would assist park managers in vegetation management and monitoring. Management actions which may take place in the Kootenay Valley would benefit from this assessment and the ability to repeat such an appraisal after any such action has taken place.

1.3 Hypothesis

In the absence of major fire in the Kootenay Valley since 1926, the process of forest succession has resulted in a reduction of open shrubland, grassland, and meadows in Kootenay. In the presence of other variables, the conditions created by a high percentage of forest crown cover result in the forest canopy being a major limiting factor in the growth of forage resources. The reduction in open shrubland and meadows has thus resulted in less forage resources available for wildlife.

1.4 <u>Limitations and Assumptions</u>

All field work pertinent to this study is specifically restricted to the critical wildlife habitat outlined in this study. All data analysis and evaluation is restricted to these areas. It is assumed that by quantifying and subjectively documenting significant changes in montane grassland/shrub habitats, historic changes in available elk winter range can be documented.

1.5 <u>Objectives</u>

1. To estimate the extent to which forest cover has encroached on elk winter range/white-tailed deer summer range in the Kootenay Valley of Kootenay National Park from earliest suitable photo record to present.

2. To discuss the extent to which the highway corridor grasslands have compensated for loss of native grasslands due to forest encroachment.

3. To determine the aerial coverage and relative abundance, and estimate the herbage biomass per hectare, of the grazing resource in each of the specified forest categories in selected montane ecosections of the Kootenay Valley.

4. To determine the browse species composition, standing stock, and utilization in each of the specified forest categories in selected montane ecosections of the Kootenay Valley.

5. To determine the density per hectare of canopy tree species in each of the specified categories of forest class in the selected montane ecosections of the Kootenay Valley rangeland.

6. To make recommendations for the use of this information in vegetation management of the elk winter range in Kootenay National Park.

1.6 Methods

A wide range of aerial photographs are available for KNP. Air photos will be interpreted and montane areas will be mapped. The extent of forest encroachment onto open areas will be measured. A graphical indication of forest encroachment onto open areas, since earliest air photo record will then be constructed.

The aerial photo comparison will be supplemented with less objective historical information gleaned from review of journals and archival materials. Sources of aerial oblique photographs exist from the fire lookout tower on Mount Daer. Photographs will be taken from similar angles for aid in comparison purposes. In addition, the timing and extent of clearing of the roadside will be documented through historical research and air photo comparison.

Present day range analysis will take place in a selected portion of the montane ecoregion of the Kootenay River Valley. The forage resources of different categories of forest canopy cover will be evaluated in this area. The Kootenay River Valley contains critical winter range for elk and moose and summer range for white-tailed deer (Poll et al, 1984), it is this area which is likely to be subject to the most intensive management actions in the future.

1.7 Definitions

KNP/Kootenay - Kootenay National Park.

Graze/Grazing Resource - all forbs and graminiods, and woody plants less than 25cm high.

Browse/Browsing resource - woody plants greater than 25cm tall and less than 6cm in diameter at 1.5m (dbh).

Canopy Species - woody plants greater than 6cm in diameter at 1.5m.

Transportation Corridor/Kootenay Parkway - Highway #93.

Stem - that portion of woody growth which protrudes from the ground.

Twig - that portion of a woody plant which is lateral from the stem and at least 5cm in length.

1.8 Summary

Highway mortality is a strong, unnatural factor which is placing continued stress on the ungulate populations in KNP. Measures to discourage use of roadsides should be coupled to enhancing or increasing habitat in other locations as alternatives to the roadside. Through documentation of habitat loss and accurate knowledge of present range conditions, management recommendations regarding the mortality problem and wildlife habitat may be better evaluated. The information gathered may form the baseline for a more detailed management plan and for future monitoring of trends resulting from attempts to emulate natural processes.

Chapter II

Review of Related Literature

2.1 Introduction

With man's interruption of the natural process of wildfire, the cycle of regeneration, which was common in many ecosystems in North America, is often no longer available to provide a great diversity of habitat for mammals. Elk habitats and food supply have been severely modified through human control of wildfire in North America. Fire was responsible for the creation of a mosaic of forest stands throughout the mountainous biome. This high diversity of natural habitat had resulted in a combination of forage and cover highly preferred by elk and many other wildlife species. Post fire succession of herbs and shrubs often provided excellent habitat for elk for 20-30 years after a fire, until the forest canopy again shaded out the ground level vegetation (Lyon and Stickney, 1966).

2.2 Succession and Fire

Succession, a directional change in a plant community which, barring interruption, follows a continuum from colonization to climax, has been compared to the developmental stages of an organism (Clements, 1916) with stages of birth, growth, maturity, and death. An ecosystem is such a type of organism, and is susceptible to exterior forces which may alter the stage of development along the continuum.

Fire is one of a multitude of forces which influence and control the development of ecosystems. The influence of fire dominates the history of forests as well as shrub communities and grasslands. With the possible exception of the wettest or coldest regions of the earth, all ecosystems on earth have been subject to periodic fires for millennia (Komerek, 1963; Spurr and Barnes, 1973).

Evidence indicates that most ecosystems in Canada have evolved with fire as a constant, if periodic, factor (Lohnes, 1981). Lightning fires have been noted as an integral part of our environment which, although variable in time and space, are rhythmically in tune with global weather patterns (Komarek, 1967). Lightning fires are an important factor in ecological succession in most forests and in maintaining a productive mixture of habitat types (See Figure 1). In natural ecosystems the vegetation regimes are seldom uniform but are a mosaic which represents all successional seres from pioneer to climax. This mosaic is that which is produced by fire.

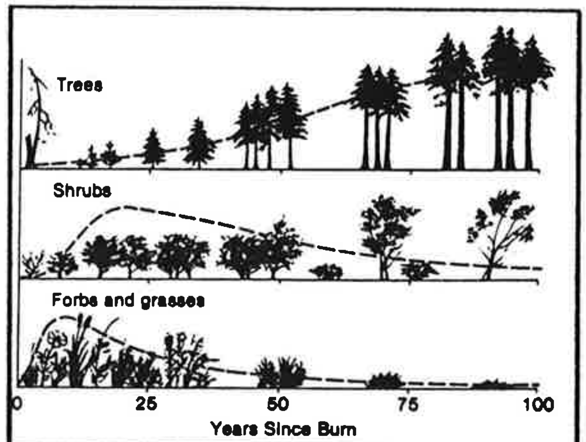

Figure 1. Natural postfire succession provides a succession from herbs immediately after fire, to shrubs, to a slow return of the forest canopy (from Lyon and Stickney, 1966).

