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PRAIRIE CREEK PROJECT
VEGETATION & WILDLIFE STUDIES, 1981

A Report Prepared For

CADILLAC EXPLORATIONS LTD
CALGARY, ALBERTA

Dall Sheep Habitat, Funeral Range

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Nic

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
N. I. GUILD

3 December 1981

Mr. N.I. Guild, P. Eng.
Ker Priestman & Associates
300-2659 Douglas Street
Victoria, B.C.
V8T 4M3

Reference: K4595 - Vegetation and Wildlife Studies, 1981
Prairie Creek Project
Cadillac Explorations Ltd.

Dear Norm:

Enclosed are two copies of our final wildlife report. Ten copies were sent to the North West Territories Land Use Advisory Committee on November 20 and received by November 25. Two copies were sent to the Cadillac Explorations office November 23. Your copies had to await development of new photographs. We are quite pleased with our effort, and so as not to disturb this illusion, I will put off contacting the North West Territories Wildlife Service a further week!

On the matter of furbearers, Paul Gray said that furbearers work was part of the project objectives set down by the North West Territories Wildlife Service, and we should not expect specific directives. When he said this - November 4 - it was too late to initiate a program. He has said nothing about this when I phoned him in September requesting some direction. As a consequence, we must assume a 1982 furbearer study.

I want to take this opportunity to thank you for your careful editing of this report and your advice at various stages of this project.

Yours very truly,

BEAK CONSULTANTS LIMITED

I. Robertson
Director, Biological Sciences

IR:jd

Encl.

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KER, PRIESTMAN
& ASSOCIATES LTD.

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FILE: K4595
DATE: SEPTEMBER 1981

PRAIRIE CREEK PROJECT:
VEGETATION & WILDLIFE STUDIES
JANUARY TO JULY 1981

Prepared For:

CADILLAC EXPLORATIONS LTD.
CALGARY, ALBERTA

STUDY TEAM

This report was prepared for Cadillac Explorations Limited of Calgary, Alberta as the vegetation and wildlife component of a series of environmental studies which will collectively form the basis of an Environmental Impact Assessment of the Prairie Creek Project.

The report was prepared by Beak Consultants Limited, Vancouver and the study team was composed of the following: Ian Robertson - Project Manager; Jane Richards and Anne Moody - Vegetation; William L. Harper, Ron Quaife and Mary Jean Comfort - Wildlife.

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ACKNOWLEDGEMENTS

We wish to acknowledge many private and government individuals who assisted in this project. Gerry Hamilton, Ruben Fast and Earl Dolan of Cadillac Explorations Ltd. were most helpful in providing logistic support. Norman Guild and John Brodie of Ker Priestman Associates provided valuable liaison and coordinating functions as part of the overall environmental management of this development.

The following personnel from the Northwest Territories Government kindly provided information used in this report or assisted in other ways.

Ken Davidge	Wildlife Officer, Government of N.W.T., Fort Simpson
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Figures were prepared by Diana Day, and the manuscript was typed by Shirley Flaata.

1.0 SUMMARY

This report has been prepared to provide information on wildlife and vegetation resources in the immediate area of a mine and winter road presently being developed by Cadillac Explorations Ltd. at Prairie Creek, N.W.T. It is the most detailed examination of wildlife resources in the series of reports prompted by the development.

The goals of the 1981 vegetation work were to identify, map and characterize vegetation cover in the 209,000 hectare study area, in a manner that would facilitate delineation of wildlife habitat. Although a large number of vegetation communities exist within the study boundaries, it is felt that they may be combined into natural groupings on the basis of floristic composition, floristic life form, and terrain features.

This report identified 11 such vegetation map units. Sampling was limited to 9 major cover types. Sampling methods were used that identified height stratification and floristic composition of each vegetation type, that could then be related to protective cover as well as food resources for wildlife.

It is recognized that within each type a significant amount of variation exists and that ground cover assessments are incomplete for these units not sampled. Fire, terrain and climate are major influences on vegetation cover in the winter road corridor east of the Mackenzie Mountains.

The objectives of wildlife habitat work were to identify, delineate and classify habitat units for Dall's sheep (Ovis dalli dalli), woodland caribou (Rangifer tarandus caribou) and moose (Alces alces) within the study area.

Preliminary habitat classification maps were developed based on vegetation, topographic features, sampling for browse and pellet groups, existing habitat maps and a survey of the pertinent literature. A total of 41 habitat map units were identified.

Statistical analysis of ranked data reveal significant correlation between forage abundance and browse utilization. There was also a weak positive correlation between browsing intensity and distance from winter road, suggesting some avoidance of the road by moose due to disturbance, or that better habitat occurs at some distance from the road.

Wildlife surveys indicated distribution patterns of Dall's sheep, woodland caribou and moose which were relatively consistent with the habitat analyses. Dall's sheep distribution on the study area varied with season, with low numbers in January and higher numbers in June. Near the mine, distribution of sheep was to the east of camp in winter, but by June sheep were observed in most uplands surrounding the mine. The low numbers of sheep, and the distance from the road of individual sightings, provides little evidence of project impacts.

Winter impacts to woodland caribou are difficult to determine due to the few sightings. The absence of major concentrations of this species in the development area is significant, and may indicate low numbers. No woodland caribou calving area was identified in the study area, rather calving seemed to be a dispersed activity throughout the Mackenzie Mountain portion of the study area. Habitat analysis did indicate that suitable caribou habitat does occur in the study area.

Two grizzly bear sightings were made in the study area, but these were well removed from any project facilities. No dens were found.

