WINTER HABITAT SELECTION AND USE OF CLEARCUTS BY ELK IN THE WHITE RIVER DRAINAGE OF SOUTHEASTERN BRITISH COLUMBIA

by

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Abstract: This study of elk winter habitat selection was conducted from June 1975 to May 1977. Surveys were conducted from November to April to observe elk use of habitat, patterns of use within clearcuts, and elk reaction to human activities and vehicle traffic. Programmes of habitat mapping, vegetation description and pellet group counts were conducted during the rest of the study period.

The two winters of the study were mild. Snow depths never exceeded 45 cm, the depth hypothesized to initiate elk movement to areas of lower snowdepth. During these mild snow conditions elk selected clearcuts for feeding but utilized forested habitats for resting and escape cover. Subsequent studies in the same area (McLellan 1978) showed contrasting avoidance of clearcuts for two months during deep snow conditions where snowdepths exceeded 50 cm.

Within clearcuts elk were observed to select moderate slopes further than 200 m from active roads for feeding and resting. Feeding activities within clearcuts showed selection for ridges, grass/forb vegetation and burned areas. Elk showed varying responses to slash accumulations during feeding activity. Elk selected the largest clearcut site and no preference for areas near edge of clearcuts was shown. Elk showed a strong avoidance reaction to human activity and vehicle traffic, fleeing to forest cover when disturbed. Recommendations for forest management are included.

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1.0 INTRODUCTION

Clearcut logging extended into mid-elevation sites in the East Kootenay region of British Columbia during the late 1960's and early 1970's. Logging was often concentrated in areas where forest diseases or pests were affecting timber values.

The mountain pine beetle (Dendroctonus ponderosae) is endemic in lodgepole pine (Pinus contorta var. latifolia) stands in southern British Columbia. Epidemic outbreaks of this insect are common in maturing lodgepole pine stands with up to 90% of the lodgepole pine in a stand killed within a 5 to 10 year period (Safranyik et al. 1974). An outbreak of mountain pine beetle in the mature pine stands in the White River drainage in southeastern British Columbia led to sanitation-salvage-logging of infected stands. Since 1970 this logging led to the clearcutting of a number of large blocks (greater than 80 ha) in the White River drainage.

The White River drainage has been recognized as an important area for wildlife, particularly elk (Cervus elaphus nelsoni), since the early 1900's. The large White River Game Reserve was created in 1936 as an early attempt to preserve wildlife. More recently, portions of the White River drainage have been observed to be winter habitat for elk (Demarchi pers. comm.). A review of recent literature on the winter ecology of elk and other ungulates (Bunnell 1978) shows that winter weather, especially snow-depths, determine winter habitat use.

Present management of wildlife in British Columbia is more dependent on active participation in multiple resource planning than blanket protection. Effective multiple resource planning depends on informed input based on an understanding of the basic ecology of wildlife species and an understanding of the impacts of logging, mining, road construction activities, and other human activities on wildlife. Insufficient data were available to evaluate the impacts on elk of large clearcut openings in forest habitats. Such data were essential if the British Columbia Forest Service was to plan logging while protecting essential elk habitat requirements for multiple use of these two resources, timber and elk.

The mountain pine beetle infestation was expected to spread, more clearcutting was planned for the valley, and site specific information was needed to manage both critical elk habitat requirements and timber harvesting.

Information on the value of different habitats to elk, the features that control elk use of habitats, and factors which restrict or modify elk habitat use patterns were required for effective multiple use planning in the White River area. Interpretation of such information required basic knowledge of the geography, climate, landforms, and logging history of the aréa. Some general background knowledge was available (Runka 1969) but site specific information was lacking.

Available information on factors affecting elk use of habitats had limited applicability to the study area. Clearcuts have previously been studied for differential use by elk (Kirsch 1962, Swanson 1970, Lyon 1976), however, these studies concentrated on elk habitat use during summer. These studies were of questionable applicability to the White River area, a winter range where average snowdepths were believed to restrict elk use of some habitats.

Elk response to human activity or vehicular traffic had also been studied (Ward 1976, Anonymous 1975, Lyon and Jensen 1980) with mixed results. The many roads developed in the logging of the White River drainage suggested that changes in elk habitat use patterns could result from human activity and vehicular traffic. Clearcut openings in the study area were also considerably larger than those in previous studies.

This study was designed to provide information on the winter ecology of elk and their responses to logging practice in the White River drainage of southeastern British Columbia. Specific information on the logging history, characteristics of habitats, activity patterns, and diets of elk was required to test hypotheses treating factors affecting elk use of the area. Objectives of the research were to:

1) Describe the vegetation and logging history patterns of the area.

2) Describe activity patterns of elk in the area.

3) Describe elk food habits specific to the area and document any changes in food habits with shallow and deep snow conditions.

4) Identify habitat types and document elk utilization of habitats in winter during both deep and shallow snow conditions.

5) Identify the use of clearcut logged areas and document patterns of use of clearcuts by elk during both deep and shallow snow conditions.

6) Test hypotheses treating factors which influence

elk use of clearcuts.

Emphasis was placed on the latter three objectives. These objectives would provide information on some hypothesized relationships for elk within forested habitats, while providing site specific information applicable to forest management. The relationships between elk use of logged habitats, the major climatic factors of snowdepth, and the effect of human activity in modifying elk habitat use were not clearly understood. The following hypotheses were proposed to clarify these relationships:

a) Elk prefer clearcuts for feeding during shallow snow conditions but are restricted in their use of clearcuts when snowdepths exceed 45 cm.

b) Elk use of clearcut habitat declines in an inverse relationship to the distance from cover.

c) Elk use of clearcut habitat declines with increasing proximity to roads.

d) Elk avoid slash when possible.

e) Elk respond to human activity by flight and this response is less common with increasing distance from the disturbance.

2.0 THE STUDY AREA

The White River is a mid-elevation tributary of the Kootenay River in southeastern British Columbia. The study area comprises the eastern side of the White River valley downstream from the major eastern turn of the river near White Swan Lake (Figure 1). The study area included the valley bottomlands at approximately 1000 m (3300 ft) elevation and the terraces and slopes up to about 1830 m (6000 ft) elevation along the eastern valley side.

In general terms, the White River valley is a narrow valley in the heart of the Rocky Mountains. The following brief description of geology, landforms, soils and climatic influences is condensed from Runka (1969).

2.1 GEOLOGY

The Kootenay-White River lineament is caused by the White River Break, a major longitudinal fault zone that limits the Western (Kootenay) Ranges from the Park (Main) Ranges. Throughout its length the fault zone lies

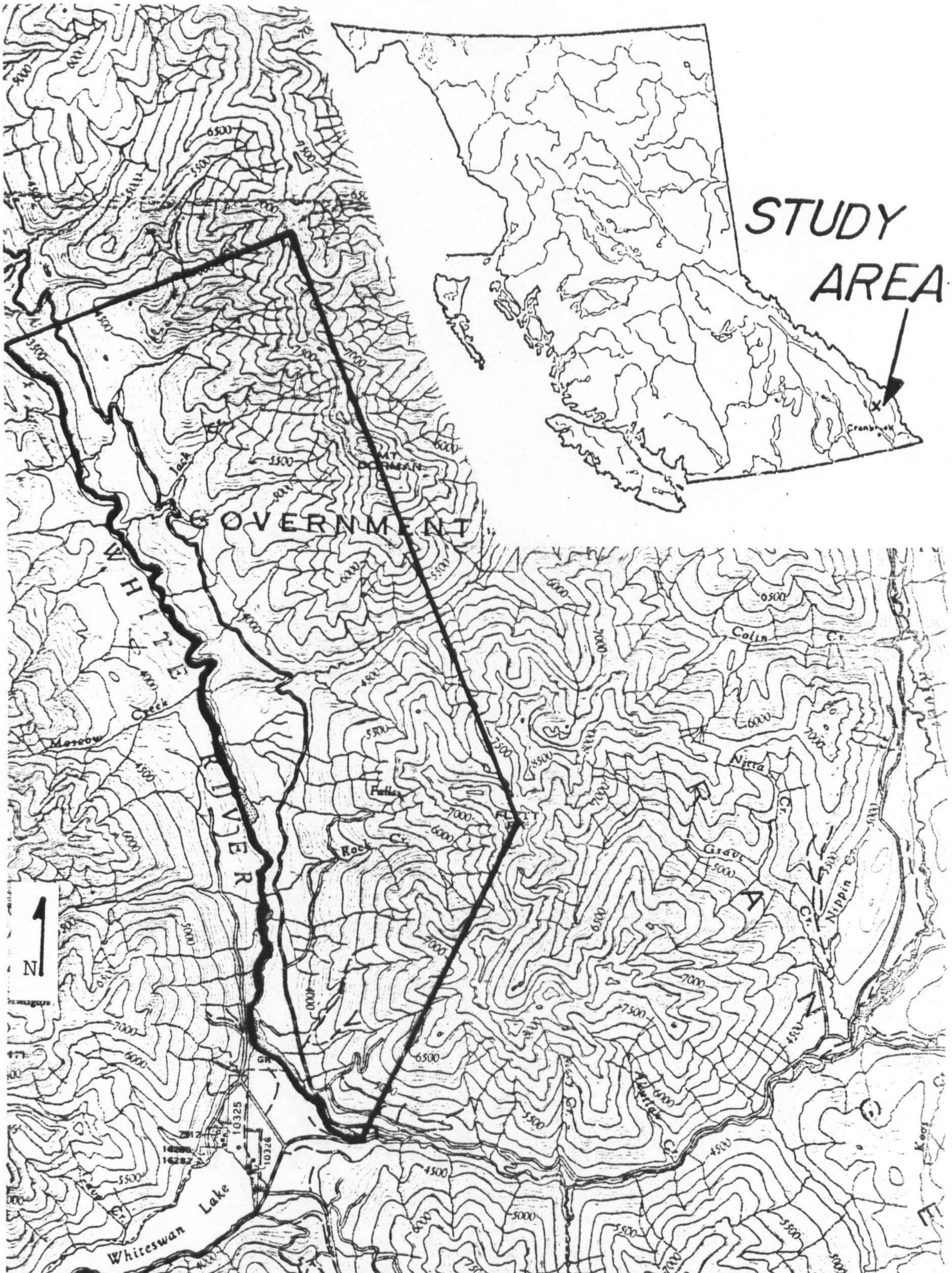

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Figure 1. The study area

entirely within Cambro-Ordvician shale of the McKay Group and is marked by a wide belt of highly-sheared, calcareous phyllite. Along this lineament, the wide through-valley of the Kootenay, Beaverfoot and White Rivers has eroded the weak fault zone (Runka 1969).

2.2 LANDFORMS AND SOIL DEVELOPMENT

Details of the present topography were formed predominantly by the last stage of ice advance and modified somewhat by erosion since the last ice retreat.

The valley is floored to a large extent with terraced valley train deposits. The wide terraces of the Kootenay-Beaverfoot-White through-valley are based on Cedrus till described by Kelley and Holland (1961). It is derived from McKay phyllites and shales and is therefore very silty and virtually stone free. Soils are primarily strongly calcerous, eutric brunisols (Runka 1969).

2.3 VEGETATION

Krajina (1965) included two biogeoclimatic zones in the White River valley. The Interior Douglas-fir zone covers most of the valley bottom while the Subalpine Engelman spruce - subalpine fir zone encompasses the higher valley sides. More detailed, recent mapping (Figure 2) confirms that the study area includes the border of these two biogeoclimatic zones. Examination for indicator species revealed indicator plants from the Subalpine Engelman spruce - subalpine fir zone and from the wet subzone of the Interior Douglas-fir zone throughout the valley. However, false boxwood (Pachistima myrsinites), an indicator of the wet subzone of the Interior Douglas-fir zone, was absent. Comparison of systems of classification is difficult, but it is probable the classification of Pfister et al. (1974) would include the vegetation of the study area in the Pseudotsuga menziesii and Picea series.

Initial timber cutting in the study area began with selective cutting programmes in the southern portions in 1954. In the next 10 years some 850 ha of a mid-elevation band on the southeast portion of the study area were logged. These selectively-logged areas had variable (5% to 30%) canopy coverage of trees when assessed in 1975. Infestation of 100 year old or older lodgepole pine stands by mountain pine beetle initiated the second phase of logging. Older lodgepole pine forest types which were susceptible to mountain pine beetle infestations constituted an additional 3400 ha of the

6. Ecological State

Ecological State is the successional stage to which vegetation has developed. The successional stages are determined by plant community structure and plant competition relationships in the community.

DC	disclimax
MCC	maturing climatic climax (usually older than 60 years)
MEC	maturing edaphic climax (usually older than 60 years)
MS	maturing seral (usually between 60-140 years)
OS	overmature seral (usually older than 140 years)
PS	pioneer seral
YCC	young climatic climax (usually younger than 60 years)
YEC	young edaphic climax (usually younger than 60 years)
YS	young seral (usually younger than 60 years)

7. Plant Species

Tree species symbols are used to signify a vegetation type. Because of the natural variability of the vegetation, the indicated species may be infrequent or even absent from some sites, but many of the characteristics of the typical vegetation will occur.

aL	alpine larch	tA	trembling aspen
alF	alpine fir	W	willow
bCo	black cottonwood	wB	common paper birch
D	Rocky Mountain Douglas-fir	wC	western red cedar
eS	Engelmann spruce	wH	western hemlock
lP	lodgepole pine	whP	whitebark pine
pP	ponderosa pine	wL	western larch
sAl	Sitka mountain alder	wS	white spruce

5. Biophysical Forest Regions, Zones and Subzones

Forest Region[1]	Map Symbol	Forest Zone[2] and Subzone[3]
DRY INTERIOR REGION (DI)		INTERIOR ROCKY MOUNTAIN DOUGLAS-FIR ZONE (ID)
	DI / ID / a	a) Lodgepole pine subzone (lacks ponderosa pine as a potential seral species)
	DI / ID / b	b) Ponderosa pine subzone (with ponderosa pine and lacks western larch as potential seral species)
	DI / ID / c	c) Western larch - ponderosa pine subzone (with ponderosa pine and western larch as potential seral species)
		SUBALPINE ENGLEMANN SPRUCE-ALPINE FIR ZONE (SAeS-alF)
	DI / SAeS-alF / a	a) Lodgepole pine-whitebark pine subzone (lacks Rocky Mountain Douglas-fir as a potential seral species)
	DI / SAeS-alF / b	b) Krummholz subzone (trees have stunted growth form and are layered in island patterns)
	DI / SAeS-alF / c	c) Rocky Mountain Douglas-fir-lodgepole pine subzone (with Rocky Mountain Douglas-fir as a potential seral species)
		ALPINE TUNDRA ZONE (At)
	DI / At	subzones have not been determined

[1] A Biophysical Forest Region is an area in which the broad regional climate and physiography determine the definitive vegetation pattern of the region. Regions can be further divided into Sections, Zones and Subzones.