Natural fires are normally limited in size and intensity (Lohnes,1981). Fires do not burn uniformly, often many unburned patches of vegetation remain within a burned area. This effect is a result of quantity and quality of fuel within the forest, the older and drier forest will burn whereas the patches of young, green vegetation will often not. The result is an ecosystem rich in biological productivity and diversity (Barbour et al, 1980).

2.3 Succession and Nutrient Cycling

Early successional species usually achieve rapid growth rates on the high, unutilized nutrient levels which occur after vegetation removal due to a disturbance. Provided with a mechanism for growth on suitable sites the succession begins. Colonizing species are able to maintain high growth and reproduction rates on the disturbance until the pulse of nutrients is diminished (Peterson and Bazazz, 1978). This growth pattern is known as the r-selection strategy.

Once the abundance of nutrients is used up the K-selection strategy becomes more dominant. Investment in roots and mycorrhizae increase, amount of carbon fixed and long-term occupancy of an area become prevalent and more effective use of nutrients occurs. As succession progresses, the accumulation of organic matter occurs in both the vegetative material and the organic debris present. The organic debris acts as an insulator which cools the soil as the biomass increases. Reduced soil and biomass temperatures slow the decomposition rate and promote accumulation of nutrients in the detritus. As this progression continues a higher moisture content in the organic layer allows the establishment of bryophytes. The establishment of moss is associated with a decline in chemical quality, further reduction in forest floor and mineral soil temperature and reduced organic matter decomposition (Van Cleve and Viereck, 1981).

The slowing of decomposition and resultant slowed nutrient cycling, result in increased deficiency with regard to nutrients important to tree growth (Heilman, 1966). Slowed tree growth and a longer term required for sexual maturation are thus characteristic of mature successional stages. Non-vascular plants and microbes become prevalent at this stage because they are effective competitors for reduced nutrient supplies (Van Cleve and Viereck, 1981). The result is a forest floor deficient of productive forage resources for ungulates.

As the mineral cycles close down and nutrient exchange between organisms and environment slow, the plant community begins to show age and self-thinning of the climax community occurs. At any point in time, fire or flooding may act to set the system to an earlier stage of succession. Fire, acting as a rapid decomposer, replenishes reservoirs of some nutrients, depletes others, and changes the albedo and thickness of the active layer. The nutrient conservation-reduced primary production stage is thus reversed to the start of a secondary successional stage (Van Cleve and Viereck, 1981).

2.4 Fire and Wildlife

There can be no doubt as to the effect of fire on wildlife habitat. After a fire sweeps through a forest ecosystem and one plant community is replaced by another, certain animal species find conditions unsuitable and their numbers recede, while other more highly specialized species disappear entirely (Monroe and Cowan, 1944). In the aftermath of such a situation a different aggregation of mammals move in, impelled by population pressure elsewhere. A different biota is eventually established, and as burned over areas become reforested this process reverses.

Fire has an immediate effect on wildlife populations, the major short-term effect being the change in food and cover. Growth of herbs and shrubs following a fire provides excellent food for a wide range of mammals, but especially for browsers such as deer, elk, and moose (see figure 1). Fire creates new habitat favoured by certain species (Revill, 1978). By returning a habitat to primary successional stages,

Year	Bulls	Cows	Calves	Yearlings			Unclass.	Total	Calves per 100 cows
				M	F	U			
1952	123	720	156			109		1108	22
1953	151	751	94			142		1138	13
1954	111	325	38			18	381	873	12
1956	83	414	11			64	446	1018	3
Oct 1962	36	191	138	35				400	72
Nov 1963	68	260	117	39				484	45
Nov 1964	58	223	101	22				404	45
Nov 1965	46	188	100	20				354	53
Nov 1966	64	155	80	17	56			372	51
Nov 1967	58	238	102	16	26		4	404	43
Nov 1968	34	160	75	21	43			333	46
Oct 1969	54	157	69	11	31			322	43
Oct 1971	25	76	50	10			107	268	66
Oct 1973	20	172	50	16	35			293	29
Nov 1974	6	71	31	6	32		37	183	44
Nov 1976	14	133	49	26	31		25	278	37
Nov 1979	7	155	55	27	14		62	320	36
Nov 1980								204	
Nov 1981	17	137	31	15	13		52	265	23
Nov 1982	21	154	64	17	7			264	42

Table 1. Maximum counts of elk in Kootenay National Park, 1952-1982 (from Poll et al, 1984).

that wildlife which requires such habitat is promoted, and species requiring later successional habitat are discriminated against. This is a natural ongoing cycle which, barring interference, continually reverses itself. Historical record indicates that a major fire may have occurred in the Kootenay Valley every 40 - 60 years prior to the parks's inception in 1920, with the last major fire occurring in 1926 (Munro and Cowan, 1944).

2.5 Elk In Kootenay National Park

Selection of habitat is conditioned by topography, weather, biological factors of forage and vegetation cover, and escape from recreationists, predators, and insects (Skovlin, 1983). Historical distribution of elk in Canada dictates a range from B.C. to southern Ontario (Banfield, 1974). The early records of elk in KNP are not well documented. Some records in park files indicate that elk were increasing in the 1930's and 1940's, perhaps in response to improved winter range conditions as a result of a major fire encompassing some 15,000 acres (park files) in 1926. Munro and Cowan (1944) listed elk as widespread and common in KNP, and Cowan (1943) suggested that the major winter range was fully stocked. Population estimates indicate that the elk population peaked in the early 1950's and has since been in decline (see Table 1), likely has a result of forest succession on the habitat which was created by the 1926 fire. Personal communication with park wardens has indicated that populations estimates for the 1950's are inflated (Poll et al, 1984); however the decline in population is apparent and is blamed on severe winters and an overstocked winter range in the late 1940's and 1950's. Table 2 lists the factors which interact to simultaneously influence elk habitat.

Table 2. Factors that influence habitat selection by elk (from Skovlin, 1982).