Moose numbers were not high on the basis of the aerial surveys in March along the winter road. The proximity of these sightings to the winter road indicates the potential for moose - vehicle collisions, and thus a potential impact on moose populations. Habitat analysis indicated that the winter road passes through Class I winter habitat immediately adjacent to the Liard River, and in the drainage of the Tetcela River.

Results of pellet surveys showed that moose were the predominate ungulate species utilizing the lowland area between the eastern escarpment of the Mackenzie Mountains and the Liard River.

Possibly the greatest impact considerations arise out of the high numbers of Dall's sheep ewes and lambs which are distributed near the mine in the late spring and summer period. Though few lambing grounds were confirmed, their existance nearby can be inferred by sightings. However in spite of the proximity of these two conflicting activities, sightings of animals immediately adjacent to the mine indicate development activities are creating only a very local disturbance.

A mineral lick near Adit #3 is being utilized by sheep. Identification of mineral content and animal access restriction through fencing of the area should be considered.

Other opportunities for mitigation include the limiting of aircraft activity of the Prairie Creek airstrip during May and June, the period of lambing; posting of warning and reduced speed zone signs along the winter road in areas of ungulate utilization; prohibiting the use of firearms; fire control and proper garbage disposal.

2.0 INTRODUCTION

As outlined in earlier reports in this series Cadillac Explorations Ltd. is proceeding to develop a lead-zinc deposit in the Prairie Creek drainage of the Mackenzie Mountains (Ker Priestman and Associates, 1980a, b and c). The development is located at approximately 61°33'N latitude and 124°48'W longitude, adjacent to Prairie Creek 43 kilometres upstream from its confluence with the South Nahanni River (Figure 1). A winter road of 160 kilometres connects the mine/mill development with the Liard Highway.

In developing this remote property, inherent environmental implications are recognized, and this report addresses those which affect wildlife and their habitat. To address these topics on behalf of Cadillac Explorations, Beak Consultants developed a wildlife and vegetation study program in consultation with Ker, Priestman and Associates and the Wildlife Service of the Government of the Northwest Territories. The agreed objectives of this program were:

i) to determine winter distribution and abundance of ungulates in the study area, i.e. along the winter road right-of-way and in the environs of the proposed mine/mill complex;

ii) to locate sheep lambing and caribou calving areas in the study area;

iii) to map and sample vegetation in the study area, placing emphasis on understory and shrub vegetation;

iv) to conduct browse and pellet group surveys to determine habitat utilization by ungulates; and

v) to locate grizzly bear dens in the study area.

The studies undertaken to meet these objectives are the subject of this report.

2.1 Study Area

The study area was generally defined as a corridor encompassing the range of the wildlife populations potentially affected by the road and mine site facilities (Figures 2a, b and c). The above corridor included a strip of land approximately 10 km in width extending from the Liard River to the Mackenzie mountains, plus two mountain ranges: a) a portion of the Nahanni Range between Bluefish Lake on the south and a point approximately 22 km northwest of the Grainger River Pass; and b) a region of the Mackenzie Mountains centered around the Cadillac mine site. This latter area is bounded on the north by Caribou Flats and adjacent peaks, on the west by the Funeral Range, on the south by Nahanni National Park, and on the east by an eastern escarpement of the Mackenzie Mountains.

3.0 METHODS

Four wildlife related field programs were conducted in 1981. These were conducted during the periods 27-29 January, 17-21 March, 9-10 June and 9-17 July. The first three were (aerial) wildlife surveys; the latter was primarily a detailed ground survey designed to assess vegetation characteristics and wildlife utilization in various vegetation units.

3.1 Ground Surveys

3.1.1 Vegetation

The purpose of the vegetation survey conducted in July 1981 was to expand the vegetation mapping presented by Ker Priestman and Associates (1980 a and b) and to provide a framework for wildlife habitat assessment. To accomplish this the study area was initially divided into two sections: the lowland road corridor; and the highlands of the Mackenzie and Nahanni Ranges.

Preliminary air photo interpretation indicated five major vegetation types in the lowland corridor. This was expanded to six following initial helicopter reconnaissance. In one large representative stand of each of these major vegetation types, one sampling transect was run along a compass bearing at right angles to the road. Each transect consisted of five sampling sites. For each transect a selection of five random numbers between 10 and 2,000 was made in advance of the field survey to establish plot location and transect total length in metres from the winter road. The upper limit of 2,000 metres was considered practical and adequate to describe vegetation variation as well as wildlife utilization in the vicinity of the road.

Successive sampling sites were located on alternate sides of the transect. The plot sizes were as follows:

Tree layer - 10 x 10 m
Shrub layer - 4 x 4 m

Herb layer - 1 x 1 m
Moss layer - 0.1 m^2

When tree plots were used the understory strata plots were established as sub-plots within the 10 x 10 m plot to encompass what was considered representative vegetation.

All plot information was recorded on a Vegetation Wildlife and Site Description form adapted from Walmsley et al (1980). A sample of this form is provided in Appendix I. A complete species list of all vegetation in the 10 x 10 plot was made during initial site reconnaissance. Samples of unknown or questionable plant species were collected and recorded by sample number. For each stratum plot the height of the top of the layer in metres, the total percentage cover of each layer, and the percentage cover and distribution code of each species within that height layer were recorded. In addition to floristics, data on site position, surface shape, slope, aspect, and gross soil characteristics were also recorded.