[2] A Biophysical Forest Zone is an area within a Forest Region of which the dominant vegetation of the climax stands on similar soils and terrain is identical. Soil, climate and topographic conditions determine the definitive vegetation pattern of zones.

[3] A Biophysical Forest Subzone is an area within a Forest Zone defined on the basis of climate-related successional trends of dominant vegetation.

Figure 2. Vegetation Zonation of the Study Area from the British Columbia Ministry of Environment mapping.

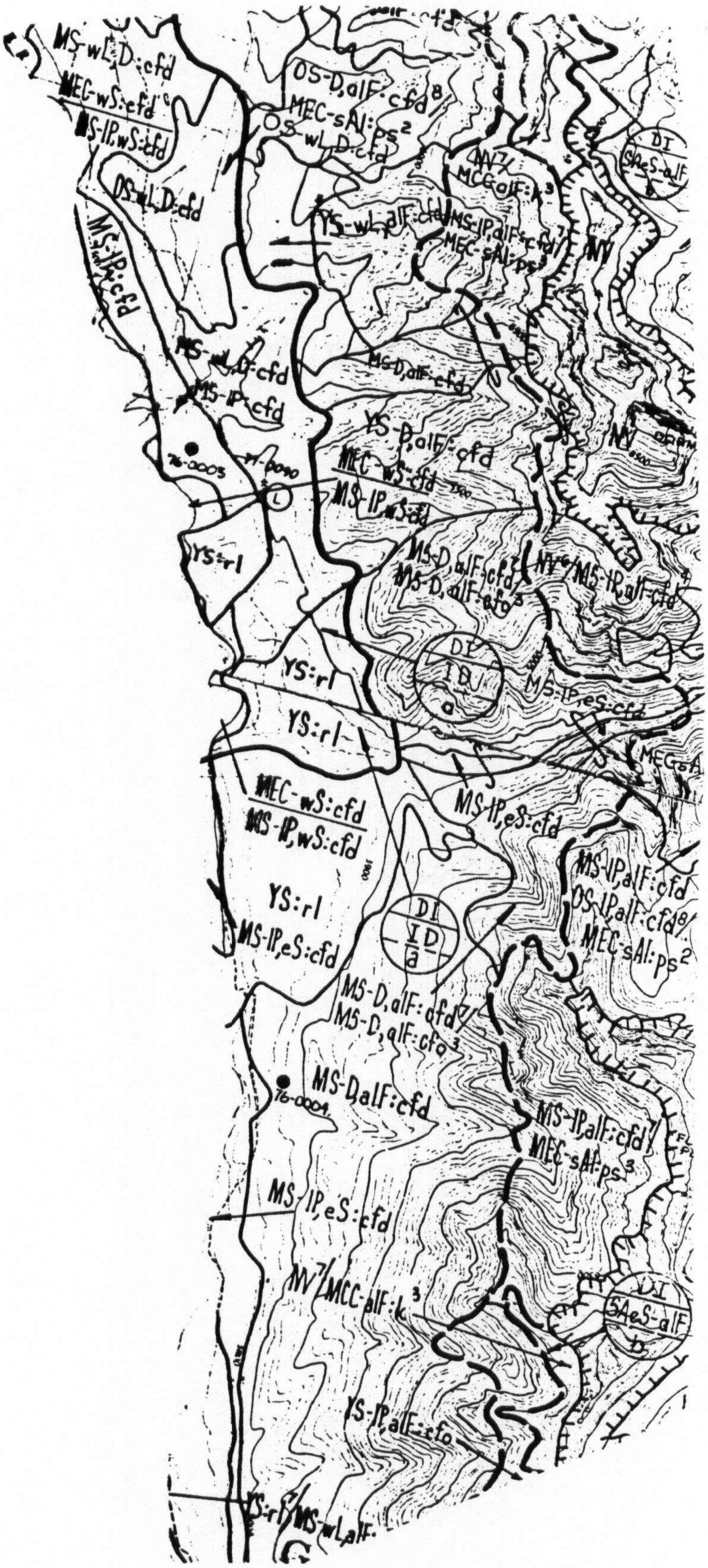


Figure 2. (Continued).

total 7000 ha of the study area. The progression of timber cutting is illustrated in Figure 3.

2.4 CLIMATE

The East Kootenay of British Columbia shows much climatic variation. The mosaic of the mountains and valleys influences the distribution of climatic types. Examining the region as a unit, summers are usually hot with sporadic rain shower activity, while winters range from mild to severe. Precipitation is fairly uniformly distributed throughout the year with approximately one third of the annual precipitation falling as snow. The main local influence on climate is the mechanical influence of topography on air movement throughout the region (Runka 1969).

The White River is separated from the nearest permanent weather station, at Canal Flats, by the Hughes Range and weather data from Canal Flats were not directly applicable to the White River valley. However, annual trends in weather patterns from Canal Flats and Cranbrook are indicative of the relative degree of severity of a particular winter within the region. The monthly mean temperatures from Canal Flats for the two winters of the study 1975-76 and 1976-77 exceeded the long term averages

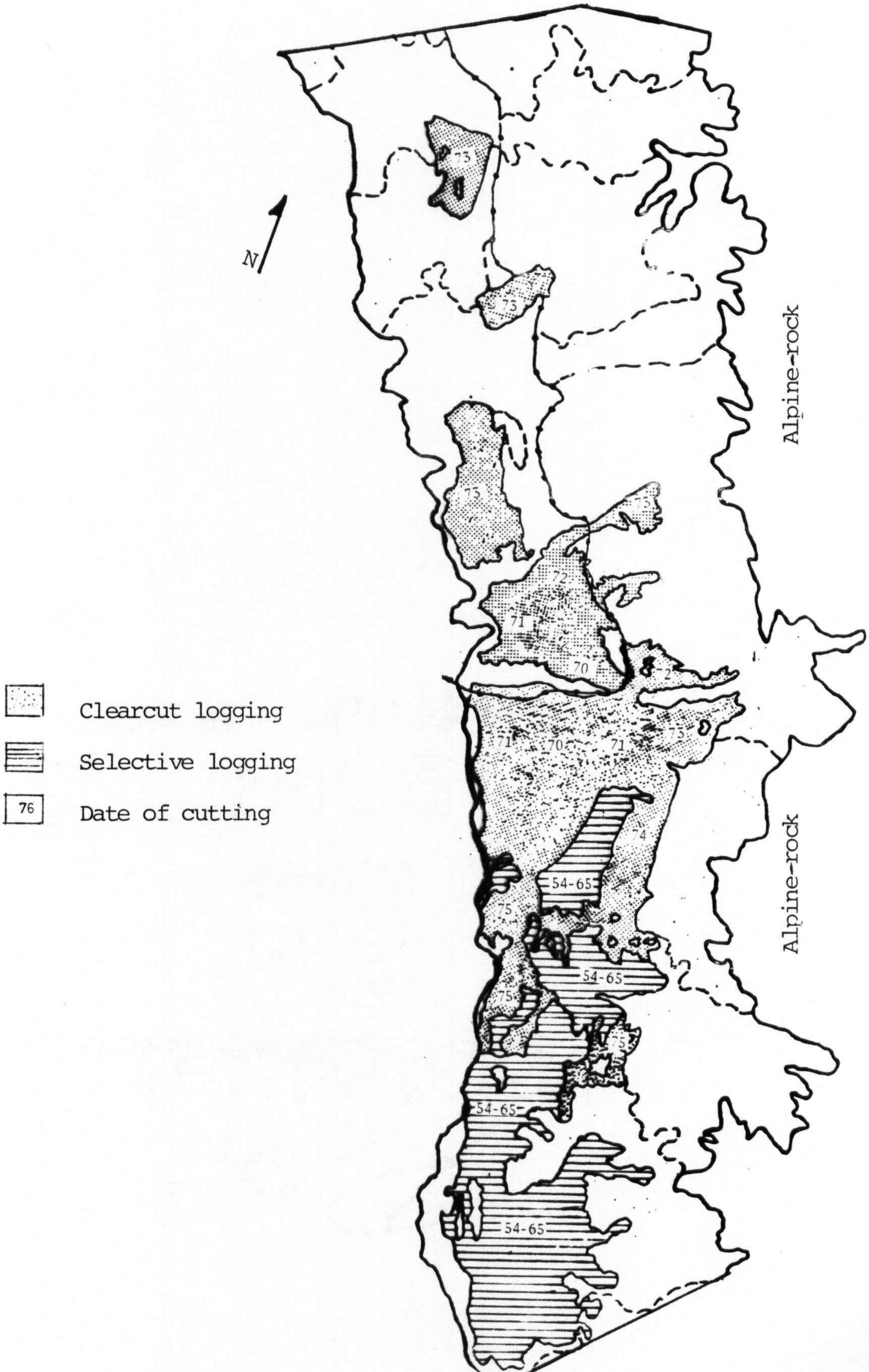


Figure 3. Logging history of the study area.

(Figure 4). In contrast, the winter of 1977-78, when McLellan (1978) reported on elk habitat selection in the area, was substantially more severe. Although long term data on snowdepths were not available, a similar contrast in snow measurements from Cranbrook between the 1977-78 winter period and the 1975-76 and 1976-77 winter period is apparent (Figure 5).

In this study, data on elk habitat selection were gathered during two winters of atypically mild temperatures and low snow fall.

2.5 STUDY PERIOD

Field work commenced in June of 1975 and terminated in May of 1977. Summer programmes consisted of habitat mapping, vegetation sampling, and collecting pellet group data. Winter programmes (November to April) concentrated on observing elk distributions, recording snow depths and noting human activities to collect data on elk habitat selection and use of clearcuts.

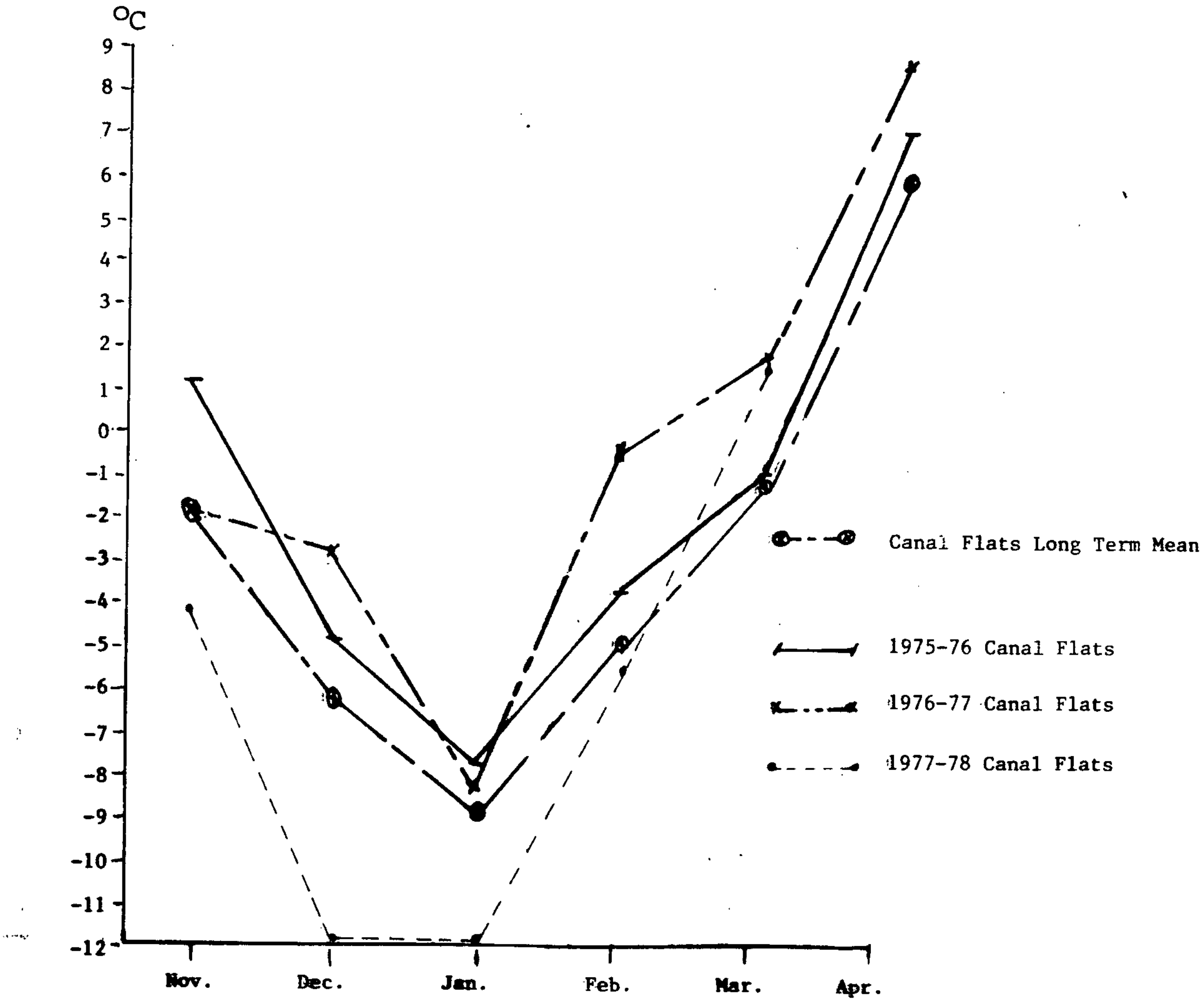


Figure 4. Monthly mean temperatures from Canal Flats, comparison of winters of 1975-76, 1976-77, 1977-78 to long term mean.