Topographic	*Food*
A. Elevation	A. Availability
B. Slope	B. Quality
1. gradient	*Cover*
2. position on slope	A. Cover type
3. aspect	1. thermal
C. Land features	2. hiding
Meterologic	B. Density
A. Precipitation—snow	C. Composition
1. depth	D. Site productivity
2. condition	E. Structure
B. Temperature	F. Successional stage
1. solar radiation	G. Configuration
a. radiation	*Space*
b. convection	*Water and salt*
C. Humidity	*Specialized habitats*
D. Barometric pressure	A. Calving
E. Wind	B. Wallows
1. velocity	C. Trails
2. direction	

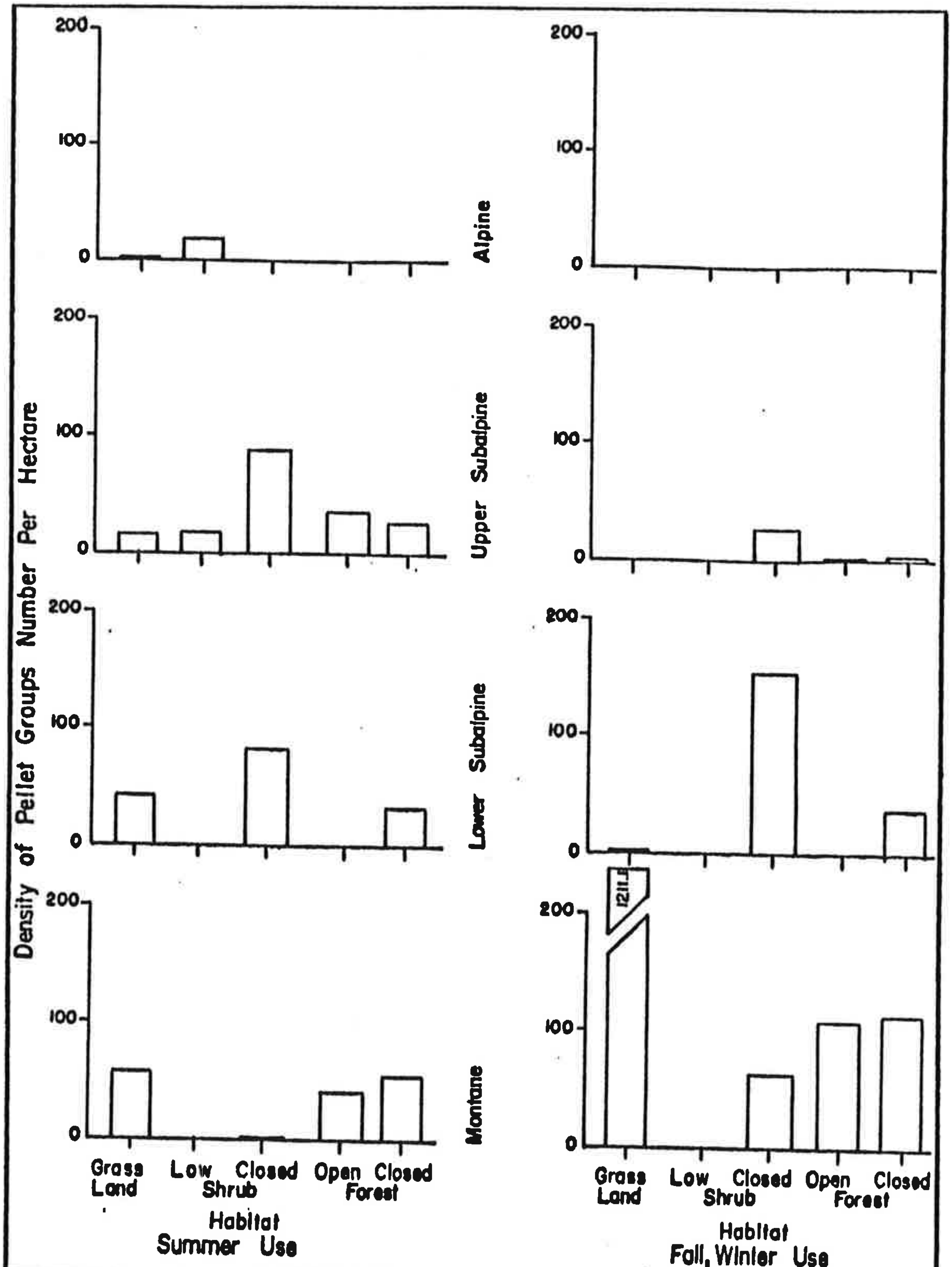

Figure 2. Elk seasonal use by Ecoregion KNP from pellet count data (from Poll et al, 1984).

Vegetation type	Pellet groups /ha	Description
Spring and early summer		
C3	78.6	lodgepole pine/juniper/bearberry
C11	100.0	lodgepole pine-spruce/feathermoss
C16	175.0	aspen/hairy wild rye-peavine
C25	108.3	Engelmann spruce-subalpine fir/green alder
C39	70.6	lodgepole pine/buffaloberry/bunchberry
C41	100.0	white spruce-subalpine fir/bunchberry-horsetail
H8	175.0	yellow dryad-willow herb
H19	195.0	bluebunch wheatgrass-hairy wild rye-showy aster
O11	133.3	spruce/labrador tea/brown moss
O14	75.0	Engelmann spruce-subalpine fir/rock willow/bracted lousewort
S2	77.8	subalpine fir-willow/valerian avalanche
S5	88.9	lodgepole pine/twinflower-fireweed burn
Late summer, autumn and winter		
C1	108.8	Douglas fir/hairy wild rye
C9	175.0	lodgepole pine/dwarf bilberry
C16	325.0	aspen/hairy wild rye-peavine
C37	205.0	white spruce/buffalo berry/feathermoss
C44	177.8	spruce-aspen-lodgepole pine-(paper birch)/buffaloberry/pine grass
H8	600.0	yellow dryad-willowherb
H11		beaked sedge-water sedge
H10	759.0	bluebunch wheatgrass-hairy wild rye-showy aster
O11	516.7	spruce/Labrador tea/brown moss
S1	312.5	birch-shrubby cinquefoil-willow/brown moss

Table 3. Highly important vegetation types for elk in KNP from pellet count groups (from Poll et al, 1984).

Elk occupy a variety of habitats in all three ecoregions, montane, subalpine, and alpine, during the summer in KNP. With the onset of winter the elk migrate from the lower subalpine slopes and valley bottoms in the Vermillion drainage system to the montane valley bottoms of the lower Vermillion and Kootenay River Valleys (see figure 2), where the snow accumulation is the lowest. Snow accumulation is a major determinant of the extent of winter range the least accumulation occurring in the Wardle Flats area of the Vermillion Valley, and between Kootenay Crossing and McLeod Meadows in the Kootenay Valley

(Poll et al, 1984). The optimum diet for elk consists of a mixture of shrubs and grasses (Poll et al, 1984), see table 3.

Even more representative of habitat alteration, changes in moose populations suggest major change in the vegetation regime of Kootenay National Park. The abundance of moose in Kootenay National Park has undergone more dramatic fluctuations than has any other ungulate in park. Records from early park files indicate that moose were relatively common in the 1920's and underwent a dramatic increase though the 1930's (Poll et al, 1984). Since moose tend to favor shrubby, subclimax habitats created by interruption of natural succession by processes such as fire, it is only natural to assume that the moose populations increased in the Kootenay Valley as a result of the habitat created by the 1926 fire. The fact that moose were considered common in the 1920's suggest that much greater parkland (shrub and deciduous forest) habitat existed in the park than what is present today. Although estimates from 1939 onward indicate that moose were decreasing steadily from the supposed 300 plus existing in the Kootenay Valley in the mid 1930's they were still considered the second most abundant game animal in KNP in the 1940's (Munroe and Cowan, 1944). Today, park wildlife cards indicate an average of 21 animal sightings and it is considered unlikely that there are more than 75 animals in the entire park (Poll et al, 1984).