The highland section of the study area was sampled with randomly located vegetation plots. In the Mackenzie Mountains three major vegetation types were sampled, the plot sizes determined by the physiognomy of the vegetation as described for the lowland sampling. Each vegetation type was sampled from at least two separate sites and each sample site had a minimum of two replicates. In the Nahanni Range only one sample site was chosen and eight replicate plots were sampled.

Table I gives the sampling intensity for vegetation composition at each sample site in the survey. Sample Site Numbers 1-8 are located in the highland section and are random plots, while Site Numbers 9-14 are found in the lowland corridor and correspond to transect locations.

Vegetation mapping of the entire study area at a scale of 1:50,000 was completed using helicopter reconnaissance. Since N.T.S. maps available for the study area give contour intervals in feet, this report relates topographical features in those units.

Floristic data from the transect plots tallied in the lowland section and the random plots of tree, shrub and tundra communities recorded in the Mackenzie highland section were tabulated by species, plot and height strata. Percentage occurrence frequency, mean percentage cover and the standard deviation of the cover estimate for each species in each height layer were computed.

Alpine vegetation data was analyzed using U.B.C. CGROUP (a cluster analysis program, Patterson and Whitaker, 1978) to indicate the degree of similarity between plots in different locations. The observations of 30 floral taxa were expressed as percentages of cover (surface area) for each 0.1 m^2 plot. U.B.C. CGROUP uses hierarchial stepwise clustering based on the following algorithm:

$$\text{Error value} = \frac{\text{Sum of the squared differences between corresponding \% coverages for each species}}{\text{Number of plots in the potential group}}$$

At each step the grouping with the smallest error value is selected.

3.1.2 Wildlife Habitat Assessment

Methods for the selection of plot and transect locations are described in vegetation section (3.1.1), and transect locations are shown in Figures 2a, b, and c. Browse surveys and pellet group counts were conducted within 10 x 10 m plots in forested vegetation types (i.e. Sites 7-14) and 4 x 4 m plots in alpine vegetation types (Sites 1-6). Historic browse utilization (greater than one year old) and current browse utilization (less than one year old) are ranked from 0-4 representing a percentage of growing tips removed. This information, plus any additional wildlife sign such as tracks or game trails, were recorded onto a standardized field data form (Walmsley et al, 1980 - Appendix I).

For statistical analysis the indices of forage abundance, browse utilization and browse index were used. Browse forage abundance (i.e. browse availability) is calculated as the sum of percent cover in the two shrub layers (high and low) and herb layer of these plant species which showed utilization on the sample transect.

Browse utilization was evaluated by multiplying each browse rank by the forage abundance of that plant species within plot and summing the products. The Browse Index is calculated by multiplying each browse rank (i.e. current and historic) by the browse availability (i.e. the percent cover of each forage species under 2 m in height) and summing the product. In this calculation negative values are given for a browse rank value of 0 (i.e. no browse) and positive values are assigned to browse ranks 1-4. Thus a high positive browse index shows that available forage is highly utilized, whereas a large magnitude negative browse index indicates that although an abundance of forage was available, it was not browsed. Browse Index is thus a measure of browsing intensity.

These transformations allowed a simple ranking of the 30 lowland plots in terms of the above measures of browsing. Correlations among variables such as forage abundance, browse utilization and distance from the road were then determined using Kendall's coefficient of rank correlation (Hollander and Wolfe, 1973).

Preliminary habitat classification maps were prepared by gathering together all data obtained during field work and synthesizing it with existing habitat maps (Prescott et al, 1973). The basis for delineation of range boundaries is usually vegetation type. Classification of units was determined by integrating evidence of animal use with vegetation type and pertinent literature.

There are a number of limitations inherent in both the type of sampling done and the time frame in which it was conducted.

Pellet groups census techniques have been reviewed extensively (Neff, 1968; Timmerman, 1974). One of the assumptions of the technique employed here is that the number of pellet groups counted is closely related to the time the animal spent in the area (Neff, 1968). However the number of groups found is also related to the defecation rate and there is a great deal of discrepancy between estimates of daily moose defecation rates (Timmerman, 1974). There is some difficulty in relating pellet group distribution as a habitat preference index as the assumption that the number of pellet groups is related to the animal/days spent in an area is not necessarily trustworthy (Neff, 1968). However, Frangmann et al (1976) found that the winter habitat selection by moose was reflected by the pellet group distribution. The general conclusion is that it is difficult to obtain accurate population estimates from pellet group counts, however population trends and relative densities may sometimes be obtained.

Despite the limitations of the pellet group census, a great deal of care was taken to sample at sites that were representative of the whole unit. The limitations of single sample site per vegetation unit are recognized.

3.2 Aerial Surveys

All aerial surveys were flown using helicopters (Bell 206 Jet Ranger with bubble windows, or Aerospatiale Gazelle). Choice of aircraft was based upon 1) safety, 2) availability, and 3) notes expressed in the literature suggesting the better suitability of helicopters for aerial surveys (Caughley, 1974; Le Resche & Rausch, 1974).

Three observers were used: two biologists (positioned on opposite sides of the aircraft) plus the pilot. Navigation was accomplished using maps of a scale of 1:50,000. All observations were registered by number on the map and information appropriate to each observation was recorded on cassette tape.

Data was collected on number of animals present, habitat type in which they were observed, and straight-line distance from the mine or road facilities. Where it was possible to record the age-sex class of observed animals, without undue aircraft harassment, this was done.

Linear Strip Survey Method

In non-mountainous terrain, linear transects were flown at 2 km intervals. Observers positioned on either side of the aircraft visually scanned a corridor 250 m in width, providing a total transect strip width of 0.5 km and a total survey coverage of 25 percent. Transect lines were flown at a speed of 100-140 km/hr, at an altitude of 75-100 m AGL (above ground level).