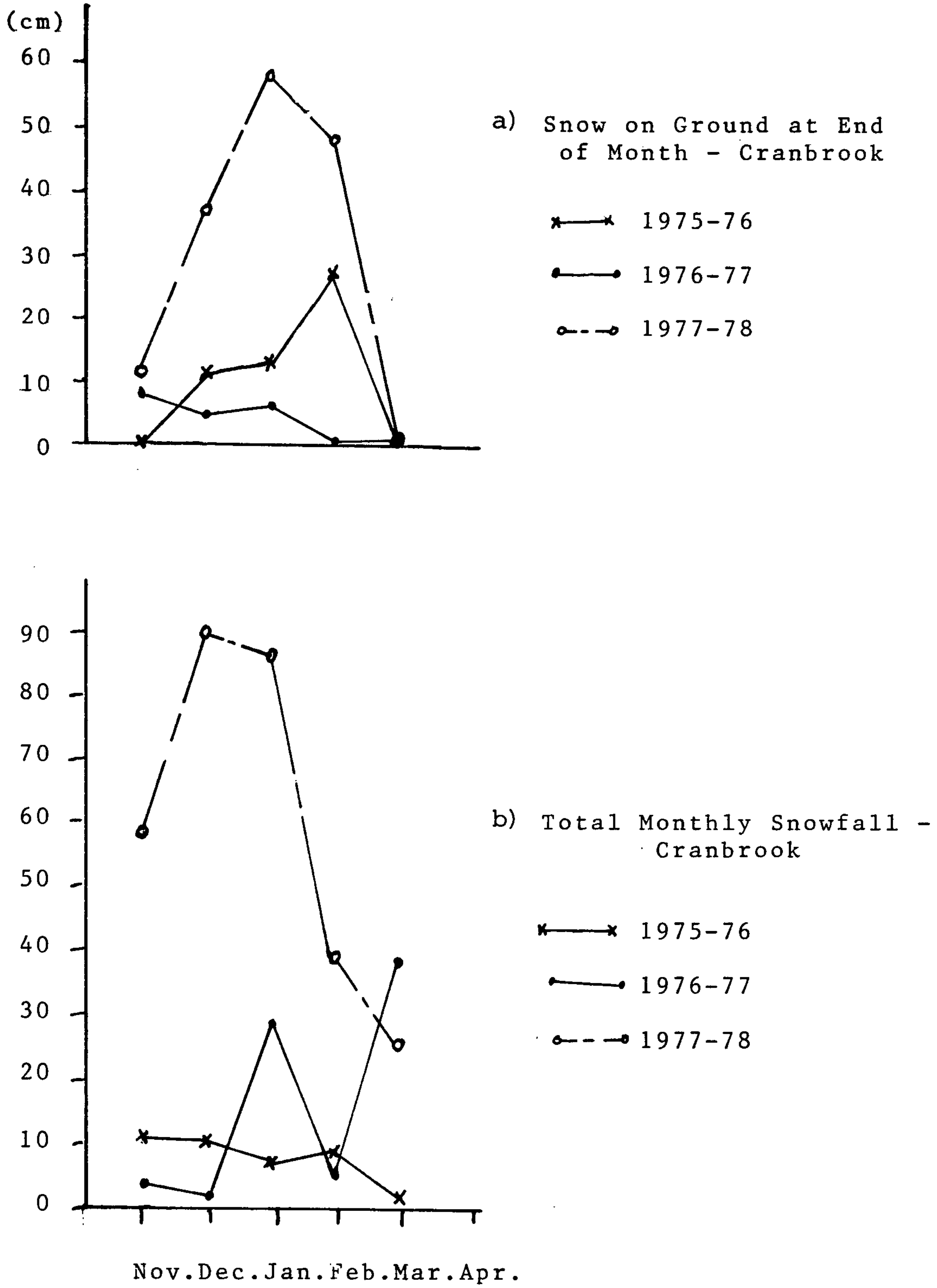


Figure 5. Snow on ground and total monthly snowfall from Cranbrook comparison between winters of 1975-76, 1976-77, 1977-78.

3.0 METHODS

3.1 HABITAT MAPPING

The logging history of the area was compiled from British Columbia Forest Service records. Mapping of boundaries of logged areas utilized available British Columbia Forest Service forest cover maps, recent air photographs (1975) provided by Crestbrook Forest Industries, and personal reconnaissance.

The habitat of an animal, "the specific set of conditions that surround the organism" (Smith 1966), can be described or analysed at different levels of detail depending on the objectives of the study. In terms of the annual home range of elk, the entire study area can be viewed as a single habitat type as it is comprised of the south facing slopes of the lower White River drainage. However, a preliminary reconnaissance of the area and a review of the objectives of the study suggested the level of detail required for habitat analysis in this study should be at the level of forest cover or timber harvesting practices.

Five habitat types were chosen, each related to forest cover types and logging history. Forest cover maps, logging history maps, aerial photographs, 1:50,000 topographic base maps (1957 edition), preliminary vegetation mapping (Environment and Land Use Committee Secretariat [E.L.U.C.S.], unpublished), and ground checking were used. Five habitat types were delineated in the study area. Vegetation was sampled in the most prevalent landscape unit in each habitat type to provide a characteristic description of the species composition and canopy coverage. Names assigned to habitat types are purely descriptive based on the physical structure or dominant species in the habitat type.

3.2 VEGETATIVE SAMPLING

Vegetative sampling for species composition and canopy coverage was modified from the standard field methodology of the ELUCS, Vegetation Section, as outlined by Van Barneveld (1976) and Walmsley and Van Barneveld (1977). A site of apparently homogeneous soils and vegetation was chosen as recommended by Arlridge (1960, in Walmsley and Van Barneveld 1977) for the prevalent landscape unit, in each habitat unit. A vegetation releve (sample plot) using ELUCS standardized methodology and data form (1st draft) was completed for each site to describe the vegetation and represent a vegetation type. Releves describe vegetation by species in a canopy stratum using ocular estimates of percent cover by species. Three releves by Vegetation Section staff (ECUCS) in 1976 were included in the analysis. Sufficient resources were not available to sample all vegetation so sampling was restricted to the minimum number of plots needed to characterize the vegetation of each habitat type.

In addition, vegetation subtypes were defined utilizing micro-relief and moisture regime in the three clearcuts selected for intensive study of elk use. These subtypes were sampled for standing crop of grass and forbs in the September-October period. Methodology was chosen to be directly comparable with other studies in the region (Kemper 1971, Demarchi 1971, Farr 1974, Churchill 1974). Five 1 m^2 subplots for each macroplot were clipped following cessation of annual growth. Subplots were located at two meter intervals along a transect randomly located in the vegetative subtype to be sampled. Samples were subdivided into grass and forb components, oven-dried, and weighed for standing crop estimates. Botanical nomenclature follows Taylor and McBryde (1977)

3.3 ELK ACTIVITY

Local knowledge on expected timing of winter concentrations of elk in the study area was solicited to determine the field season for collection of data on elk use and activity. Incidental sightings of elk and the observation of fresh tracks and pellets in the study area during summer programmes were used further to refine timing of winter study periods.

Records were kept of the time of the observation, the date, the size of the elk group, the sex and age group of individual animals, and the activity of the elk group for each observation during periodic surveys of the area. Elk group activity was assessed as the activity of the majority of individuals within the group during the observation. Surveys were planned to cover all of a predetermined route in the shortest amount of time to ensure all elk groups were seen. Observation numbers were assigned to each elk group sighting to aid in retrieval of information in data processing.

3.4 ELK DIET

During the two winter study periods rumen samples were taken from hunter killed elk (2), collected elk from within the study area (5) and from road killed elk from nearby Kootenay National Park (2). Rumen contents from each animal were mixed and one gallon samples were preserved in 10% formalin. Rumen samples from this study and others collected from the East Kootenay region were analysed by the Research Section, British Columbia Fish and Wildlife Branch , Victoria, British Columbia.

In the laboratory, subsamples of each jar were drained of excess formalin. The contents were then placed into a graduated 1000 ml beaker partially prefilled with water in order to determine the total volume. The contents were then thoroughly washed with tap water through number 3 1/2 and number 5 sieves (5.66 and 4.00 mm). The contents remaining on the screens were washed into a white porcelain dish and separated, with the aid of forceps, into species. Each plant species of the sample was then placed on nylon cloth and all excess moisture was squeezed out. Measurements of all samples 0.5 ml and over were made by placing the moist material into a 250 ml graduated cylinder partially prefilled with water.

Similarly analysed data from other locations in the Kootenays were supplied by the British Columbia Fish and Wildlife Branch , Cranbrook office. These data were stratified by biogeoclimatic zones in which the animal was found at the time the rumen sample was collected and are presented for comparison with data collected from the study area.

Determination of food habits by observation of animals feeding, followed by examination of the feeding site, has been used to identify diet of elk (Capp 1968, Joslin 1975). A similar technique, trailing, has been used for moose (Alces alces) winter diets (Silver 1976), but Peek (1974, original not seen, cited from Silver 1976) suggested some limitations of the method. These problems were:

1. Determination of what constitutes "fresh use".

2. Differential observability of use of different plants.

3. Determination of a single bite.

4. Definition of feeding areas (casual feeding or curious browsing vs. preferred feeding areas).

In this study one objective was to determine changes in elk diet with varying snow depth. Initial tests of the trailing technique indicated:

a. Individual animals could not be trailed for adequate distances due to the herd behaviour of the species obscuring the tracks of individual animals.

b. Trailing, in areas of heavy elk use with lesser use by moose, whitetail deer (*Odocoileus virginianus*) and mule deer (*Odocoileus hemionus hemionus*), compared to random transect in a similar area indicated that "fresh use" could not be differentiated from previous use of both grasses and shrubs.

These considerations indicated that the trailing technique was not feasible to meet the objectives of the research.

3.5 ELK USE OF HABITATS

Data collected for documentation of elk use of habitats included direct observations of elk and measures of track abundance. These data were collected throughout two winter study periods. Surveys were conducted from a four-wheel-drive vehicle along the primary road system and from established observation points. Regular surveys were supplemented by foot surveys when vehicle access was restricted.

The Universal Transverse Mercator (U.T.M.) Grid system printed on 1:50,000 scale topographic base maps was used to record the location of elk observations throughout the study area, with the exception of those areas selected for intensive study of elk use. The U.T.M. Grid system was superimposed on a combined habitat-logging-topographic map to aid in accurately locating observed elk. Although the grid system allows pre- or post-recording of habitat type and other characteristics, the best resolution of the grid is 10,000 m^2. After consideration, habitat type and other characteristics of the observation site were recorded at the time of observation.

Elk track abundance was recorded along the primary road system following fresh snowfalls of sufficient depth to effectively eliminate previous tracks. Track surveys were stratified by habitat types. Every individual set of fresh tracks of elk, other ungulates, lynx (Lynx lynx canadensis) and cougar (Felis concolor) which crossed the road from berm to berm were recorded. When elk tracks were encountered in groups, the number of tracks recorded were the number of individuals that could be determined, not estimates of the size of the group. Track abundance surveys were conducted 12 to 24 hours following the cessation of a snowfall.

3.6 ELK USE OF CLEARCUTS

Portions of three clearcuts were selected for intensive study of elk use. Data on elk use of clearcut openings were collected by observing elk and by counting elk pellet groups.

3.6.1 DIRECT OBSERVATION OF ELK

During the two winter study periods, surveys to observe elk in the designated clearcuts were conducted concurrently with surveys to observe elk activity and habitat use. A grid system based on the configuration of the clearcuts designated for intensive study was devised to record observations of elk.

The three clearcuts were measured with a metric tape (nylon) and grid points were marked by driving a colour coded wooden post, 2.5 m in length, into the ground. Spacing between grid points was fifty meters in two of the clearcuts and one hundred meters in the third clearcut. Fifty meter spacing was required to provide sufficient sampling of habitat parameters in the two smaller clearcut sites. The larger size (3x) of the third site and the limited resources of the study dictated a wider spacing of sample points in the third site. Distances between grid posts were measured in true profile, rather than corrected for vertical projection, as is the common practice in forestry.

Each grid post represented the midpoint of a grid cell and a number of characteristics for each cell were recorded during the summer field seasons. The following were recorded for each grid cell:

a. slope - measured with a Suunto level and recorded in percent.

b. elevation - recorded in intervals of 7.62 m (25 ft.).

c. aspect - determined from a compass bearing and corrected for true north.

d. microrelief positions - assessed and recorded as gully slope, gully bottom, ridge slope, ridge top or fan.

e. vegetation - subtypes within clearcuts determined from releves.

f. evidence of broadcast burning since logging - recorded as burned or not burned.

g. slash accumulation - assessed as nil, light, moderate or high.

h. distance from forest (cut block) edge - determined from grid location and recorded in 50 m or 100 m classes.

i. minimum distance from nearest usable road - estimated ocularly using grid posts and recorded in 100 m classes.