2.6 General Parameters of Vegetation Sampling

The scientific need for accurate measures and descriptions of species and communities has made it necessary to sample. For descriptive purposes, comparative purposes, and as a base for experimental or managerial purposes, the characterization of plant communities is a necessity. Usually the members of an entire association cannot be counted or measured due to the size or volume of the community. Vegetation sampling is a means by which an investigator can make inferences about a plant community based on information gathered from an intensive examination of a small proportion of the population. Based on a true characteristic of the plant community inferred statistics are developed. Development of a sampling scheme that closely approximates the actual parameters of a community has been the guiding principle in the evolution of sampling methodology

There are many different types of sampling schemes employed today. These are basically determined by the parameters one wishes to investigate. The various general parameters include cover, production, biomass, utilization, density, and frequency. These parameters are often interrelated and very dependent upon the vegetation type being sampled. Cover is defined as the proportion of the ground which appears covered when viewed from a position perpendicular to the community. Productivity is the rate of change in biomass per unit area over the course of a growing season or a year. Biomass is the weight of vegetation per unit area; synonyms often used are standing crop or stock and phytomass. Utilization is the amount available vegetative matter which is harvested, usually by animals, in a particular season. Density is the number of plants rooted within each quadrat, and frequency is the percentage of total quadrats which contain at least one rooted individual a given species.

It is very important that the sample quadrats provide an unbiased estimate of the parameters of the vegetation being studied. Knight (1978) states four rules which should always be followed: (1) Sample points should be distributed throughout the sample units and not just within a small portion of the sample unit. (2) Sample points should be located without any bias of the investigator. (3) Sample points should be located for enough within the sampling unit to avoid transition zones and the edge effect created by highways, river, and so forth. (4) The objective selection of random sample points is best accomplished with the use of a random numbers table.

As sample plots must be distributed randomly in the area, methodology involving conscious or unconscious prejudgement (or subjectivity) must be eliminated (Kershaw, 1973). Subjective judgments are those which are made on the basis of values, feelings, and beliefs. Interpretation of data, or the designing of sample schemes, subjectively, renders scientific accuracy impossible in an analysis. Objective judgments, on the other hand are those which involve or use facts that are observable or verifiable, by scientific methods, which do not depend on personal reflections, feeling or prejudices. This does not suggest that knowledgeable persons will always make the same objective judgments. There is much disagreement among scientists and other scholars on important points of theory and interpretation of data.

Selecting the proper size and shape quadrat is very important for effective sampling and is directly related to the type of vegetation being sampled. After reviewing the literature (Barbour et al, 1980; Cain and Castro, 1959; Clapham, 1932; Daubenmire, 1968; Kershaw, 1973; Lyons, 1968; and Van Dyne et al, 1963.) the following generalizations can be presented:

(1) The type of vegetation community being sampled and the parameter being investigated should determine the plot size and shape.

(2) Optimum plot size and shape depends on the distribution of the species being studied, (i.e larger plots are needed for sparser vegetation.

(3) Small sample units, although generally easier to use, have the potential to yield unrealistic data as vegetation species tend to be grouped together.

(4) More species are generally included in long, narrow (rectangular) plots.

(5) The larger the number of plots sampled and the further their distribution - the higher the total number of species encountered.

It is generally agreed that rectangular plots are more accurate because species tend to be grouped together and a rectangular plot has a higher chance of intercepting several groups without falling within the enclosure of one. A disadvantage of the long, narrow plot is a large margin in proportion to their area. This can be a problem when tallying density or basal area (Daubenmire, 1968). Marginal area can cause confusion in determination as to whether or not a species should be included in the list, this is best solved simply by the inclusion of any species which had any portion of its aboveground biomass appear within a plot.

In sampling a plant community it is evident that the amount of species encountered rises rapidly at first and then the amount of new additions decline until it is no longer useful to sample more plots. A determination of the minimal, adequate sampling area is thus useful in four ways (Daubenmire, 1968): (1) Determination of the least amount of area which need be studied to gather an accurate estimate of the parameters in question. (2) The smallest sample is the most desirable for specific correlation of biotic assemblages with environmental factors. (3) The sample used to characterize a stand is equal to the minimal area, and (4) the minimal area serves as an additional trait of the diversity and richness of an association.

2.7 Assessment of Range Condition

Traditionally, differences of opinion have always arisen as to whether range condition should be measured giving emphasis to rangeland productivity (Humphrey, 1949) or to vegetation change (Dyksterhuis, 1949). As the concept of range condition entails many attributes the most functional approach to measurement of range condition will be an approach which incorporates methods from both frameworks. Areas of primary concern are vegetation composition, productivity, and land stability. Whatever the attribute in question is, or whether the management option is to enhance the range for wildlife or domestic stock, the range condition must be measured in terms of vegetation.

Each vegetation measure will place different emphasis on the various forms of plants in the community (Wilson and Tupper, 1982). Biomass gives primary emphasis to large species and provides valuable information on the potential food base for wildlife and domestic livestock (Walmsley et al, 1980). Canopy cover is correlated with biomass but tends to give more emphasis to prostrate species (Wilson and Tupper, 1982). Basal cover is a related measure used on perrenial grass communities (Brown and Chambers, 1983).

When natural communities are being dealt with, an assessment of vegetation composition and ground coverage should be included in the analysis. If sample sites are to be used for future analysis of range trend then analysis of species composition is certainly required. By correlating cover/species composition and biomass of the grazing resource, and relative abundance, standing stock and utilization of shrub species, a relatively accurate assessment of present range condition and change over time can be achieved.

As forage production in the forest zone declines with increasing canopy cover (Dodd et al, 1972), measurements of forage resources can be correlated with tree crown cover estimates from air photos. Assessments in different categories of canopy cover can then be compared to historical air photos to estimate the forage resource at different years within specific ecosections.

2.8 Summary

Forest succession is a cyclic process by which natural vegetation associations alternate the r-selection and K-selection strategies of community development. Fire, which plays a natural role in this cyclic process, has largely been removed from its role in developing vegetation mosaics.

A lack of diversity in vegetation communities has removed much of the forage resources in combination with edge effects, this mixture being highly prized by large ungulates. Fire suppression in Kootenay National Park, a result of political boundaries and lack of knowledge in the role of wildfire, has allowed forest succession to remove open meadow and shrub habitats and replace these resources with uniform forest stands. The result has been a corresponding lack of forage in the winter habitat for elk. The montane ecoregion is noted as being critical winter habitat for this species.