Contour-Line Survey Method

Mountainous portions of the study area were surveyed by flying along contours such that 100 percent of the area was systematically searched. Specific spacing of contour flightlines varied according to the degree of vegetation cover present. Flightlines were flown at a speed of 80-100 km/hr and at an altitude of approximately 75-100 m (although this figure varied according to topographical dictates).

Field Programs

The January survey utilized contour survey methodology and was directed at identifying woodland caribou, Dall's sheep and moose wintering areas in the vicinity of the mine site. Observers were I. Robertson and A. Moody.

March investigations addressed late-winter ungulate distribution throughout the entire study site. Two survey methodologies were used. Firstly, that portion of the study area between the Liard River and the Mackenzie Mountains was flown by the linear strip method. A total of 445 km were flown over 39 transects, providing 25 percent coverage of this region. Secondly, contour aerial survey methods were used to census populations in the Nahanni Range (in the vicinity of the Grainger River Pass) and in the Mackenzie Mountains in the region of the mine site. Observers were R. Quaife and M.J. Comfort.

June studies were directed to identifying those areas used for caribou calving, sheep lambing and grizzly bear denning in the western (mine site) portion of the study site. Contour survey methodology was employed, as well as ground inspection of possible den sites. Observers were R. Quaife and K. Davidge.

Additional wildlife observations were recorded during the habitat evaluation and vegetation mapping program conducted in July by W. Harper and J. Richards.

Caughley (1974) discusses the bias inherent in aerial surveys and concludes there is a tendency to undercount. He points out the greatest bias within aerial surveys is the inherent sightability of animals. This is related to air speed, altitude and the size of the area scanned by each observer. The coloration of the animals and their preferred habitat also influences their sightability. Recognizing these limitations these surveys were treated as relative measures of abundance.

4.0 RESULTS

4.1 Vegetation

A complete list of plant species identified in the entire study area is given in Table 2 arranged alphabetically by scientific name and life form. Common names are also given. A total of 136 plants were recorded: 9 tree species, 38 shrubs, 43 herbs, 13 species of sedges and grasses, 3 club mosses, a fern, 11 mosses and 18 lichens.

In total 11 vegetation types were identified in the study area and mapped at a scale of 1:250,000 as shown in Figures 2a-2c. Sampling locations, both transect and random plots, are also indicated on these maps.

Table 3 provides a listing of these vegetation units and the area covered by each within the study boundary.

4.1.1 Vegetation and Site Descriptions of Map Units

Floristic data from the transect plots tallied in the lowland section and the random plots of tree and shrub communities recorded in the Mackenzie highland section were tabulated by species, plot and height strata. Percentage occurrence frequency, mean percentage cover and the standard deviation of the cover estimate for each species in each height layer were computed. The results are given in Tables 4-12.

Lowland Units: 1-8

Unit 1: Aspen - Liard Floodplain - Sample Site 14 - Table 4

This vegetation type occupies the floodplain of the Liard River and lower reaches of the Grainger River near its confluence with the Liard. Crampton (1973) describes this site as a freely drained dystric brunisol (pH 3.5), without near-surface permafrost. The climax tree species on this site was white spruce (Picea glauca), but the high frequency of fire has led to an aspen (Populus tremuloides) dis-climax. The evenly aged stand structure suggests the stand origin to be of suckering reproduction following fire. About 30% of this vegetation map unit consists of clumps of pure white spruce, and these are presumably located on moister sites which proved resistant to fire (Photo 1). No sampling was done within these spruce clumps.

Within the pure aspen stands, numerous patches of seasonally waterlogged and bog areas occur; these contain a low shrub cover (1-2 m) of labrador tea (Ledum groenlandicum) and dwarf birch (Betula nana), and a ground cover dominated by Sphagnum moss.

The sampling transect in the pure aspen type was 800 m in length. It traversed a basically level plain with a straight surface shape. The main canopy was 20 m and the understory trees ranged from 12 to 16 m in height. The tall shrub layer ranged from 2-3 m, the low shrubs from 0.5 - 1.5 m and the herbs from 0.1 - 0.2 metres. Moss cover was only about 5% since deciduous litter approximately 2.5 cm thick dominated the ground cover. No ground lichens were recorded. In total, the LFH (forest floor organic layers) measured 10 cm to mineral soil.

Total species number was 25, consisting of 3 tree species, 10 shrubs, 10 herbs and 2 mosses.

Unit 2: Interior Plain - Floodplain / Tillplain Mosaic

This type was not sampled because its heterogeneity precluded selection of a representative transect. It comprises areas of tillplain, ancient glacial lakes and floodplain with their associated surficial deposits of morainal, lacustrine and alluvial materials. The road follows the Grainger River and its tributaries, and thus the vegetation immediately adjacent to the road during much of its course through this type is developed on more freely drained alluvials. Beyond these floodplains the terrain is flat to gently sloping within the 10 km wide corridor, and has a deranged drainage pattern with permafrost in some of the bogs. These lands are generally peaty where surficial morainal or lacustrine deposits are thick. Low beach lines delineating the periphery of lacustrine deposits, or morainal ridges of various origins are better drained (Crampton, 1973).

The alluvial deposits of the Grainger River supports a cover of mixed coniferous and deciduous clumps comprised of approximately 60% aspen type (as described in Unit 1) and 40% pure white spruce cover type. This mixture extends from Kilometre 10 to Kilometer 27 (as referenced from the Liard River) along the western side of the winter road. On the eastern side are seasonally waterlogged flat lands vegetated with a black spruce (Picea mariana) muskeg cover (as described in Unit 4).