At the time of observation of elk, snowdepth was recorded from the closest snow stake to the animals. Snow stakes were panels (10 cm x 122 cm), painted white and marked in 2 cm graduations in black, affixed to some grid posts. Snow stakes were located on two sets of two transects perpendicular to each other in each of the three designated clearcut sites. Additional snow stakes were located at convenient locations throughout other portions of the study area. Snowdepth could be read with an accuracy of 1 cm by viewing snow stakes with a 15 or 25 x spotting scope from the nearest point on the primary road system or from an established observation point.

Observations of elk in the three clearcuts were recorded on the same forms as those used for observations in other locations of the study area. Vegetation type and other parameters were not recorded for observations of elk use of the three clearcuts, as this information had been pre-determined for these smaller grid cells during summer field work.

3.6.2 PELLET COUNTS

Elk use of the three study clearcuts was also measured by counting pellet groups. Pellet groups were counted in circular plots centered on each grid point in October 1975, October 1976, and May 1977. Leaf drop had occurred before the October surveys and leaf growth had not commenced before the May, 1977 survey so visibility of pellets should not have been affected.

Pellet plots were 3.56 m in diameter (10 m^2) and grid posts served as permanent markers of the center of the plots. Ten pellets of similar appearance were arbitrarily defined as a group. Groups were included only if the majority of the pellets lay within the plot boundaries. Pellet group plots were not cleared and efforts were made not to disturb them. Groups were tabulated for each plot in the two October surveys but noted as old (greater than 9 months old) or new in the May, 1977 survey. Selection of type of pellet plot was based on Smith (1977, p. 17).

> "The small plot size chosen was based on a review by Neff (1968) and work by Smith (1968). They felt that small plots were more efficient and more precise than larger plots because of the reduction of bias associated with missed groups. Batcheler (1975) has shown, however, the inverse relationship between plot size and estimated density of groups is mainly the result of bias due to border effect and definition of pellet groups, not missed groups. Thus small plots may be more precise, but they are not necessarily more accurate...
>
> "Although the data may not provide an accurate estimate of total numbers, it seems valid to assume that any bias associated with using small bounded plots will be equal in each habitat. Since my main objective in counting pellet groups was to determine relative levels of use, any consistent bias is of no consequence."

3.7 ELK RESPONSE TO HUMAN ACTIVITIES

The effects of human activity on elk behaviour and consequently on elk habitat use are an integral part of elk ecology in areas of multiple resource use. Records were kept of the types of human or vehicular activity, the observed response of elk, and the distance between the activity and elk at the time of elk response. Data were collected concurrently with other surveys. Response distances were estimated in 100 m classes from U.T.M. and established grids.

3.8 ANALYSES

Analysis of data utilized computing facilities at the University of British Columbia and the Michigan Interactive Data Analysis System (MIDAS) written by the Statistical Research Laboratory of the University of Michigan. Details of analytical methodology are available from Fox and Guire (1976). All tests were deemed significant at 0.05 level of probability unless otherwise noted.

4.0 RESULTS

4.1 HABITAT TYPES

Five habitat types, Old Pine Forest, Clearcut habitat, Selective Logged Habitat, Mature Mixed Conifer Forest, and Young Pine Forest, were described for the study area. Figure 6 is a map of the distribution of these habitat types in the study area. Table I lists the proportions of habitat types and Table II lists representative plant species composition in the habitats. Figures 7 and 8 present illustrations of the various habitat types.

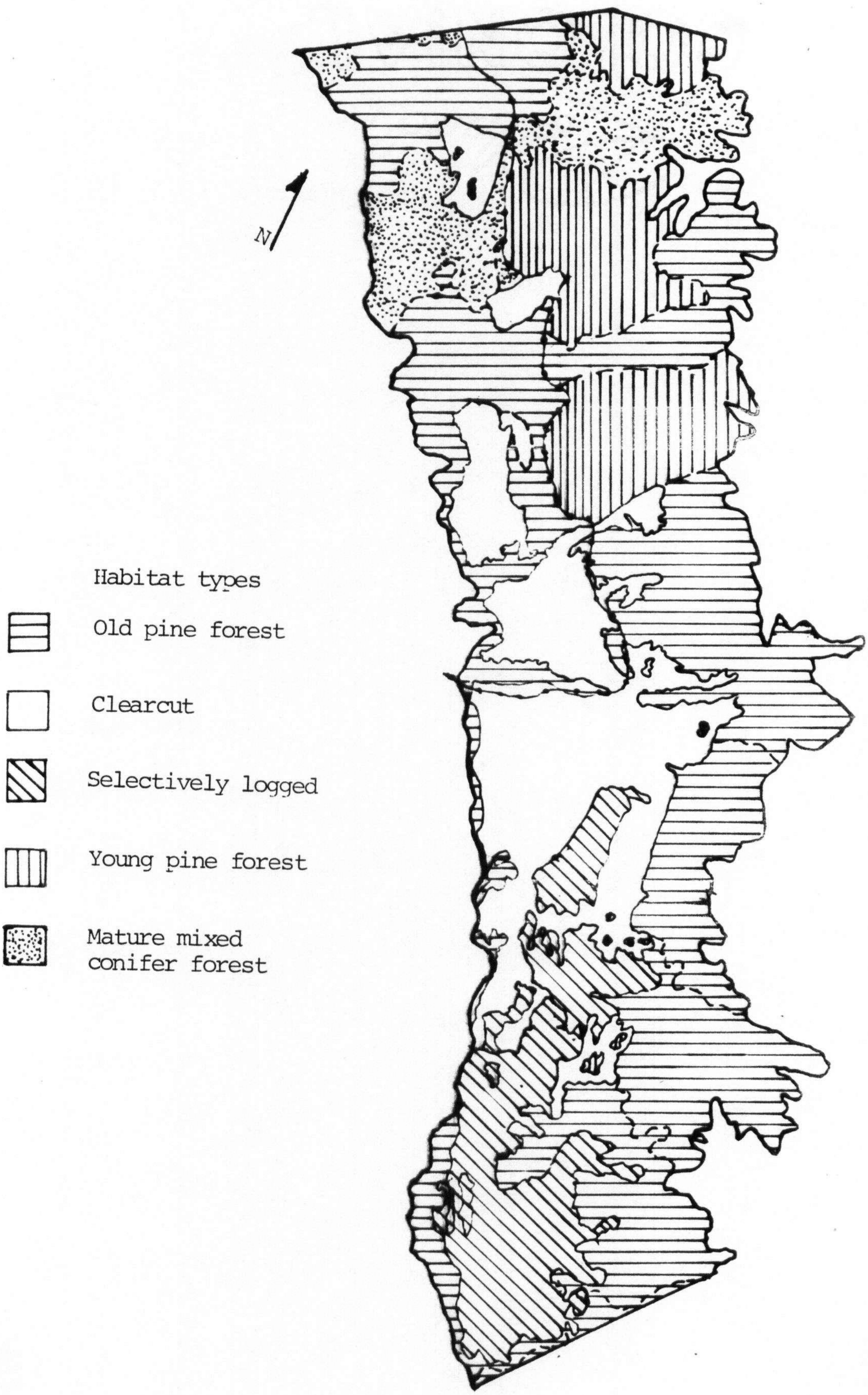


Figure 6. Distribution of habitat types in the study area.

Table I. Area and proportions of habitat types in the White River study area.

	Study Area Total	6985 ha	---
1.	Old Pine Forest	3425 ha	49%
2.	Clearcut	1350 ha	19%
3.	Selectively Logged	850 ha	12%
4.	Mature Mixed Conifer Forest	695 ha	10%
5.	Young Pine Forest	665 ha	10%
	All Forested Habitats Combined	4785 ha	69%

Table II. Canopy coverage in percent for representative vegetation samples of habitat types.

Species[a]	Clearcut[b]	Clearcut	Clearcut	Clearcut	Clearcut	Clearcut	Selective Logged	Selective Logged	Mature Mixed Forest	Old Pine Forest	Young Pine Forest
TREES											
Populus tremuloides	x			20[c]	x					x	
Populus balsamifera trichocarpa				20[c]							
Pseudotsuga menziesii	x						18		15	x	x
Larix occidentalis							x	x	15	x	x
Pinus contorta var. Latifolia							x	x	30	60	50
Picea engelmannii	x						x	10	x		x
SHRUBS											
Alnus incana tenuifolia				x			x	20			
Betula papyrifera		x		x			10	x		x	
Acer glabrum douglasii		x		10			x				
Mahonia aquifolium		x	x			x	x		x	x	x
Rubus idaeus		x	x	15	15	x					
Rosa woodsii	x	x	15	35	25	x	25		x	x	x
Amelanchier alnifolia	x	x	x	10	x	x	x	x	x	x	x
Symphoricarpos albus albus		x	10	40	x	x	10		x	x	x
Shepherdia canadensis	x	12	x		x	x			10	25	x
Spirea betulifolia lucida	x	x	x	x	x	x	x		10	x	x
Linnaea borealis		x	x					x	x	17	x
FORBS											
Arnica cordifolia										10	
Cornus canadensis									10	10	
Epilobium angustifolium			30								
Chimaphila umbellata											25
Aralia nudicaulis		17	20	15	17						
Lathyrus ochroleucus			10		15						
GRASSES											
Calamagrostis rubescens	35	78	35	x	25	60	65	20	60	70	10
Oryzopsis asperifolia			25		10				10		
Elymus canadensis				10	x						
MISCELLANEOUS											
Mineral soil	20			10							
Mosses (unspecified)									35	20	30

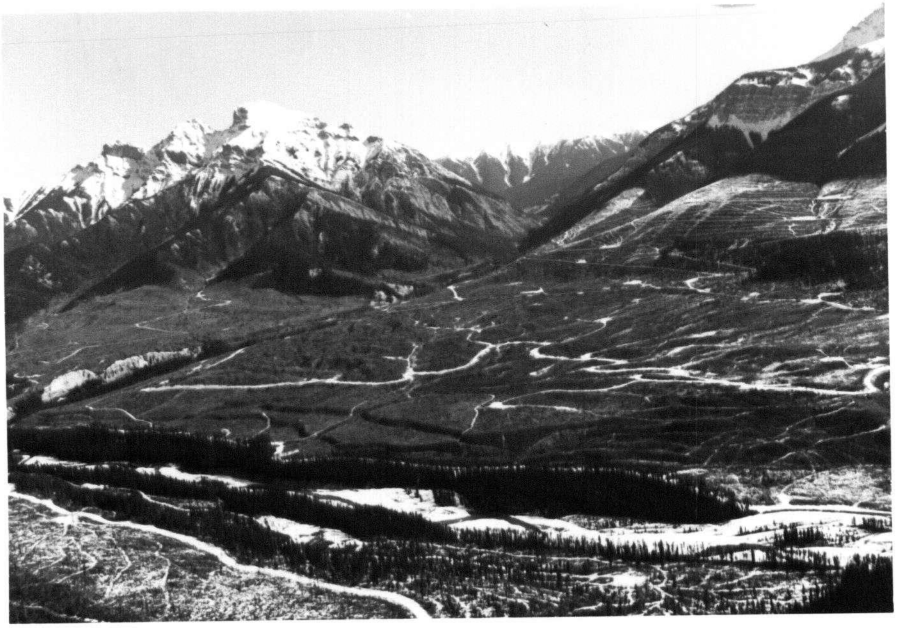
[a] Only species with canopy coverage greater than 5% by ocular estimate.

[b] Several examples are given for these habitat types to show variation.

[c] Shrub.

x Canopy coverage in percent, species $\geq$ 5% $<$10% canopy coverage.

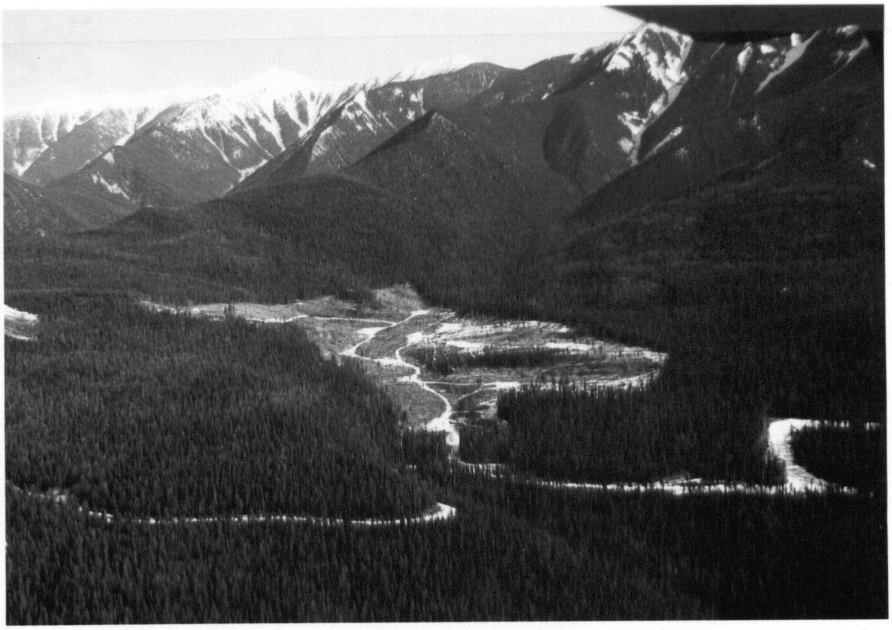
a) Selectively logged habitat



b) Large opening of clearcut habitat

Figure 7. Pictorial views of selectively logged and clearcut habitats.

a) Clearcut habitat - strip of old pine forest



b) Mature mixed conifer forest - lower left
Clearcut habitat - centre
Old pine forest - lower right
Young pine forest in background at higher elevations

Figure 8. Pictorial views of clearcut and forested habitats.