The removal of grassland and shrub habitat must be quantified, and the present condition of the winter range must be assessed. Academic debate continues regarding the use of species attributes vs. production attributes for range analysis. For this assessment, a two-pronged approach, botanical composition and production/utilization will result in an accurate assessment for the purposes of this study.

Chapter III

Methodology

3.1 Overview

Vegetation change through the later history of the park will derived from air photographs with historic photos and documents to aid in subjective comparisons. All data on the present range condition will be evaluated from sample points located by range transects. Each sample point will locate a vegetation quadrat, clip plot, and random point. The quadrats and clip plots will yield quantitative measures reflecting the present condition of the grazing resource of the elk winter range in Kootenay National Park. The random points will be used for point centered quarter analysis of the browse resource, and information on canopy species density. These transects will be permanently located to provide a replicative measurement system for future monitoring of range trend. The methods used for data collection and analysis are widely recognized, statistically valid, and are designed to minimize subjectivity.

3.2 Study Area

The study area is known as the Kootenay River Valley. The elk winter range is primarily restricted to this valley bottom. The air photo analysis shall be restricted to the montane ecoregion displayed in figure 3, and the range analysis shall be restricted to a smaller portion of the montane ecoregion which is recoginized as critical habitat. The Ecological Land Classification (ELC), (Poll et al, 1984),

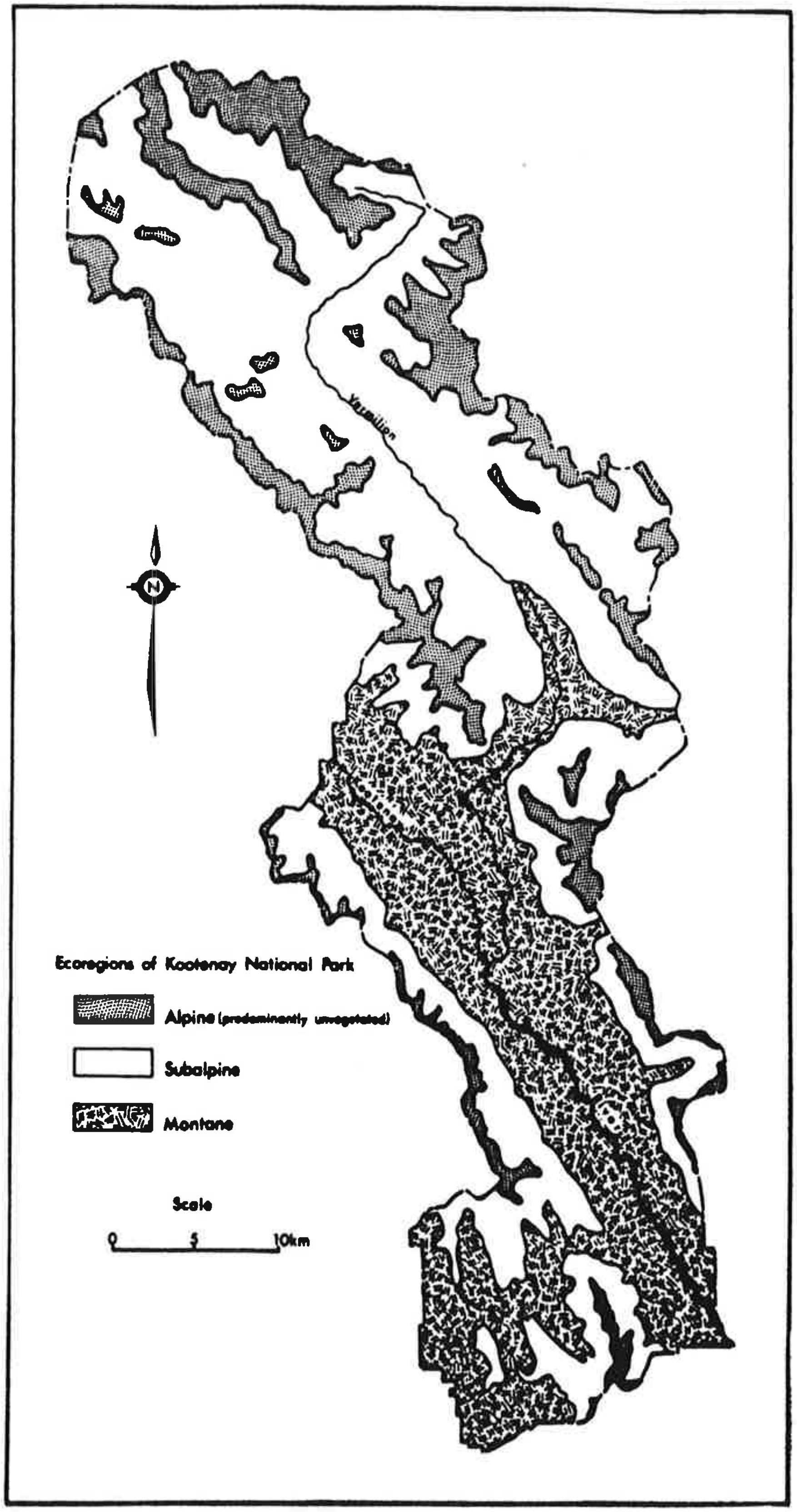

Figure 3. Ecoregions of Kootenay National Park (from Achuff et al, 1984).

notes this area as containing critical winter range for elk and moose and summer range for white-tailed deer, and indicates the importance of fluvial and morainal landforms in this valley. As the optimum winter diet for elk consists of a mixture of shrubs and grasses (Poll et al, 1984) the range analysis will be confined to the valley bottom which is most likely to support these lifeforms.

All range transects will be established below 1212m (4000 ft), inclusive, between Nixon Creek/Pitts Creek trails and the East Kootenay Fire road south of Kootenay Crossing. This restriction will include all montane (FR, AT, VL, HD) ecosections noted highly important to elk and also includes some glacial (DR) ecosections. Figure 4 illustrates the relationships among ecosites in the Kootenay Valley; most winters the elk remain confined to the fluvial ecosections.