From the Grainger River crossing (km 27) to approximately km 45, the mosaic increases in complexity. Deciduous forest patches of aspen and paper birch (Betula papyrifera) intersperse with jack pine (Pinus Banksianna) and white spruce, patches of pure pine, sections of black spruce muskeg and low shrub communities of primarily alder (Alnus crispa) and dwarf birch (as described in Unit 3). The explanation for such a patchwork is probably post-fire succession on different surficial materials.

Photo 2 illustrated the irregular configuration of this vegetation complex.

Unit 3: Grainger Tillplain - Sample Site 13 - Table 5

The Grainger Tillplain is differentiated from the Interior Plain mosaic by the absence of forest cover. It is a rolling, drumlinized tillplain characterized by low elevational changes (Photo 3).

The sampling transect was 1,260 m in length and revealed the following community types.

Depressions are either wet sedge meadows of predominantly Carex rostrata (Photo 4) or dry sedge meadows with wet organic soil but no standing water (Photo 5). The drier meadows are characterized by an 80% shrub cover (less than 0.5 m) of dwarf birch, cinquefoil (Potentilla fruticosa), labrador tea and Myrica gale; a 75% herb cover of sedges (C. rostrata and C. vaginata), red bearberry (Arctostaphylos rubra), and horsetails (Equisetum spp.) and a 90% Dicranum spp. moss cover.

These meadows give way to low shrub communities of dwarf birch and shrubby cinquefoil and on slightly more elevated slopes, especially those with S aspects, a taller shrub community ranging from 1.5 - 3 metres. This high shrub type is characterized by a 95% shrub cover of alder, dwarf birch and willow (Salix planifolia), a 25% herb cover of wintergreen (Pyrola asarifolia) and bunchberry (Cornus canadensis), and a 40% Rhytiadelphus spp. moss cover.

The crests of the mounds offer better drainage conditions and are covered in aborescent thickets. These are of two types, a primarily deciduous or a mainly coniferous cover.

The deciduous thickets are characterized by a 20-40% overstory cover about 3.5 to 4 metres in height. Balsam poplar (Populus balsamifera) is the most prominent species, with lesser amounts of black spruce, willow and birch. The shrub cover ranges from 50-90% and consists of mainly alder with some black spruce, willow and dwarf birch. Herb cover is low (20%) and consists mainly of labrador tea and twinflower (Linnaea borealis). Moss cover of Rhytiadelphus is also scattered. Mineral soil is brown, silty and deciduous litter layer is thin (0.1 - 2 cm). A few jack pine snags 1 metre in height were observed although no live regeneration of this species was present.

The coniferous thickets are of black spruce 4 m in height with a 7% coverage. An 80% shrub cover (between 1-2 m) is dominated by dwarf birch and black spruce. Herb and moss cover are less than 10%. Litter and organic layers are about 2.5 cm in total depth to a silty mineral soil.

Table 5 presents a transect summary.

Unit 4: Black Spruce Muskeg - Sample Site 12 - Table 6

This unit is primarily a shrub community about 1.5 m high dominated by black spruce. It is located at 1,600 feet (488 m) in the valley between the Nahanni Range and the Silent Hills and between 800 and 1,000 feet (244 and 305 m) in the Fishtrap Creek depression area west of the Silent Hills. It occupies seasonally waterlogged sites that grade downward into open wetlands.

The transect sampled was 600 m in length and was located between the winter road and the Silent Hills in what is considered the drier muskeg type (no standing water). The shrub layer ranged from 35-60% cover of black spruce (1.6 m) and Salix myrtillifolia, labrador tea and dwarf birch (0.5 m). The herb layer varied between 25 and 50% and consisted of red bearberry, grass and low height labrador tea. A ground cover of Dicranum moss and lichens formed a 10 cm thick mat over the organic soil. A large number of blanched spruce snags 3-4 metres in height provided evidence of former fire (Photo 6).

Table 6 provides a fairly representative description of this map unit.

Unit 5: Mixed Coniferous / Deciduous - Sample Site 11 - Table 7

This type ranges in elevation from 1,200 - 2,800 feet (366 to 854 m) and represents a post-fire successional forest. Two subtypes may be distinguished, the Silent Hills and the Tetcela Plateau.

The western slopes of the Silent Hills provides a steeper elevational gradient than the Tetcela Plateau and consequently, better drainage. An 80% deciduous tree cover of aspen and birch intergrades with a 20% white spruce component. The overstory is thus very similar to map unit 1.

A ground sampling transect of 540 metres was located at 2,800 foot (854 m) elevation on the Tetcela Plateau. Sections of black spruce parkland (unit 7) intersperse with dense coniferous / deciduous forest.

Fire is undoubtedly the origin of this mosaic. Pieces of charcoal were evident in the FH (partially decomposed) organic layer and mixed into the top mineral soil layers. The felling of a jack pine showed it to be 25 years at a height of one foot with no scars evident. This would date the fire at over 30 years previous, and is probably part of the burn that occurred in this region in 1942 (camp personnel, pers. comm.). In one plot a 20% cover of 8 metre tall black spruce snags had dessicated cones still clustered at the top, which indicates that the original cover was of black spruce and that reseeding following the fire was available from an on-site source.

All but one plot have developed on grey silty mineral soil (as in map unit 7) and have black spruce in lower tree and all shrub layers, indicating a return to the black spruce parkland type. The one exception has developed on a well-drained 30%, upper slope position plot. Here a silty brunisol developed on a stoney till 1-2 inches in fragment size carried a pure pine forest cover.