Old Pine Forest

Old Pine Forests covered 3425 ha (49%) of the study area. Most of the old pine stands at lower elevations have been logged (Figure 6) leaving most of this habitat type at mid- or upper-elevations on steeper slopes.

The Old Pine Forest habitat is characterized by an even-aged stand of lodgepole pine approximately 90 to 120 years old. The trees are predominantly between 20 and 26 cm D.B.H. with a canopy height of up to 26 m. Basal area of the stand was 55 m^2ha^{-1}. Other tree species occurred within the canopy in minor proportions, however, the lack of a juvenile tree understory created the impression of an open forest with relatively long sight distances.

The shrub strata had seven species but was markedly dominated by soopolallie (*Shepherdia canadensis*). Twinflower (*Linnaea borealis*), a low growing shrub, combined with Prince's-pine (*Chimaphila umbellata*), mosses, arnica (*Arnica cordifolia*) and pinegrass (*Calamagrostis rubescens*) to form a moist, spongy grass/forb layer. Pinegrass is very widespread in this habitat, however, its growth form of widely spaced single stalks resulted in little biomass for the large amount of canopy coverage.

Soopolallie has not been identified as a preferred forage species for elk and no evidence was observed of its utilization. The low biomass of pinegrass and preferred shrub species indicated low forage volumes for elk in this habitat. The susceptibility of pine trees of this age class to beetle infestation and the potential clearcutting of most of the Old Pine Forests to remove infested trees make the evaluation of the importance of this habitat type for elk cover requirements critical.

Clearcut Habitat

Recent clearcutting created 1350 ha of this habitat in the study area (19%), mostly at lower elevations. Clearcutting had been practiced almost exclusively in beetle infested pine stands for removal of dead and potentially susceptible trees. Consideration of economics and wind stability led to small inclusions of other tree species being cut.

The result was a variety of micro-relief and micro-water regimes in this habitat type. Evaluation of the movement patterns of elk indicated that for the objectives of this study the high mobility of the animals nullified selection of micro-habitats within the Clearcut habitat type. Common factors of unlimited line of sight, abundant forage and relatively uniform snowdepth patterns allowed consideration of clearcuts as a single habitat type for the purposes of the study.

Clearcut vegetation on all landforms except alluvial fans was dominated by pinegrass. In this open habitat pinegrass grows in dense tufts, providing the major forage for elk. Forbs, although represented by a variety of species, were not abundant during the midsummer survey period with only sarsaparilla (Aralia nudicaulis), fireweed (Epilobium angustifolium) and peavine (Lathyrus ochroleucus) having canopy coverage greater than 5%.

Shrubs, although not dominant except on alluvial fans, were abundant with 10 species found in the clearcut habitats. Rose (Rosa woodsii), saskatoon (Amelanchier alnifolia), and raspberry (Rubus idaeus), utilized by ungulates for forage, were abundant; while dogwood (Cornus sericea), the most heavily utilized shrub, occurred sporadically on very moist sites (not sampled). Other shrubs, not preferred as elk forage, (soopolallie, spirea [Spirea betulifolia lucida] and snowberry [Symphoricarpos albus albus]) were also common.

Juvenile cottonwood (Populus balsamifera trichocarpa) and aspen (Populus tremuloides) were the dominant tree species and were utilized as forage. Spruce (Picea engelmannii) and lodgepole pine regeneration was evident with pine abundant in planted areas. Pine seedlings commonly were browsed with planted and naturally regenerating stock showing needle and tip removal.

Selectively-logged Habitat

Selective cutting in the late 1950's to mid 1960's effectively removed all homogeneous stands of mature Douglas-fir (*Pseudotsuga menziesii*) from the study area. The Selective Logged habitat, when assessed in 1975, consisted primarily of open areas with scattered mature trees and a developing canopy of regenerating conifers. Total canopy coverage of trees was extremely variable (5-30%) and was made up mostly of the secondary canopy of regenerating conifers. The few remaining Douglas-fir and larch (*Larix occidentalis*) veterans were 140 to 190 years old and up to 31 m tall. The secondary canopy consisted primarily of Douglas-fir with lodgepole pine, spruce, and larch.

Pinegrass was the main component of the grass/forb layer, growing vigorously in tufts in the open areas. The shrub community was heterogeneous with up to 10 species present. Rose was the most abundant shrub with lesser amounts of birch (*Betula papyrifera*) and snowberry. More peferred forage shrubs, including Saskatoon, willow, and maple (*Acer glabrum douglasii*) were present in smaller amounts.

The vegetation of the Selective Logged habitat was found to be heterogeneous and the limited sampling of this study was insufficient to address properly the complexity of the vegetative community. This complex habitat has relatively short sight distances and moderately abundant forages. This habitat appeared to be treated as a homogeneous unit, by the highly mobile elk.

<u>Mature Mixed Conifer Forest</u>

Forests with larch and Douglas-fir codominant with lodgepole pine were found on 695 ha (10%) of the study area. Mature mixed stands were found to be 100 to 120 years old, 26 to 34 m in height and with basal area of 48 m^2 ha^{-1}. Larch were the largest trees in these stands, 50-60 cm D.B.H., while lodgepole pine of a similar height were 20-30 cm D.B.H.

Shrubs in this habitat were sparse, although seven species were present. Soopolallie and the low growing spirea were the only two shrubs with canopy coverage greater than 10%.

The moist, spongy grass/forb layer in this habitat was similar to the grass/forb layer of the Old Pine

Forest habitat. Pinegrass was very widely distributed in a single stalk growth form, while ricegrass (Oryzopsis asperifolia) was present in small tufts. Ricegrass, although present in small quantities, was observed to be heavily utilized by elk in this habitat. Bunchberry (Cornus canadensis) was the only forb with a canopy coverage greater than 10% in the midsummer sampling period.

The role of this habitat as cover for elk must be evaluated considering that fewer trees in this habitat are susceptible to beetle infestation and that the value of larch as cover is modified by the shedding of needles in the winter. Sight distances and forage quantities were similar to Old Pine Forest habitats.

Young Pine Forest

Young Pine Forest was found in small patches at low elevations and two larger stands at higher elevations in the northeast portion of the study area. The 665 ha (10%) of the study area of Young Pine Forest was mainly inaccessible for intensive study. The 15 ha block adjacent to the clearcut south of Jack Creek was the only accessible Young Pine Forest in the study area. This habitat type was characterized using the vegetation releve of the ELUCS from a stand approximately 5 km to the north of the study area.

Young Pine Forest stands were totally dominated by young lodgepole pine. Trees in the sampled stand were approximately 60 years old, 20 m in height and had a basal area of 32 m^2ha^{-1}. Moss and pinegrass are the major components of the understory, although seven species of shrubs had canopy coverage in the 5% to 10% class. Young Pine Forest stands had very low forage quantities and short sight distances. No use by elk in this habitat was observed, both within and outside of the study area.

4.2 ELK ACTIVITY

Few elk were observed using the study area in the summer months. Substantial numbers of elk were first observed in the study area in the mid- to late-October period. Substantial numbers of elk were observed throughout the two winter periods of the study (Table III).

Proportionately fewer elk were observed during the midday periods than during surveys in early mornings and late evenings (Table IV). Analyses of variance show significant differences in the number of elk seen per

Table III. Summary of numbers and classification of elk observed during the two winter study periods.

	December 1975 - April 1976	December 1976 - April 1977	Total
Number of surveys	68	91	159
Number of elk groups observed	263	300	563
Classification:			
Cow elk	635	796	1431
Calf elk	388	359	747
Spike bull elk	26	100	126
Bull elk (exclusive of spikes)	31	25	56
Unclassified elk	530	1745	2275
Total number of elk observed	1611	3026	4637

Table IV. Elk observed during surveys at different periods throughout the day with statistical treatment.

	No. of surveys	No. of elk groups observed	No. of elk observed	elk per survey[a)] $\bar{x}$	S.D.	No. of elk per group[b)] $\bar{x}$	S.D.
Early morning (before 9:00 am)	79	397	3223	41	26.4	8.1	7.9
Late morning (9:00 am to noon)	42	71	630	15	19.6	8.9	9.2
Early afternoon (noon to 4:00 pm)	17	35	303	18	17.2	8.7	9.3
Evening (after 4:00 pm)	21	60	481	23	19.6	8.0	7.4
	159	563	4637				

a) Analysis of variance (F = 6.5771 DF = 3) indicates significant differences in numbers of elk during different periods of the day.

b) Analysis of variance (F = 0.21711 DF = 3) indicates no difference in size of elk groups during different periods of the day.

survey during different periods of the day. Similar analyses of the numbers of elk within groups indicate no concurrent changes in group sizes.

Examination of the activity of the groups of elk shows proportionately more elk were feeding in the morning and evening surveys (Table V) than during midday. Conversely, larger proportions of elk were observed resting during the midday periods. During all periods of the day some elk groups were observed with a primary activity of directional movement. As most elk were observed in clearcut habitat directional movement has been referred to as crossing in Table V.

Most observations of elk activities in this study were in the clearcut habitat. Elk in the forested habitats were sufficiently wary to preclude observations of their activities in this habitat. Observations are strongly related to activities of elk in clearcuts and may not reflect the overall proportions of activities of animals in all habitats.

In general most elk were observed feeding in the clearcut habitat in the early mornings. Many elk would move into the forested habitat by midday as part of their feeding activity or when disturbed. During the midday period more of the groups observed were resting than in

Table V. Elk activity during surveys at different periods throughout the day.

	No. of groups of elk	Feeding[a)]		Resting[b)]		Crossing[c)]	
		No. of groups	% in period	No. of groups	% in period	No. of groups	% in period
Early morning (before 9:00 am)	397	298	75	26	7	72	18
Late morning (9:00 am to noon)	71	30	42	27	38	14	20
Early afternoon (noon to 4:00 pm)	35	18	51.4	13	37.1	4	11.4
Evening (after 4:00 pm)	60	50	83	4	7	6	10
Total activity	563	396	71	70	12	96	17

a) Feeding - activity assessed as feeding when more than 50% of individuals feeding

b) Resting - activity assessed as resting when more than 50% of individuals resting

c) Crossing - activity assessed as crossing when group showed directional movement without feeding activity the morning or evening periods. Most elk observed in the clearcut habitat in the evening were feeding. Infrequent and unrecorded observations of elk during the hours of darkness indicated that some elk were feeding, moving about, and resting in the clearcut habitat at night.

4.3 ELK DIETS

Samples were taken from nine elk rumens from animals killed in or adjacent to the study area during the two winter periods of the study. Determination of 'typical' elk diets from these samples was impossible due to the high variability between the different rumens (Table VI).

Grasses were the major diet volume ($\overline{X}$ = 52%; SD = 32), but ranked not much greater than shrubs ($\overline{X}$ = 39%; SD = 31). Conifers ($\overline{X}$ = 6%; SD = 6) and forbs ($\overline{X}$ = 3%; SD = 6) were minor proportions by volume.

Meeting the objective of describing elk food habits relative to snowdepth was prohibited by the abnormally mild winters of the study, the limited number of rumens available, and the high variability of the data. Other unreported rumen samples collected from the East Kootenay over a period of years were available. These data (Table VI) show a similar, high variability. A very general

Table VI. Percent volumes of winter food types in rumen samples from the study area and other East Kootenay locations.

Biogeoclimatic Zone and Locality[b]	Sample size	Food types[a] - % identifiable rumen content							
		Grasses		Shrubs		Conifers		Forbs	
		$\overline{x}$	SD	$\overline{x}$	SD	$\overline{x}$	SD	$\overline{x}$	SD
East Kootenay samples from Engelmann spruce and Subalpine fir zone outside of study area[c]	7	49.7	39.8	20.4	34.6	12.6	11.6	17.4	37.3
East Kootenay samples from Interior Douglas fir or Ponderosa pine - Bunchgrass zones outside of study area[c]	12	67.0	38.2	22.6	31.9	1.8	3.7	8.6	24.6
White River study area - low snow conditions	9	52.4	31.7	39.0	30.5	5.5	6.3	3.4	5.8
White River study area - severe snow conditions (McLellan, 1978)	2	0.0	0.0	97.0	4.2	3.0	4.2	0.0	0.0

a) Food volumes by species lumped into types for analysis

b) All samples included were collected from animals killed in winter

c) From the British Columbia Fish and Wildlife Branch records trend of grasses being a major diet item was consistent both in the data presented and in the reviews of elk diet by Singleton (1976) and Capp (1968).

Two samples collected by McLellan (1978) from the study area during the severe winter period following the two mild winters of this study show less variation. However, interpretation of trends from these two samples where almost all rumen contents identified were shrubs ($\overline{X}$ = 97%), is prohibited by both the small sample size and the high variation in other data.

The value of rumen samples as a technique to test even major shifts in diet remains to be determined. The high variability in the data collected could result from small sample sizes, inadequacies in the technique of analysis, or from high variability in diets. Reviews by Singleton (1976) and Capp (1968) indicate variation between studies, but no indication is given of the variation between samples within a study.

4.4 ELK USE OF HABITATS

Direct observations of elk (Table VII) and track counts (Table VIII) were utilized to identify relative levels of elk use of different habitats. In both cases a

Table VII. Numbers of elk and numbers of elk groups observed by habitat type during both winters.

Habitat type	Number of elk n = 4637	Proportion of elk observed	Number of elk groups observed	Proportion of elk groups observed	Habitat type as proportion of study area
Clearcut	4222	91%	521	92.5%	19.3%
Selectively Logged	83	1.8%	10	1.8%	12.2%
All Forested Types	332	7.2%	32	5.7%	68.5%

Table VIII. Track counts within habitats during shallow (<45cm) snow conditions.