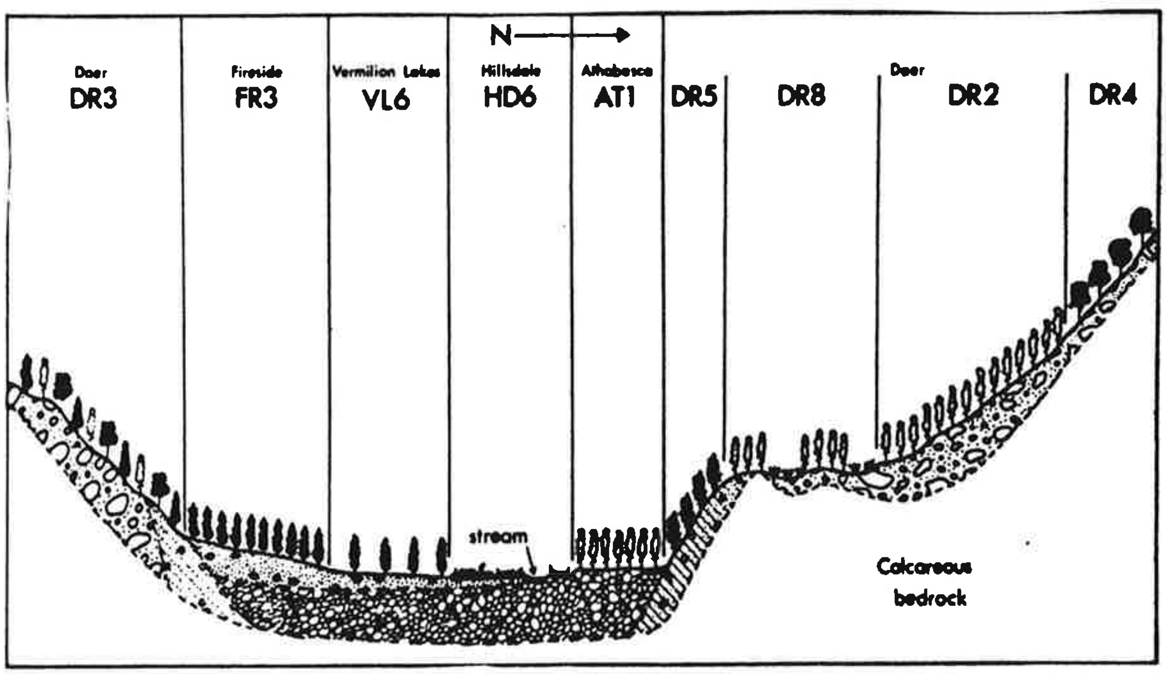

Figure 4. Landscape schematic of topographic relationships among ecosections in the Kootenay Valley (from Achuff et al, 1984).

3.3 Range Transects

The location of the range transect shall be chosen according to the amount of crown canopy cover. Dodd and others (1972) have concluded that air photo analysis is very useful in initiating range surveys of forage production in coniferous forests, and suggested that crown cover classes be divided into four categories: 0-20%, 21-35%, 36-55%, and greater than 55%. As these categories are very specific and difficult to indentify on older photo sets, forest crown cover shall be divided into the following classes for each set of air photos analyzed: greater than 40%, 10-40%, and less than 10%; within the first two canopy classes the vegetation will be broken down into the following types: pine forest, white spruce/Douglas-fir forest, mixed forest (deciduous and conferous), and within the last canopy class vegetation shall be divided into wet meadows, and dry meadows. Ground checks will be made in each vegetation type to ensure proper interpretation of air photos. The vegetation canopy types chosen reflect the prime objective of quantifying forest encroachment onto open areas.

Each range transect will be located within a homogenous vegetation association representative of that forest class; and will avoid transition zones. Vegetation quadrats and random points will be located with the stratified random method (Knight, 1978). A 200m baseline will be located through the middle of the sample unit. Points along this baseline will be spaced 20m apart. Using the first two digits on a random numbers table a paired quadrat/random point will be located that many metres perpendicular to the baseline. If the random number is even the sample point is on the right; if it is odd it is on the left-hand side of the baseline (this is determined by the baseline facing predominantly north or west). The furthest peg from the baseline will be considered the random point, this point is numbered, the second peg will be aligned on the perpendicular axis from the baseline, these two pegs correspond to two holes in the sampling frame. Sampling size will primarily be limited by time constraints, however, an attempt will be made to place at least two transects (20 smaple points) within each vegetation type.

3.4 <u>Data Collection - Vegetation Change</u>

Air Photos exist for KNP with dates ranging from 1924 to 1982 and scales from 1:5,000 to 1:66,000 (Map and Air Photo Reference Library - Edmonton; National Air Photo Library - Ottawa; Northern Forest Research Centre, Edmonton). Air photo interpretation will take place to determine different categories of crown forest class in the montane region of the Kootenay Valley. Estimation of crown cover density will take place using an overlay dot grid or a crown density scale, with ground checks at each range transect. Forest type in the montane ecoregion of the Kootenay valley will then be interpreted and mapped onto a 1:50,000 scale map using a Bausch and Lomb Stereo Zoom Transfer Scope. The zoom stereoscope is capable of enlarging viewing areas and also contains an eyepiece rotation mechanism which can optically correct the "crab" encountered on aerial photographs caused by drifting of the imaging platform from the intended flight line (Ambrosia and Whiteford, 1983).

By converting all photo scales to the 1:50,000 or 1:25,000 map scale and mapping the vegetation type for the latest suitable photo record, 1978, and for the earliest 1954 or 1945 (whichever can be used) a graphical indication of tree and shrub encroachment onto open areas can be provided for this time span. Although a 1924 set exists for the the Kootenay Parkway it is presently not known whether the coverage is sufficient for this purpose. The values determined for forage resources from the present assessment may be then be applied to the earlier air photos as they are mapped, and a graphical indication of the estimate of change in forage resources may be attained. This estimate can take place by forage class (forbs, graminoids, shrubs) per canopy type only, because it is impossible to know what the species composition was at the time of the photo.

The measurement of different forest canopy areas in each photo record will be accomplished by the use of a numonics planimeter, or if available, a G.I.S. (SPANS) computer program and digitizer. The numonics planimeter is operated by tracing the outline the outline of the desired area in a clockwise direction using the planimeter arm, which automatically records the area of various scales with readouts in user required measurement units (Alberta Remote Sensing Center, 1988).

Areal measurements can be calculated quickly and accurately with an electronic digitizing system. Digitizing is the process of assigning coordinate X-Y values either to points and drawing a line between them or to a symbol such as a circle representing a pole. A microcomputer can assign binary values to a map, line by line and symbol by symbol, and store them in digital form (Ambrosia and Whiteford, 1983). If a G.I.S. (Geographic Information System) is available for digitizing, the method of operation will be explained in more detail.

The aerial photo comparison will be supplemented with less objective historical information gleaned from review of journals and archival material, and observation and comparison with historic photographs. Aerial oblique photographs exist from fire lookout tower on Mount Daer. These photos will be duplicated for subjective comparison purposes. As the highway corridor has enlarged forage resources in its periphery, the timing and extent of clearing associated with the roadside right-of-way will be documented from historic material and aerial photographs.