On the level plateau tree cover ranges from 60-100% and is dominated by birch, alder, and willow with lesser amounts of black spruce and jack pine (Photo 7). Paper birch usually dominates in the height category where it averages 10 metres. The main canopy stands at 8 metres and is composed of Salix scouleriana. Alder has consistently high coverage (40-75%) in the 5 m suppressed tree stratum. Shrub cover varies from 15-30% of mostly willow, alder and black spruce; herb cover is low (2-10%) and is primarily wintergreen and lingonberry (Vaccinium vitis-idaea). Moss cover shows considerable variability (5-50%) with the principal species being plume moss (Ptilium crista -castrensis).

In the pine patches of the mosiac jack pine is present in the A_1 - A_3 tree layers. The top height observed was 8.4 m. The low tree layer (5.5 m) is dominated by willow. Overall tree cover was 50%; shrub cover averaged 40% of an alder, willow and blueberry (Vaccinium uliginosum) mixture and the 80% herb cover was provided by lingonberry and twinflower. Moss layer was negligible.

The black spruce sections of this unit's patchwork represent forest cycling rather than succession. Eight metre high black spruce snags with fire scars testify to this.

The low tree cover (7%) is composed of 4 m tall black spruce. Shrub layers occur at 65% cover with species composition being black spruce (15%) at 2.5 m and willow, dwarf birch, cinquefoil and alder totalling 70% at the 1 metre height level. A 75% coverage in the herb layer is supplied primarily by twinflower. Moss cover is again less than 5%.

Table 7 provides the average species composition for the whole transect.

Unit 6 - Pine Parkland - Sample Site 10 - Table 8

This unit occurs primarily on well-drained upland slopes. It is found in large areal coverage in two sections of the study area 1) the western slopes of the Nahanni Range where it ranges from 1,800 - 2,500 feet (549 to 763 m) on thin colluvial substrate and is generally of low stature; and 2) from 3,000 - 3,200 feet (915 to 976 m) on a section of the Tetcela Plateau where the top of the canopy is 6.4 metres.

Ground sampling was done in the Tetcela Plateau Section with a 630 metre transect. Three of five plots fell in a predominantly pine type having a 10% slope and southwest aspect, while the remaining two plots were located in a depressional black spruce cover type which emphasizes the importance of drainage and thermal conditions to jack pine distribution.

The pine parkland type was characterized by a low tree stocking (8-15%) of primarily jack pine with lesser amounts of black spruce and occasional white spruce. Since pine was found to be regenerating in the herb and shrub layers, this type is felt to be on a pine site. Mineral soil is silty and has developed on a rough sort of drift veneer in which small pieces of slate were observed. The fire origin of this stand was indicated by numerous pieces of charcoal on the forest floor.

Shrub cover on the pine site was low to moderate (5-45%) and consisted of dwarf birch and willow (S. arbusculoides and S. scouleriana). The herb layer ranged from 15-65% cover with bunchberry, lingonberry and twinflower being the most prominant species. A thin (1 cm) but complete (100%) ground cover of Pleurozium moss and Cladonia lichen characterized this parkland type.

Concave depressions are completely dominated by black spruce (10-15% cover) with a main canopy height of 10 metres. The taller nature of this canopy with respect to the pine on the upland slopes (6.4 m) indicates that it was not burned in the last fire. This is probably due to the resistance offered by the greater amount of moisture on the site.

Shrub cover on the black spruce type ranged from 15-20% and consisted of black spruce, dwarf birch and willow. Herb coverage was low (15-25%) and was provided by crowberry (Empetrum nigrum), lingonberry and grass (Agrostis scabra). The moss layer was complete (100%) and thick (0.4 m depth to soil). Principal species are of Pleurozium, Sphagnum, Polytrichum and Dicranum mosses.

Table 8 provides the mean species composition of the transect plots. Note that stratum heights are overall means.

Unit 7: Black Spruce Parkland - Sample Site 9 - Table 9

This unit is the predominant cover type of the western portion of the Mackenzie Plain with an elevational range of 2,600 - 3,000 feet (793 - 915 m). It is a rather monotonous 'climax' type of low species diversity (only 20 plant species were recorded). On well drained south aspect slopes more dense forest clumps of pure white spruce exist, but these comprise less than 15% of the total area and were not sampled.

The sampling transect was 900 metres long and traversed a primarily level plain. The overall appearance was of a very "groomed" parkland with a complete moss and lichen ground cover (approximately 10 cm thick) and no standing snags or visible deadfall. In all but one plot the mineral soil was of moist grey silty (less than 10% sand) texture with no large fragments. The one exception contained a wet organic layer 5 cm deep developed over the grey silty soil.

Tree cover in the black spruce parkland is low (5-30%) and is comprised solely of black spruce 6-10.4 metres in height. Branching occurs to near ground levels and both branches and bole support a rich corticolous lichen cover of Alectoria and

Parmelia species. Shrub cover is low to moderate (20-45%) comprised of dwarf birch and willow (S. glauca) ranging in height from 0.5 - 1 metre. Herb cover is also moderate (10-45%) and comprised of Kinnikinnick (Arctostaphylos uva-ursi), labrador tea and blueberry. The 100% ground cover is primarily of Pleurozium moss with smaller patches of Cladina stellaris lichen.

Table 9 presents the species composition of this unit.

Unit 8: Riparian Alluvial

This unit was not ground sampled, but low level helicopter reconnaissance indicated a moderate percentage of willow species on the rough gravel deposits. Along the stream banks balsam poplar was noted as the major arborescent species with alder, dwarf birch and willows in the understory.