Habitat		Clearcut Logged Habitat				Selective Logged Habitat				All Forested Habitats			
Proportion of total survey distance		= 0.27				= 0.43				= 0.30			
Survey date	Total tracks all habitats	No. of tracks	Proportion of total tracks of this survey	Confidence interval[a)]	Selection[b)]	No. of tracks	Proportion of total tracks of this survey	Confidence interval[a)]	Selection[b)]	No. of tracks	Proportion of total tracks of this survey	Confidence interval[a)]	Selection[b)]
Dec. 13, 1975	12	2	0.17	±0.26	0	4	0.33	±0.32	0	6	0.50	±0.34	0
Dec. 31, 1975	271	217	0.80	±0.06	+	44	0.16	±0.05	-	10	0.04	±0.03	-
Jan. 5, 1976	69	45	0.65	±0.14	+	24	0.35	±0.13	0	0	0.00	±0.00	-
Jan. 8,]976	42	23	0.54	±0.18	+	18	0.43	±0.18	0	1	0.02	±0.05	-
Mar. 1, 1976	54	15	0.28	±0.15	0	28	0.52	±0.16	0	11	0.20	±0.13	0
Mar. 10, 1976	190	151	0.79	±0.07	+	39	0.20	±0.07	-	0	0.00	±0.00	-
Mar. 25,]976	107	86	0.80	±0.09	+	21	0.20	±0.09	-	0	0.00	±0.00	-
Mar. 27, 1976	115	53	0.46	±0.11	+	3	0.03	±0.04	-	59	0.51	±0.11	+
Nov. 26, 1976	96	69	0.72	±0.11	+	27	0.28	±0.11	-	0	0.00	±0.00	-
Jan. 13, 1977	136	60	0.44	±0.10	+	76	0.56	±0.10	+	0	0.00	±0.00	-
Feb. 24, 1977	99	45	0.45	±0.12	+	54	0.55	±0.12	+	0	0.00	±0.00	-
Mar. 2, 1977	111	77	0.69	±0.10	+	34	0.30	±0.10	-	0	0.00	±0.00	-
Mar. 3, 1977	142	71	0.49	±0.10	+	13	0.09	±0.06	-	60	0.42	±0.10	+
Mar. 13, 1977	22	22	1.00	±0.00	+	0	0.00	±0.00	-	0	0.00	±0.00	-
Summary	1468	936	0.638	±0.030	+	385	0.262	±0.027	-	147	0.104	±0.019	-

a) Confidence interval, utilizing Bonferroni Z statistic.

b) Selection is indicated by one of 0, + or - when confidence interval of observation overlaps (0), or is greater than (+), or is less than (-) the proportion of the habitat in that category.

paucity of data for some forested habitats encouraged grouping of data from old pine forest, young pine forest and mature mixed conifer forest under a single category, forested habitat.

Observations of 4639 elk during 159 observation surveys, showed most elk (92.5%) in clearcut habitat, which comprised only 19.3% of the study area, indicative of a strong preference for clearcut habitat. Elk were more easily observed in this open habitat. Sight distances were up to 3 km in clearcut areas, 200 m in selectively-logged habitat and 100 m in forested habitats. Consequently, almost all clearcut habitat was surveyed and only a relatively small portion of selectively-logged and forested habitats were surveyed. Locations of elk observed were recorded only for the initial observation of the elk to reduce this bias. Varying climatic conditions during the 159 observation surveys precluded quantifying the proportion of habitats visible.

Analysis of track densities also indicates a strong preference for clearcut habitat (Table VIII). A goodness of fit (chi-squared) test showed highly significant ($P \leq 0.01$) differences from a proportional distribution for all track counts.

Evaluation of preference or avoidance of a habitat is provided through use of a Bonferroni Z statistic as outlined by Neu *et al.* (1974). Proportions of tracks found in the clearcut habitat showed elk preferred this habitat on 12 of 14 surveys. Proportions of elk tracks observed were similar to the proportions of the clearcuts surveyed in the other two cases. Evaluation of track counts for selectively-logged habitat utilizing this technique showed elk avoidance for 8 of the 14 surveys, proportional use for 4 of the 14 surveys and selection of selectively-logged habitat type by elk on only 2 occasions. Forested habitats were similarly preferred by elk on only 2 surveys, utilized proportionately on 2 occasions, and avoided by elk in 10 of 14 surveys.

Evaluation of all track surveys combined shows strong selection of clearcut habitats, with the observed proportion of tracks 0.638 ± 0.030 compared to the proportion of the total survey (0.27). A concurrent avoidance of selectively-logged habitat (observed proportion of tracks 0.262 ± 0.027; proportion of total survey 0.43) is also shown. Similarly, forested habitats were avoided by elk, (observed proportion of tracks 0.100 ± 0.019; proportion of total survey 0.30).

4.5. ELK USE OF CLEARCUTS

4.5.1 DESCRIPTION OF CLEARCUT STUDY SITES

A generalized description of clearcut habitat was given in section 4.1. The areas chosen for intensive study were labelled Elk Creek North (ECN), Jack Creek North (JCN) and Jack Creek South (JCS) for convenience. Figure 9 shows the location of these sites and Figures 10, 11, 12 illustrate them. The sites were chosen to represent some variations within clearcut habitat in the study area while considering the logistics of being able to observe all elk within the site during surveys. Consequently two of the sites are only portions of larger logged blocks. Table IX summarizes the size of the study sites and presents areas of all the logged blocks in the study area. Descriptions of the slope, elevation, aspect, microrelief, vegetation subtypes, burned areas, and slash accumulation are listed for the three sites in Table X.

Elk Creek North at 130 ha was the largest of the three sites selected and it was part of a 301 ha block just north of Elk Creek. This site included two ridge features and portions of two alluvial fans which resulted in higher proportions of the mesic grass/forb vegetation subtype (35%) and the presence of shrub dominated

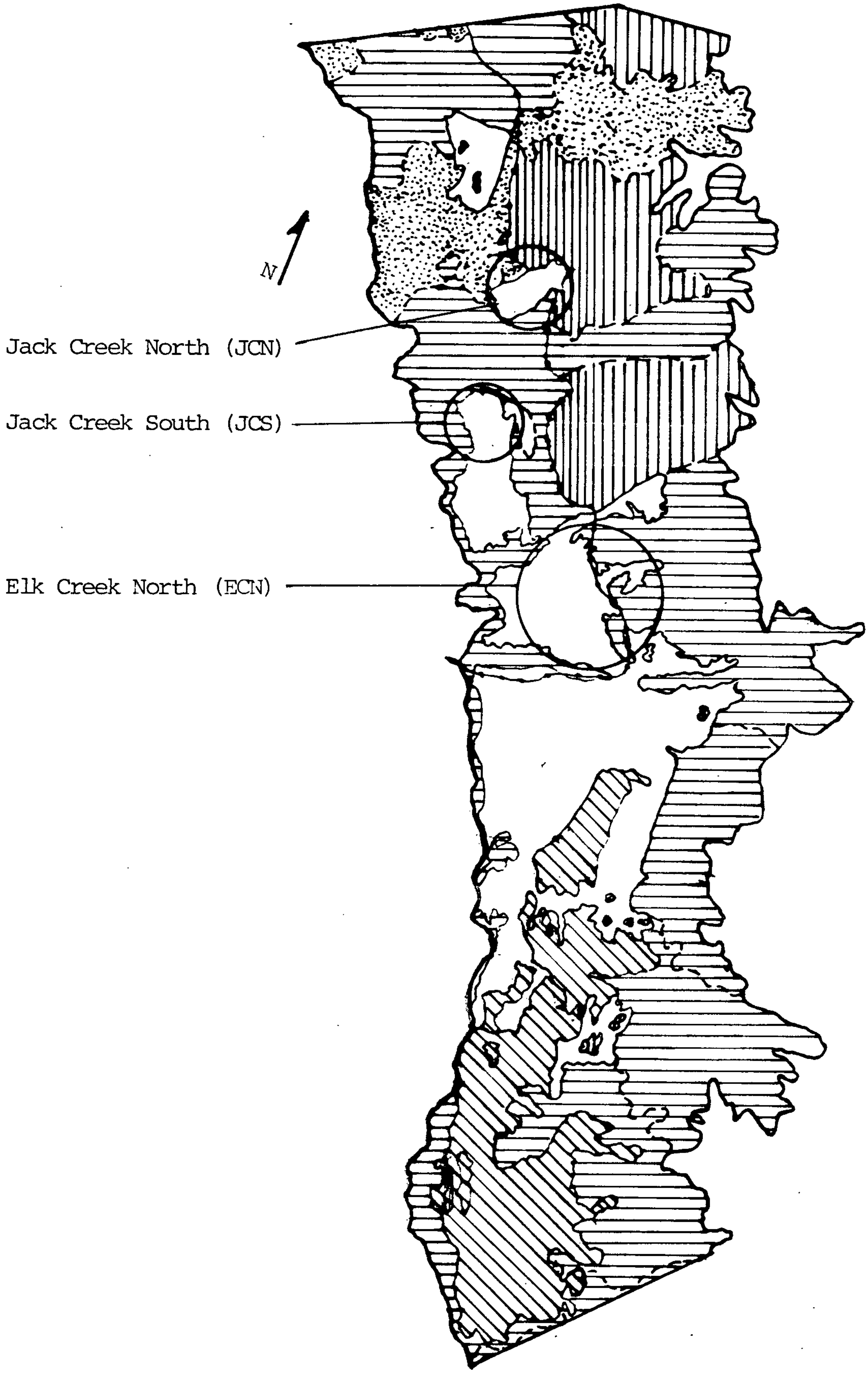


Figure 9. Location of intensive study sites in clearcut habitat.

a) Overview

b) Detail

Figure 10. Pictorial views of intensive study site - Elk Creek North.

a) Overview

B) Detail

Figure 11. Pictorial views of intensive study site - Jack Creek South.

a) Overview

b) Detail

Figure 12. Pictorial views of intensive study site - Jack Creek North.

Table IX. Size of clearcut study sites and adjacent clearcut and selectively logged blocks.

Size of Clearcut Study sites	
Elk Creek North (ECN)	130 ha
Jack Creek North (JCN)	40 ha
Jack Creek South (JCS)	43 ha
Size of Clearcut blocks	
	749 ha[a)]
	301 ha (includes ECN)
	143 ha (includes JCS)
	40 ha
	67 ha
Size of Selectively Logged blocks	
	102 ha
	113 ha
	47 ha
	593 ha

a) Includes all continuous clearcut area surrounding isolated 102 ha block of recent selective logging.

Table X. Proportions of strata of slope, elevation, aspect, vegetation subtypes, micro relief, burning history and slash accumulation in clearcut study sites.

		ECN (n = 229)	JCS (n = 142)	JCN (n = 139)	$\overline{X}$ (n = 510)
Slope (in percent)	<10	0.33	0.38	0.10	0.28
	11-20	0.26	0.43	0.25	0.30
	21-30	0.18	0.15	0.46	0.25
	31-40	0.14	0.04	0.17	0.12
	>41	0.09	—	—	0.05
Elevation (in feet)	3700-3800	0.21	0.26	—	0.17
	3801-3900	0.36	0.54	—	0.31
	3901-4000	0.18	0.20	—	0.14
	4001-4100	0.13	—	0.17	0.10
	4101-4200	0.08	—	0.33	0.13
	4201-4300	0.04	—	0.34	0.11
	4301-4400	—	—	0.16	0.04
Aspect	E	0.02	—	0.22	0.08
	SE	0.04	0.06	0.35	0.15
	S	0.36	0.28	0.27	0.31
	SW	0.41	0.37	0.15	0.31
	W	0.11	0.25	—	0.12
	NW	0.01	0.03	—	0.01
	N	0.04	0.01	0.01	0.02
Vegetation Subtypes					
Mesic grass/forb		0.35	0.05	0.15	0.21
Shrub dominated		0.11	—	—	0.05
Xeric grass/forb		0.34	0.74	0.61	0.53
Disturbed		0.20	0.22	0.24	0.22
Micro-relief					
Ridge		0.61	0.88	0.66	0.69
Gully		0.09	0.13	0.34	0.17
Alluvial fan		0.26	—	—	0.12
Logging landing		0.04	—	—	0.02
Burning history					
Burned		0.43	0.03	0.03	0.21
Unburned		0.57	0.97	0.97	0.79
Slash Accumulation					
Nil		0.57	0.07	0.10	0.30
Light		0.31	0.35	0.68	0.42
Moderate		0.12	0.58	0.22	0.28

vegetation (11%). Some broadcast burning had occurred in ECN (43% burned) a contrast to JCS and JCN (3% burned) where only landings had been burned. Slash accumulations were consequently less in ECN. Aspect in ECN was generally south to southwest with 77% of the grid cells in these two aspect categories. Jack Creek North (JCN) and Jack Creek South (JCS) sites were similar in size (40 and 43 ha). JCS was slightly flatter (81% of area < 21% slope) and more westerly in aspect (90% of area S, SW or W aspect) than JCN (63% of area > 20% slope, 84% of area S, SE and E aspect). Elevation of JCN clearcut was entirely between 4001 and 4400 ft while JCS was entirely between 3700 and 4000 ft. ECN was between 3700 and 4000 ft with 75% of the site below 4000 ft.

Disturbed vegetation and grids were noted for more than 20% of all grid cells for all sites (ECN 20%, JCN 24%, JCS 22%), with most of the disturbance resulting from skid trails. Analysis of measures of standing crop of grass and forbs clipped in October revealed no difference between vegetation subtypes, when disturbed sites where little or no vegetation grew were excluded. Variation within all subtypes was high (Table XI). A mean value of 68 g m^{-2} (SD = 36.1) of standing crop of grass and forbs for all samples from the clearcut habitat was observed. In comparison, mean grass and forb standing crop from forest habitat was 24 g m^{-2} (SD =

Table XI. Analysis of standing crop estimates of grass and forbs within vegetation subtypes of clearcut habitat.