3.5 Data Collection - Range Condition

Paired Vegetation Analysis Quadrats will be established for collection and comparison of this data from the different forest canopy zones which will be determined from the air photo analysis. Sampling from these quadrats will take place by point quadrat analysis of species composition and coverage, and clipping of vegetation. Range Condition will be measured by comparing the percent coverage by species, the proportion of bare ground and litter, and the available biomass per forage class. Amount of biomass of the grazing resource will be collected from the quadrat adjacent to one used for determination of species composition. The coverage of palatable and non-palatable species, as determined from Poll, 1984, will then be compared.

The point quadrat method (Brown and Chambers, 1983) can be used to determine aerial and or basal cover and the species composition within a plant community. Five pins will be lowered at five intervals within each quadrat for a total of 25 strikes per quadrat. The individual sharpened pins are lowered down through the vegetation canopy and the first vegetation contact or first contact with bare ground, gravel, rock, or litter is recorded (note that woody material above 25cm is not recorded in this stage of analysis). Percent aerial cover for each species equals the sum of all first hits on vegetation divided by the sum of all first hits on vegetation plus first hits on bare ground, gravel, rock, and litter. All species data will be converted to forage classes for statistical analysis, the level of variability in nature is such that would be impossible to arrive at a statistically valid sample in the more complex vegetation types without a much larger sampling effort. As the same design must apply to all sampling the same analysis will be applied throughout.

Productivity of the grazing resource, in terms of available biomass at the time of sampling, shall be measured by the harvest method. The available aboveground vegetation is harvested from the three dimensional volume of the quadrat (Brown and Chambers, 1983). The vegetation within every second $0.75m^2$ quadrat is clipped to ground level using hand shears or clippers. Parts of plants that are rooted within the quadrat but do not occupy space within the volume are not harvested, while parts of plants that are not rooted within the quadrat but overlap into the volume are harvested. Vegetation is separated by forage class (forbs, graminoids, woody material below 25cm), oven-dryed to a constant weight (air-drying may be used if difficulty arises in accessing a drying oven), and then weighed. Dry weights are recorded by forage class for each quadrat. Total biomass per hectare and percent composition per forage class are then calculated using the following formulae. An inference may then be drawn toward species biomass by correlating the information from the pin-drop with the information from the harvest.

$$\text{Biomass} = \frac{\text{Total of dry weight values}}{\text{Total \# of quadrats sampled}} \times (\text{Quadrats per area conversion factor})$$

$$\text{Percent Composition} = \frac{\text{Biomass for forage class}}{\text{Total Biomass for all classes}} \times 100$$

Browse Composition and Utilization will be determined at each sample point using the point-centered quarter method (Barbour et al, 1980). Quarters are set between true north and east, east and south, south and west, and west and north. The closest clump of browse greater than 25cm high (a clump may be one living stem or several) in each quarter is analysed and the distance from the random point is measured. The species is noted. The number of stems in the clump are counted. Twig counts on the closest stem will take place in the forage availability zone for elk, which is from zero to approximately 2.3m from the ground (Nelson, 1982), and will be multiplied by the number of stems in the clump.

Twig counts will note the number of twigs which are current year's growth and the number which are previous years' growth; assuming that the current years growth has not yet been subjected to much browse pressure the count will then note the number of browsed twigs versus the total number of twigs of each type. The density of stems and twigs (browsed and unbrowsed of each age type) per hectare can then be calculated for each species, using the density equation below. The percentage of twigs browsed in previous years' will provide an indication of the present level of use per each shrub species and the total number of unbrowsed twig will provide a measure of the standing stock available for the coming winter.

Twig counts will be converted to weight measurements to provide estimates of standing stock and utilization of browse per hectare. An average diameter-at-point-of-browsing (dpb) will be defined for each species after Shafer (1963), and twigs of each species will be clipped and weighed, distal to the defined diameter. Measurement of the dpb of each species will take place on 100 twigs of each species, the mean will be calculated and the standard deviation added to the mean, as utilization has the possibility of being higher than the mean (Telfer, 1981). One hundred twigs of each species from the surrounding community will be selected at random and clipped at the dpb for each species. These twigs will then be dryed in the same fashion as the forage resource and weighed. The mean weight can then be multiplied by the number of browsed twigs per species to arrive at a weight estimate per hectare for utilization, and can be multiplied be the number of unbrowsed twigs to arrive at a weight estimate per hectare for standing stock or available browse.

A height of 25cm is used to determine a browse clump, this was arrived at by determining the mean snow depth value for Kootenay Crossing weather station for the past eight years in the months of December, January, and February. As the height at which a plant is used is somewhat less than the mean snow depth (due to cratering, etc.), the standard deviation was subtracted from the mean to arrive at the figure used. Woody species less than 25cm in height are recorded in the quadrat analysis of the grazing resource.

Density of canopy species will also be determined at each sample point using the point-centered quarter method in the same fashion as above (Barbour et al, 1980). Each tree is identified and its distance from the random point is measured. Average distance for all trees taken together is computed and this is converted to total density per hectare by the following formula. Basal area will be noted and applied to an age class conversion factor.

$$\text{density/hectare} = \frac{10{,}000}{(\text{average distance in metres})^2}$$

3.6 <u>Sample Site</u>

Each site will feature a vegetation composition/coverage quadrat, an adjacent clip plot, and a random point marker. Two marker pegs will be used for each site. The furthest marker peg from the baseline will be used as a random point for the point-centered quarter analysis of shrub composition, and canopy density. The quadrat aligns two holes in the frame over the marker pins for placement for re-analysis. The species composition analysis takes place on the right side of the pegs, the frame is then reversed for the clip plot analysis which will take place on the left of the pegs, the position of the holes in the frame being reversed (right and left are determined facing away from the range transect. The peg farthest from the range transect is used as the random point for the point-centered quarter analysis.

In order to provide for relocating, each transect and sample site will be mapped and identified by a reference number. The sites will be marked with two 1m pegs (the placement of the pegs corresponds to two holes in the quadrat frame), at vegetation height above ground, which will be engraved with an identification number. The following information will be recorded for each site: site identification number; location and vegetation type; and date established.

3.7 Details

The sampling grid will measure 750x1000mm inside, and will be constructed of lightweight steel. This grid will employ levels and adjustable legs to ensure horizontal placement at the vegetation level. The grid will be fitted with a removable pin frame which guides the placement of pins to ensure a vertical angle at every 200 millimetres for the length of the quadrat, five pins across the width of the quadrat, each pin being placed at 150mm. The grid will feature a 10mm hole in two adjacent corners on one edge for accurate grid placement in the field.