Highland Map Units: 9-11

The most prominent plant communities in the vicinity of the winter road in the Mackenzie Mountains are the black spruce / lichen forests of the lower mountain slopes (Unit 9), a subalpine shrub zone comprised primarily of dwarf birch and willows on the upper slopes (Unit 10), and alpine tundra cover at the higher elevations (Unit 11). This topographic sequence is shown on Photo 8.

Unit 9: Spruce / Lichen - Sample Sites 7 and 8 - Table 10

This cover type occurs from the valley bottom (Photo 12) to the upper slope positions of relatively stable colluvial slopes and has an elevational range of 3,200 - 4,200 feet (976 - 1,281 m). The extent of tree cover is aspect and topography dependent, with more dense cover prevalent on south, southwest and west facing slopes and in the draws. The cream-coloured ground mat is provided by a thick layer of Cladina stellaris lichen. Numerous sections of sparsely vegetated talus intergrading with the forest type indicate the inherent sensitivity of the forest cover which can be dislodged by snow sliding. Soil development from the talus increases in depth from the upper to lower slope position.

Two sampling locations on south facing slopes reflect a certain amount of change in vegetation composition from the bottom to the top of forested slopes. Generally speaking the spruce / lichen zone contains elements of the black spruce parkland and the subalpine shrub cover types.

Sample site 8 represents a lower slope community on 60% slope and south aspect. A 7 cm LFH layer exists over a brunisolic mineral soil of undetermined depth. Tree cover is light (7%), and consists primarily of black spruce with scattered tamarack (Larix laricina). The height of the canopy ranges from 8.5 to 12.7 metres. Shrub cover is moderate (40%), ranges in height from 0.5 - 1 metre, and is primarily a mixture of cinquefoil, dwarf birch, blueberry and lapland rosebay (Rhododendron lapponicum). The 30% coverage of herbs has a species composition of Carex scirpoidea, Agropyron boreale, Kinnikinnick and red bearberry. The ground layer has 85-100% coverage of mostly Cladina stellaris (Photo 11).

Sample site 7 (Shown in Photo 10) is located at a 4,200 foot (1,281 m) elevation and represents a timberline community on 65% slope and south aspect. Soil development is very slight consisting primarily of a talus and bedrock parent material covered by a 4 cm organic mat which was removed by the surveyor's footsteps. This upper 200 -300 feet (61-92 m) of forest has a superficial resemblance to that below, but black spruce is replaced by white spruce. Tree cover is 8% at a height of 8.1 metres and is formed solely of white spruce. Shrub cover is 25%, varies in height from 0.25 - 1 metre, and is composed of juniper (Juniperus communis), willow (S. glauca), dwarf birch and soopalalie (Shepherdia canadensis). Herb cover is 20% dominated by grass (Festuca altaica), Kinnikinnick and red bearberry. The ground layer has 85% cover with Cladina stellaris, a mountain avens (Dryas integrifolia) basal leaf mat, and Cetraria lichen the major contributors.

Table 10 provides the mean species composition of south aspect slopes in the spruce /lichen cover type.

In general, the South Pass spruce / lichen map unit is more sparsely stocked in its tree cover than the Prairie Creek unit, due to the steep and narrow valley topography which influences thermal conditions. More slope surface area in the South Pass section is occupied by talus, and hence it contains less total plant cover than the Prairie Creek region.

Unit 10: - Subalpine Shrub - Sample Sites 5 and 6 - Table 11

This unit varies in elevation with aspect and topography. In the Prairie Creek drainage, shrub communities (Photo 13) generally do not occur lower than 4,000 feet (1,220 m). In the South Pass section (Photo 9) shrub cover types are found on the creek terraces along the valley bottoms as low as 3,500 feet (1,068 m).

Sample site 5 represents a true elevation (4,400 feet, 1,342 m) subalpine shrub community. Substrate consists of a thin organic layer over soil deposits at least 12 cm deep. A few scattered frost polygons of bare cracked rock were noted.

Shrub cover is 80%, averages 1 metre in height, and is completely dominated by dwarf birch with a 5% addition of willow (S. glauca). Herb cover is low (5-10%) and comprised of grass (Festuca altaica) and wormwood (Artemesia arctica). Ground cover is 100%, mostly composed of Cladina stellaris lichen with lesser amounts of Peltigera lichen and Dicranum moss.

Sample Site 6, located at the falls in the South Pass section of the winter road, represents the lower elevational limit of this map unit at 3,500 ft (1,068 m). The plots were located on creek terraces formed from stony to boulder fluvial deposits. More recent terraces are very stony with a thin (1 cm) organic layer over the rough sort substrate. Older terraces support thick (10-20 cm) moss carpets over organic soils of varying depths (6 - 25 cm).

Shrub cover varies from 10% and 0.25 metre height on the recent terraces to 100% and 1 metre on the older terraces. Dwarf birch and labrador tea are the primary contributors to cover on the older sites, with lesser amounts of willow (S. glauca) and stunted black spruce. The sparse shrub cover on the recent terraces is of shrubby cinquefoil and lapland rosebay.

Herb cover is light to moderate (20-30%) in both types. Kinnickinnick, Salix polaris and wintergreen are most common on the older sites, while mountain avens and grass (Calamagrastis purpurascens) characterize the recent terrace.

Ground cover on the older terraces is 100%, made up of Rhytiadelphus moss, Cladina stellaris and Cladonia lichens. The more recent terrace support a more alpine-like ground cover of Cetraria and Alectoria lichens in a 60% cover. This is indicative of primary succession.