Analysis of variance table

Source	DF	Sum of sqrs	Mean sqrs	F-statistic	Signif
Between	2	8112.6	4056.3	3.4393	.0407
Within	45	53073	1179.4		
Total	47	61185	(random effects statistics)		

Vegetation subtype	N	Mean[a)]	Variance	Std Dev
Mesic grass/forb	16	80.862	1429.2	37.805
Shrub dominated	10	44.860	545.42	23.354
Xeric grass/forb	22	70.395	1272.6	35.674
Grand	48	68.565	1301.8	36.081

a) weight of standing crop of grass and forbs in October in ($g\ m^{-2}$).

18.0).

Clearcut study sites indicated that clearcut habitat included a complex of microrelief features, slopes, vegetation subtypes and history of burning. These features could affect elk patterns of use of the sites.

4.5.2. OBSERVATIONS OF ELK WITHIN CLEARCUT STUDY SITES

During the two winters of this study 2287 elk were observed in the three clearcut study sites. Proportionately more elk were observed in the larger study site (ECN), than in the other two (Table XII). Goodness of fit comparisons and analysis of this data using the Bonferroni Z statistic as outlined by Neu et al. (1974) indicates a selection for ECN.

Section 4.5.1 indicated differences between relief features, slopes, vegetation subtypes and burning history for the three study sites. Observations of elk within the three study sites and stratified within these features are presented in Table XIII. Goodness of fit comparisons were significant for all cases.

Selection criteria show a preference for ridges in all three sites and less than proportional use of

Table XII. Elk observations in clearcut study sites in comparison to proportions of clearcut study sites surveyed.

Study site	Proportion combined area of 3 study sites (213 ha)	Number of elk observed (n=2287)	Expected number of elk observed[a]	Proportion of elk observed	Confidence interval	Selection[b]
ECN	0.61	1701	1395	0.74	±0.01	+
JCN	0.20	410	457	0.18	±0.01	-
JCS	0.19	176	435	0.08	±0.01	-

$$\chi^2 = 226.2 \quad df = 2$$

a) Expected number of elk is proportion of total clearcut study site area times the total number of elk observed.

b) Selection is indicated by one of 0, + or - when confidence interval of observation overlaps, or is greater than, or is less than the proportion of the habitat in that category.

Table XIII. Observations of elk within the three study sites stratified by relief, slope, vegetation subtype and burning history.

	ECN				JCN				JCS			
	Proportion of site (n=229)	Number of elk observed	Proportion of elk observed	Selection [a]	Proportion of site (n=139)	Number of elk observed	Proportion of elk observed	Selection [a]	Proportion of site (n=142)	Number of elk observed	Proportion of elk observed	Selection [a]
Relief features												
Ridge	.61	1205	.73	+	.66	362	.89	+	.87	170	.98	+
Gully	.09	121	.07	-	.47	45	.11	-	.13	4	.02	-
Alluvial fan	.26	324	.20	-								
Logging landing	.04	8	<1	-								
		1658				407				174		
Slope (%)												
<10	.33	366	.22	-	.10	1	<.01	-	.38	25	.15	-
11-20	.26	355	.21	-	.25	43	.11	-	.43	126	.72	+
21-30	.18	496	.30	+	.46	254	.62	+	.15	23	.13	-
31-40	.14	345	.21	+	.17	91	.22	+	.04	0	.00	-
>41	.09	96	.06	-	.02	18	.04	+				
		1658				407				174		
Vegetation subtype												
Mesic grass forb	.35	449	.27	-	.15	5	.01	-	.04	0	.00	-
Shrub dominated	.11	149	.09	-								
Xeric grass forb	.34	738	.85	+	.61	347	.85	+	.74	125	.72	-
Disturbed	.20	322	.14	0	.24	55	.14	-	.22	49	.28	+
		1658				407				174		
Burning history												
Burned	.43	1016	.61	+	.03	407	1.0	+	.03	174	1.0	+
Unburned	.57	642	.39	-	.97	0	.0	-	.97	0	.0	-
		1658				407				174		

a) Selection is indicated by one of 0, + or - when confidence interval of observation overlaps, or is greater than, or is less than the proportion of the habitat in that category.

gullies, alluvial fans, and landings. Selection for moderate slopes (21% to 40%) in two clearcuts, moderate but slightly flatter (11-20%) slopes in the third clearcut (JCS) and selection of greater than 41% slopes in JCN is evident. Moderate slopes occur on ridges so selection to these features is probably related. The xeric grass forb vegetation subtypes, found on well drained sites also primarily occurs on ridges, so selection for this feature in two of the sites and heavy though slightly less than proportional use in the third site (JCS), was consistent with selection for ridges and moderate slopes.

More burning had occurred in ECN than in the other sites, however, observations show selection for burned habitat in all sites. Elk were not observed using unburned sites in either JCN or JCS although unburned sites comprised 97% of the available habitat.

Table XIV presents data on observations of elk use of the study sites stratified by distance from cover, distance from road, and slash accumulation. These features of the clearcut habitat were hypothesized to affect elk patterns of use. Goodness of fit comparisons show differences from proportional distributions in all cases.

Table XIV. Observations of elk within clearcut study sites stratified by distance from cover, distance from road and slash accumulation.

	ECN				JCN				JCS				COMBINED			
	Proportion of site (n=229)	Number of elk observed	Proportion of elk observed	Selection[a)]	Proportion of site (n=139)	Number of elk observed	Proportion of elk observed	Selection[a)]	Proportion of site (n= 142)	Number of elk observed	Proportion of elk observed	Selection[a)]	Proportion of area intensively studied	Number of elk observed	Proportion of elk observed	Selection[a)]
Distance from edge (m)																
<100	.22	429	.26	+	.65	207	.51	-	.44	79	.45	0	.40	715	.32	-
101-200	.20	348	.21	0	.35	200	.49	+	.38	78	.45	+	.29	626	.28	0
201-300	.23	394	.24	0					.18	17	.10	-	.15	411	.15	0
301-400	.17	336	.20	+									.08	336	.15	+
401-500	.11	66	.04	-									.05	66	.03	-
501-600	.07	67	.04	-									.03	67	.03	0
>600	.01	18	.01	0									.01	18	.01	0
		1658				407				174				2239		
Distance from road (m)																
<100	.32	329	.20	-	.14	11	.03	-	.28	31	.18	-	.26	371	.17	-
101-200	.15	80	.05	-	.16	13	.03	-	.30	64	.37	+	.20	157	.07	-
201-300	.14	398	.24	+	.21	83	.21	0	.25	35	.20	-	.18	516	.23	+
301-400	.15	381	.23	+	.17	88	.23	+	.16	44	.25	+	.16	513	.23	+
401-500	.13	224	.13	0	.12	77	.20	+	.01	0	.00	-	.09	301	.14	+
501-600	.09	196	.12	+	.10	91	.23	+					.07	387	.13	+
>600	.02	50	.03	0	.10	26	.07	-					.04	76	.03	0
		1658				407				174				2239		
Slash																
Nil	.57	1150	.69	+	.10	14	.03	-	.07	7	.04	-	.57	1171	.52	-
Light	.30	309	.19	-	.68	341	.84	+	.35	97	.56	+	.31	747	.33	+
Moderate	.13	199	.12	0	.22	52	.13	-	.58	70	.40	-	.13	321	.14	0
		1658				407				174				2239		

a) Selection is indicated by one of 0, + or - when confidence interval of observation overlaps, or is greater than or is less than the proportion of the habitat in that category.

Selection of areas within 100 m from the edge is different for each of the clearcuts and in overall evaluation shows slight avoidance. Observations show proportional use or selection of areas from 100 m to 400 m from the edge, avoidance of the 400 to 500 m area, and proportional use or avoidance of areas more than 500 m from the edge.

Observations showed elk avoidance of the area within 100 m of road for all sites. Elk showed avoidance of areas between 101 and 200 m from roads in two of the three sites and overall. Overall, selection or proportional use was observed for all areas more than 200 m from the road.

Assessment of elk observations in relation to slash accumulations is not clear. Selection for areas without slash in ECN is contrasted with elk avoidance of such areas in JCN and JCS. Light slash was avoided in ECN but selected for in the other two sites. Moderate slash areas were used in proportion in ECN and avoided in the other two sites.

A large proportion of ECN had been broadcast burned and consequently had no slash. These burned areas were well vegetated. Light slash occurred in areas that had been unburned. Moderate slash was seen either in areas that had not been burned, or in areas that had considerable slash buildup before burning that resulted in a tangle of partially burned trunks remaining. In contrast the areas with no slash in JCN and JCS were the areas of disturbance where vegetation growth was sparse or non existent. Light and moderate slash accumulations were usually vegetated sites.

4.5.3. PELLET GROUP SURVEYS WITHIN CLEARCUT STUDY SITES.

Evaluation of levels of use of the area by elk as measured by pellet group counts indicates significant differences between surveys (paired t-tests by plots); Table XV. Elk use during the 1975-76 winter (October 1976 survey) was appreciably lower than use during the 1974-75 winter (October 1975 survey). Use levels as recorded for the 1976-77 winter are not directly comparable as the survey was conducted in the spring and considerable loss of pellets could be expected during the summer.

Comparison of old pellet groups in the 1977 survey and old pellet groups in the 1976 survey indicate no significant loss of pellet groups during the seven month winter period (pair t-test by plot, $t = 1.3362$, $df = 227$, $sig = 0.1828$). Different levels of elk use of the three

Table XV. Mean and 95% confidence intervals of pellet group densities within all clearcut study sites for October 1975, October 1976, and May 1977 surveys.

	$\bar{x}$ pellet group density m^{-2}	SD	Confidence interval (95%)
October 1975	.10627	.13976	(0.092510, 0.12002)
October 1976	.064637	.10979	(0.055076, 0.074197)
May 1977 (all groups)	.26287	.21245	(0.24437, 0.28131)

different study sites were measured, the October 1976 survey is presented to illustrate the differences (Table XVI). Orthoganol comparison of the three sites indicates that elk use levels in JCN and JCS were not different but that use in ECN was significantly higher.

Of the seven features of the clearcut study sites evaluated only two were significantly correlated (product-moment correlation coefficient) to pellet density. Slope and distance from road were correlated with pellet density in all surveys. Selection or avoidance of the strata categories was evaluated utilizing use of Bonferroni Z confidence intervals for observed proportions of pellet groups in comparison to the proportion of the study site. Table XVII gives of the outcome for the October 1976 survey in ECN as an example.

4.6. ELK RESPONSE TO HUMAN ACTIVITY

Data were gathered on elk reaction to disturbance during the two seasons of this study. Elk appeared to react only to visible disturbance. Although noise of various intensities was noted at different times throughout the study, no elk were observed to react to noise in any fashion other than a few moments of

Table XVI. Mean density of pellet groups from the October 1976 survey for the three study sites.

Study site	$\bar{x}$	SD	Confidence interval (95%)
ECN	.094737	.13689	(.076873, .11260)
JCN	.048921	.081975	(.035173, .062669)
JCS	.031690	.062308	(.021353, .042027)
(JCN + JCS)	.040214	.073085	(.031631, .048796)

Table XVII. Comparison of $\bar{x}$ pellet densities between strata of slope and distance from road, October 1976 survey in ECN study site.

Slope category (%)	Proportion of ECN	Pellet groups content	Proportion of pellet groups	Confidence interval	Selection[a)]
<10	.33	36	.17	.002	-
11 - 20	.26	46	.21	.003	-
21 - 30	.18	42	.19	.003	+
31 - 40	.14	70	.32	.004	+
>41	.09	22	.10	.002	+

$\chi^2 = 72.83$ df = 4

Distance from road (m)					
< 100	.32	37	.17	.002	-
101 - 200	.15	15	.07	.001	-
201 - 300	.14	29	.13	.002	-
301 - 400	.15	48	.22	.002	+
401 - 500	.13	51	.24	.002	+
501 - 600	.09	31	.14	.002	+
> 600	.02	5	.02	.001	0

$\chi^2 = 51.62$ df = 6

alertness, usually in response to sharp sounds. An extreme illustration of lack of reaction to noise was a group of elk observed feeding out of sight but within 200 m of active logging with loggers, skidders, chainsaws, and falling trees creating considerable noise. No opportunity was available to record elk reaction to smells.

During the study 79% of all elk groups observed were within a line of sight of human activity. Most elk (86%) fled when they saw human activity (Table XVIII). A total of 14% of all disturbed elk groups observed showed no flight response, however, 4% of all disturbed elk groups showed no response, indicating the elk were unaware of a disturbance that seemed to the researcher to be within their line of sight. Only 10% of elk that were exposed to disturbance were aware of the disturbance and did not show an avoidance reaction.

Elk response to activities within line of sight did not appear to change with increasing distance (Table XIX). Most groups (68%) were within 100 m when the disturbance was judged to be within their line of sight, due mainly to microtopographic features which often hid approaching vehicles. Although sight distances within large clearcuts or combinations of large clearcuts were up to 3 km no elk indicated that they were aware of

Table XVIII. Elk reaction to human activity, primarily motor vehicles during the two winter study periods.

Elk reaction to disturbance[a)] within line-of-sight[b)]	No of elk (n=3772)	Proportion of total elk observed	No of elk groups (n = 444)	Proportion of elk groups
Fled to cover				
Immediate reaction	2996	0.80	353	0.79
Delayed reaction[c)]	233	0.06	27	0.06
Total	3229	0.86	380	0.85
Watched disturbance or showed alertness[d)]	396	0.10	39	0.09
No reaction - elk probably not aware of disturbance	147	0.04	25	0.06

a) Disturbance was any human activity. In this study 99% of disturbance was movement of motor vehicles; 1% was humans out of motor vehicles.

b) Of all elk observed in this study 79% were judged to be able to observe human disturbance. 21% of elk observed were either out of sight of human activity or there was no human activity in the area at the time.

c) Motor vehicle out of sight before reaction.

d) Elk returned to pre-disturbance activity.