All photos and slides will be taken with a Contax 137 Quartz using a 50mm Zeiss lens for panoramic photos. F-11 will be the aperture used, and Fujichrome 100 slide film will be used for film as this film is more sensitive to the green of vegetation than are other brands.

All vegetation will be identified with reference to field manuals. Species which cannot be identified will be collected from adjacent areas and mounted for later identification. Species proving difficult to identify will be identified by a taxonomist.

Manuals to be used:

Cunningham, G.C. 1958. Forest Flora of Canada. Bulletin 121. Forestry Branch, Department of Northern Affairs and Natural Resources. Canada.

Kuijt, J. 1982. A Flora of Waterton Lakes National Park. University of Alberta Press.

Pohl, R.W. 1954. How to Know the Grasses. WM. C. Brown Company Publishers. Dubuque, Iowa.

Scotter, G.W. and H. Flygare. 1986. Wildflowers of the Canadian Rockies. Hurtig Publishers Ltd. Edmonton, Alberta.

Canadian Department of Forestry. 1963. Native Trees of Canada. Queen's Printer and Controller of Stationery. Ottawa.

3.8 Recording Data

All data will be recorded on forms prepared for the purpose and then input to a computer for statistical analysis.

3.9 Statistical Requirements

Vegetation research in the field has usually required the use of quadrats 0.5m to 1.0m square for the type of vegetation expected to be encountered in the herbage assay (Barbour et al, 1980; Brown and Chambers, 1983; Cole, 1978, 1983). By reason of this data the $0.75m^2$ quadrat is expected to produce accurate results for this study. The number of quadrats used in each site will be determined largely by the amount of time available to the investigator. Statistical analysis by forage class will take place to later test the standard deviation of the mean for the sample size.

To determine whether all transects within each forest type are placed within similar plant communities, Bray and Curtis' (1957) version of Sorenson's Similarity Index will be used. This is a simple direct method of comparing the plant communities represented in each transect. Similarity indices are a function of the number of plant species or plant life forms found in both communities as well as the number found in only one community or the other. Bray and Curtis' (1957) version is a computational simplification of the similarity indice which requires the use of percent values for each species or life form rather than the importance values.

$$\text{Index of Similarity} = \frac{2\ MW}{200} \times 100$$

MW = Sum of the smaller importance values of the species or life-forms common to both areas.

All vegetation analysis will take place after August 20th or later to allow for all plant species to reach the reproductive stage of their life cycle in the different cover categories. Although the biomass of forbs will have begun to decline by this time, this will cause little concern as this study is primarily concerned with forage resources available for the winter season.

3.10 Data Analysis

Data from each variable, for each area, will be combined. All variables of each analysis shall be subjected to standard statistical tests using mean, standard deviation, t-tests, and associated probabilities where applicable. Data from each vegetation quadrat will be combined for each forest type to derive the mean percentage cover per species, and biomass per forage class/per hectare for each area. Data from each random point will likewise be combined to determine the browse resource, percent by species and weight factors of standing stock and utilization per species for each forest type.

3.11 <u>Data Evaluation</u>

The document will accurately portray all data gathered and analyzed during the course of this study, and all methods and requirements for further study will be qualified. The relationships between the variables and the results will be explained, and methods of analysis and evaluation will be outlined. If applicable, hypothetical situations may be used to clarify data evaluation and the use of information in the management process.

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Bray, J.R. and J.T. Curtis. 1957. An ordination of the upland forest communities of southern Wisconsin. Ecological Monographs 27 pp.325-349.

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Appendix

Budget and Time Frame

Literature research for this project began in June, 1988. Field research shall take place during the August-October period, with air photo analysis occurring prior to the field work and after completion of the field work. Analysis and writing will take place primarily during the fall and spring. Completion is expected in April, 1989.

Action	Time Scale
Literature Research	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
Preparation of Equipment	XXXXXXXXXXXXXXXXXXXXXXXX
Air Photo Analysis	XXXXXXXX XXXXXXXX
Site Establishment	XXXXXX
Statistical Requirements	XXXXXXXXX
Vegetation Analysis	XXXXXXXXXXXXXXXXXXXXXXXXX
Data Analysis	XXXXXXXXXXXXXXXXXX
Preparation of first draft	XXXXXXXXXXXXXXXX
Preparation of Final Draft	XXXXXXXXXXXX
Duration	June/July/88 August Sept. Oct-Dec./88 Jan.April/89

It is understood that changes in this schedule may take place from time to time. Completion date will continue to be April, 1989.

Budget Estimate

Salary - Principal Researcher

.......................$1000.00/month for June-October/88 (incl)

--summer salary is calculated at $10.00/hour for 37.5 hours a week, which is slightly less than the wage for a 4th year undergraduate student on the Co-op program.

Summer Salary $5000.00

......................$200.00/month for Oct/88-March/89 (incl)

--fall/winter salary is a stipend for a minimum 15 hrs/week expected to take place in mapping, data analysis, evaluation, and document preparation.

Fall/Winter Salary $1200.00

Salary Total...............$6200.00

Expenses

<u>Travel Expenses</u>.........($80.00/day for approx. 1 week literature research in Calgary and Edmonton, and 2 weeks air photo analysis in Edmonton.)

........................$1680.00 .. client.

........................$200.00/month for Aug., Sept. and October for travel involved in completing field analysis.

.........................$600.00 ..deficit

<u>Apparatus and Equipment</u>

Field Equipment: packs, sleeping bag, photographic equipment, quadrat equipment, will be provided by the principal researcher.

<u>Measurement Wheel</u>.. client.

<u>Pocket Transit</u>..... client.

<u>Pegs for Range transects and sample site locations</u>.. client

<u>Film</u>...................$51.00 ...client.

<u>Computer Cost</u>

Microcomputer for analysis and writing provided by the principal researcher.

Mainframe................$1000.00 ($500.00/hr for document text printing; provided by N.R.I.

<u>Office Expenses</u> ....$100.00 ..client.

<u>Long Distance Telephone Charges</u>

........................$300.00 ..client.

Report Material...publications, symposiums, thesis reports.
.........................$200.00 .. deficit

Cartography and Plates in Document
.........................$500.00 .. client.

Total Expenses.............$4431.00*

*$1000.00 of laser printer computer text processing reduces the total expense to $3431.00.
Covered by client $2631.00

Basic expenses are covered by the client, the client being Kootenay National Park, British Columbia.
-present expense deficit on principal researcher--$800.00

Total Project Budget..$10,631.00

The amounts shown in the respective categories of the above "Budget Estimate" are estimates, and it is the intention that changes from item to item will be accepted for billing purposes as the work proceeds.

Total deficit on principal researcher is equal to $7000.00