Table XIX. Elk reaction to human activity by distance from disturbance categories.

Distance from disturbance (m)		Fled to cover	Watched disturbance or showed alertness	No reaction - elk probably not aware of disturbance	Total
100	no of groups	143	15	10	168
	proportion	.85	.09	.06	.68
200	no of groups	10	2	-	12
	proportion	.83	.16		.05
300	no of groups	14	-	-	14
	proportion	1.0			.06
400	no of groups	9	1	-	10
	proportion	.90	.10		.04
500	no of groups	9	1	-	10
	proportion	.90	.10		.04
600	no of groups	8	-	1	9
	proportion	.89		.11	.04
700	no of groups	6	3	2	11
	proportion	.54	.27	.18	.04
800	no of groups	4	2	-	6
	proportion	.66	.33		.02
900	no of groups	3	-	1	4
	proportion	.75		.25	.02
1000	no of groups	1	1	-	2
	proportion	.5	.5		.01
>1000	no of groups	1	-	-	1
	proportion	1.0			<.01

vehicles or human activity at such long distances. I utilized these long sight distances to observe elk with the aid of a spotting scope but it appeared that elk either could not see or would not respond to activity at distances greater than approximately 1.5 km.

5.0. DISCUSSION

The consensus of most workers is that weather, especially snowdepths, determines the areas in which elk spend the winter (Lyon 1975). The relationships between forest cover and ungulate winter-habitat had not been investigated in the intermountain valleys of southeastern British Columbia. In the drier Rocky Mountain Trench areas these relationships have been well documented (Smith 1977).

Forest cover in the study area was being rapidly modified by timber salvage operations following an epidemic of mountain pine beetles in lodgepole pine stands, the predominant forest type. The mortality rate of attacked trees is high, commonly up to 100% in even-aged stands (Safranyik et al. 1974), and salvage logging operations in the study area often removed all forest cover from large areas.

Forage production for ungulates is greatly enhanced in areas where forests have been removed, in the Rocky Mountain Trench (Kemper 1971, Smith 1977), in Douglas-fir vegetation types (Lyon 1971) and as a general trend (Smith 1977). Conversely, forest cover reduces snowpack (review of Bunnell 1978), a critical factor for ungulate survival, in areas of heavy snow. Forest cover can be essential ungulate winter-habitat, as on Northern Vancouver Island where deer were confined to forests during conditions of deep snow (Jones 1975).

Human activities, particularly motor vehicle traffic, have been observed to affect elk activity. Avoidance of roads and vehicles within 2 to 6.4 km have been recorded (Ward 1976, Morgantini and Hudson 1979, Lyon and Jensen 1980, Perry and Overly 1976, Marcum 1976, Redgate 1978, see Bunnell 1978 for others). In this study, elk have been shown both to avoid habitat close to roads and to show avoidance reactions to disturbance. In contrast, Beall (1974) and Kirsch (1962) noted that a few elk became accustomed to logging activity and used areas near active logging. Only the study reported by Morgantini and Hudson (1979) documented elk avoidance of human activity during winter.

The objectives of the study reported here included the testing of hypotheses examining elk habitat selection and behaviour in relation to forest cover and human activities. The first hypothesis proposed that elk would select clearcut habitat for feeding during shallow snow conditions but would be prevented from using these open areas when snowdepths exceeded 45 cm. Snowdepths during the entire two winters of this study were considered shallow, consistently less than 20 cm, and did not reach 45 cm, the approximate depth that has been observed to prompt elk to seek areas with shallower snowpack (Beall 1974, Sweeny 1975, Hershey and Leege 1976, Leege and Hickey 1977). Elk selected clearcut habitat for feeding during shallow snow conditions, indicating acceptance of the first part of the hypothesis. The second part of the hypothesis remained untested in this study.

During shallow snow conditions, elk utilized the forage in the clearcut areas and most elk observed in clearcuts were feeding. Fewer elk were observed during the midday period, but a higher proportion of the animals observed at midday were resting rather than feeding. Movement of elk to higher elevation forested habitats was observed during midday periods.

Throughout the two winters of this study, temperatures were relatively mild, usually between -18° and $2^{\circ}C$. Beall (1974) recorded activity patterns for elk during similar mild temperatures:

> ...a normal pattern would be that daytime bedding sites are located in dense timber stands on ridge tops with slight north aspect. Travel to feeding areas was normally 2-3 miles, with feeding periods at dusk and dawn...[For] nighttime bedsites...elk would bed within the feeding area. Night bedsites appeared to be selected for proximity to the feeding site, rather than protection from the cold...

Beall (1976) further showed that elk movement to high elevation bedding sites during the day was strongly associated with selection of cover types to aid in thermal regulation. Provision of forests to provide thermal cover was needed at all elevations. Although snowpack might restrict elk use of forests at higher elevations during severe conditions, higher sites provided better thermal cover during milder weather.

McLellan (1978) studied elk habitat selection in the White River study area in the winter of 1977-78 and encountered snowdepths exceeding 50 cm for more than 2 months. Elk showed an almost total avoidance of clearcut habitat during that time. Measuring elk use of different habitats by track counts, McLellan (1978) recorded no concurrent increase in tracks in other habitats with the decreased use of clearcuts. However, his monitoring of radio-collared elk during this period showed that elk decreased their total movements during deep, crusted snow conditions. Elk used forested, riparian, and selectively-logged habitats for feeding and travel during the period of deep snow in McLellan's (1978) study.

Elk selection of clearcut areas and open brushlands during shallow snow conditions and contrasting avoidance of these habitats during deep snow conditions has been shown by Hershey and Leege (1976) and Leege and Hickey (1977). Baglien and Biggens (1976) also have noted selection of clearcuts during shallow snow. Jensen (1973) stated that elk avoided open grassland areas during deep snow conditions.

The following hypotheses were proposed to test responses of elk to features within clearcuts:

a) Elk use of clearcut habitat declines with increasing distance from cover;

b) Elk use of clearcut habitat declines with increasinf proximity to roads; and

c) Elk avoid slash when possible.

Differential elk use within clearcuts was studied using two methods. Observations of elk and density of pellet groups were compared between categories of various features of the site. Observations of elk indicated that elk use was not proportional within the categories for seven of the nine features analyzed; elevation and aspect were exceptions. Pellet group density, however, showed significant associations with only two of the nine features, slope and distance from road.

The two hypotheses, elk avoidance of areas with slash accumulation and decreasing elk use with distance from cover, were rejected when elk use was measured by pellet group distribution but both these hypotheses were accepted when elk use was measured byobservations of elk. The hypothesis that elk use declined with increasing proximity to roads was accepted using both measures of elk use. The differense in elk use as measured by the two methods could indicate either a difference in precision or that the two methods were measures of different elk activities.

Lyon and Jensen (1980) noted that fewer pellet groups occurred inside clearcut openings than were found in the surrounding forest, indicating that animals used the openings to feed but did not remain to ruminate. Observations of white-tailed deer by Smith (1977) identified that animals decefacte most often in resting areas, resulting in disproportionate accumulations of pellet groups in these habitats. Similarly, this study indicates that observations of elk were biased to the feeding activity while pellet group density was biased toward the resting activity.

By using observations to indicate feeding activity and pellet group density to indicate resting activity, a number of inferences can be drawn about elk use of clearcuts. Elk avoidance of areas within 200 m of roads was evident from observations of elk. Less than average density of pellet groups up to 300 m away from the roads indicated that resting elk showed even greater avoidance of areas near roads than feeding elk. Elk clearly selected for moderate to steep slopes for both feeding and resting. Both methods of measuring elk use showed no overall avoidance of areas with slash accumulations; however, slash accumulations in the area were generally light and the results may reflect a lack of accumulation of slash great enough to cause avoidance by elk. Within clearcuts, the numbers of elk observed at different distances from the edge of the clearcut were proportional to the amount of habitat in that distance-from-edge category. Both pellet group densities and observations showed elk used the larger study site (130 ha.) more than the other smaller sites, indicating no general avoidance of areas farther from cover.

An hypothesis that elk respond to human activity by flight and that this response is less common with increasing distance from the disturbance was also tested. Most elk fled when they saw human activity irrespective of the distance to the disturbance. The first portion of this hypothesis, that elk flee from human activity, was supported by the data and was accepted. The second part of the hypothesis, that the flight reaction diminishes with distance, was rejected. Elk did not appear to respond to human activities at distances greater than 1.5 km.

A line-of-sight to the activity was required to initiate an elk avoidance reaction to the disturbance. Observations of elk within short distances of logging activity were also recorded in the study, but the activity was not within sight of the elk and no avoidance reaction was noted. Clearcutting was initiated in the study area in 1970 with the two largest clearcut blocks cut first. Consequently, the elk using the area had been exposed to human activities on their winter range for a minimum of six to seven years. There is little evidence of the elk becoming accustomed to disturbance; 90% of the animals exposed to human activity fled from the disturbance. During shallow snow conditions human disturbance clearly reduced the amount of time that elk could utilize clearcuts, the preferred feeding areas.

In summary, this study was conducted during two atypical winters with mild temperatures and low snowfall. Interpretations of elk habitat selection and use of clearcuts are valid only for shallow snow conditions.

The vegetation, logging history, elk activity patterns, and food habits were described as background information to the primary objectives of the study - documentation of elk use of logged and unlogged habitat and testing of hypotheses of factors influencing elk use of clearcuts. Elk selected clearcuts, primarily for feeding, during shallow snow conditions. Within clearcuts, elk selected moderate (20 to 40%) slopes and avoided areas within 200 to 300 meters of active roads. Elk did not select areas near the edge of clearcuts, as elk use within clearcuts was proportional to the amount of habitat irrespective of the distance from edge. Elk avoided human activities within a line-of-sight and fled to forest cover when human activities were seen.

6.0. MANAGEMENT RECOMMENDATIONS

The elk of the White River valley are a product of forested land. The numbers, habits, and even survival of the elk are dependent upon how the forests are managed. Normal snowpacks in the White River valley can reach depths that preclude the survival of elk in open habitats. Multiple-use management of the forests must, therefore, consider not only providing substantial benefits for elk during shallow snow conditions, but also must ensure the survival of elk during critical periods of deep snow conditions.

This study has identified habitats that provide food, shelter, and security during shallow snow conditions and noted the role of human activity in restricting elk use of clearcuts. Clearcuts provided the most valuable component of elk requirements during shallow snow conditions - feeding areas. Forests, particularly forests at higher elevations along ridges, appeared to provide both shelter and security during these conditions. Elk moved freely in shallow snow but disturbance by human activity restricted elk use of areas within a line-of-sight. These conclusions suggest the following recommendations for joint elk-forest management:

a) Logging plans should manage the forests on south-facing slopes such that there are clearcuts less than fifteen years old on these slopes throughout the forest rotation to provide enhanced forage for elk during shallow snow conditions.

b) Main access routes should be located so that south-facing slopes are screened from traffic. Screening can be accomplished through utilization of topographic features or vegetative cover. Screening could be provided by regrowth of vegetation if flatter sites near main roads were logged ten to fifteen years before logging the south-facing slope. The critical factor is prevention of elk from seeing vehicles or human activity while using clearcuts.

c) Main roads should be located below preferred south-facing slopes if possible, because elk generally move uphill for resting or escape.

d) Roads crossing clearcuts utilized by elk should be closed to use in winter. Cruising, layout, insect surveys, etc. should be carried out at times of the year other than winter.

e) Use of off-road vehicles such as snowmobiles should be prohibited during winter in areas used as winter-range.

f) Essential human activities on elk winter ranges should be timed for the midday period, as this is the period of least elk activity. Activity in the early morning hours is to be avoided most. Activity during darkness appeared to have little effect.

g) Winter logging, if required, should be confined to an area as small as possible and screened from existing clearcuts, openings, or south-facing slopes to allow elk use of these areas.

h) Soil disturbance from logging, skid trails, and landings should be reduced as much as possible as these sites would be of more value to elk if left undisturbed.

During deep snow conditions elk in the White River valley are restricted from using the clearcuts and are found only in forested habitats (McLellan 1978). Similar results have been shown by Hershey and Leege (1976) and Leege and Hickey (1977). Survival of elk during deep snow conditions requires different emphasis than that indicated in the recommendations above. Recommendations for forest management have already been made by McLellan (1978) and I will not repeat those specifics here. However, it appears that if elk are to survive during deep snow conditions, adequate amounts of forest with sufficient canopy cover to provide snow interception must be maintained at all times throughout the logging rotation. Corridors of forest, selectively-logged, or riparian habitat, must also be maintained to provide habitat for feeding and movement during deep snow conditions.

This study and others mentioned do not provide all the information required for multiple-use planning for elk and timber in the White River or other inter-mountain valleys in southeastern British Columbia. Further studies are needed to determine:

1. The canopy coverage and snow interception of various forest types and their ability to provide suitable habitat for elk during deep snow conditions;

2. The carrying capacity of forest habitats critical to elk during deep snow; and

3. The length of time until clearcut areas no longer provide significant forage for elk during shallow snow conditions.

Observations of elk use of clearcut habitats during shallow snow conditions indicates preference for ridge areas with moderate slopes and a grass/forb vegetation for feeding. Areas where broadcast or spot burning had occurred were selected by feeding elk. Elk were observed to avoid areas within 100 to 200 meters of active roads. Measures of elk use by pellet group density show selection for moderate slopes (20 to 40%) and avoidance of areas within 300 m of active roads. Observations of elk response to disturbance showed most elk (86%) reacted to the sight of vehicles or humans by fleeing from clearcuts into forests.

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