The sampling done at this falls site illustrates the variability in elevational distribution of all the highland vegetation units. Whereas the bench terraces above the creek are shrub covered, the slopes rising from the creek to these levels have only herbaceous cover. On these slopes the herb cover averages 44% and consists primarily of Carix vaginata (8%), red bearberry (7%), mountain avens (7%), alpine blueberry (Vaccinium uliginosum) (6%), and lapland cassiope (Cassiope tetragona) (4%). Ground vegetation has 100% cover and is dominated by Cladina stellaris lichen which gives the light cream color to the hillsides. Above the terraces clumps of stunted black spruce / lichen cover are found.

Unit 11: Alpine Tundra - Sample Sites 1-4 - Table 12

Alpine vegetation was sampled at 4 sample sites, three in the Mackenzie Mountains (Site 1 - 5,600 ft., (1,708 m), Site 2 - 5,200 ft. (1,586 m), Site 3 - 5,000 ft. (1,525 m)) and one in the Nahanni Range (Site 4 - 4,500 ft. (1,373 m). Site locations are shown on the vegetation map (Figure 2). Photos 15-17 show this vegetation type and illustrate the variability in plant cover. A total of 23 0.1 m^2 random quadrats were sampled.

The result of the computer cluster analysis (U.B.C. CGROUP) is given in the dendrogram shown in Figure 5. The "items" are the 23 sample plots. The error value, which is based on the similarity of species coverage, shows a steady progression rather than a sudden jump that would indicate an optimum choice of number of groups. In other words, no major site differences are distinguished and all four sample sites are representative of one vegetation type - Alpine Tundra.

The cluster groupings were examined to determine if specific trends were identified. Sample site did not emerge as a major factor of clustering. It was found that plots located on nonaspect-dependent gentle slopes (15-30%) clustered at first level before being linked to those plots located on level surfaces. Similarily, plots located on level surfaces generally grouped together with lower error term before that cluster was joined to other clusters of non-level plots. The major species differences that were identified through this analysis were that the heather Cassiope tetragona was located on slopes of all aspects and the creeping willow Salix nivalis and the lichen Cetraria nivalis have more coverage on level terrain than on slopes.

Table 12 presents the average species cover for the 23 quadrats.

Figure 3 provides a profile of the winter road from the Liard River to the mine site terminus. The major vegetation units crossed by the road and the generalized geological and geomorphological features traversed are illustrated.

Figure 4 provides a comparison of the 8 major vegetation types found along the winter road corridor in terms of percentage cover in the tree, shrub, herb and moss layers. The average height of each layer in each type is also given.

4.2 Wildlife Habitat Descriptions

4.2.1 Lowland Vegetation Types

The vegetation map units (Figure 2a, b and c) are described in terms of wildlife habitat beginning with Unit 1 on the Liard River, and ending with Unit 7 where the winter road enters the highland section of the study area.

Unit 1: Aspen - Liard Floodplain - Sample Site 14 - Table 14

This vegetation type is dominated by tall forest of pure aspen with a dense understory of Alnus crispa and Rosa acicularis (common and scientific names of plants are presented in Table 2). This type occurs on the rich alluvial deposits of the Liard Floodplain and has the lowest elevation in the study area (less than 200 m). The dense shrub cover is considered to be a significant hindrance to wildlife movement, and insect harassment in July is rated as high.

Light browsing of Populus tremuloides and moderate browsing of Viburnum edule occurred in only one plot of five. Overall browse utilization was slight along the transect in this vegetation type (Table 14).

Unit 2: This site was not sampled due to its diverse nature and the difficulty in selecting a representative transect. This unit has characteristics of both Unit 1 and Unit 3.

Unit 3: Grainger Tillplain - Sample Site 13 - Table 15

The Grainger Tillplain is characterized by an absence of forest cover, high shrub biomass, and rolling topography of alternating strips of sedge meadow and arborescent thickets. This topographic sequence greatly increases the value of this vegetation unit to wildlife because of the increased amount of edge, and hence habitat diversity. The wet sedge meadows provide water and forage for caribou and moose, while the thickets provide thermal cover and browse material. A more complete description of the vegetation sequence is given in vegetation section 4.1.1 of this report.

Browse species utilized, in order of forage abundance, are Alnus crispa, Betula nana, Salix planifolia, Populus balsamifera, Rosa acicularis and Betula papyrifera. In order of browse utilization ranking, Salix planifolia is highest (6-25% utilization) followed by Betula nana and Populus balsamifera (Table 5).

A total of 4 caribou and 3 moose pellet groups were observed along the transect both within and outside of plots. The scattered skeletal remains of an adult moose were also found.

Unit 4: Black Spruce Muskeg - Sample Site 12 - Table 16

This vegetation type is located in the valley bottoms of the lowland section on poorly drained sites which grade into open wetlands. The sample transect was located on a fairly dry site which showed evidence of previous fires. Evidently fire on such a hygric site does not result in the early successional stages of deciduous cover that occurred on better drained lowland sites. A moderately dense stocking of small black spruce is replacing the original black spruce forest, which is now represented by blanched snags 3-4 metres tall. Insect harassment in July is rated as moderate for this area.

Browse utilization was found only on Betula nana and Salix myrtillifolia which occurred with 6% and 14% cover respectively (Table 16). A total of only 3 moose pellet groups were observed along the transect.

Unit 5: Mixed Coniferous / Deciduous - Sample Site 11 - Table 17

The Mixed Coniferous / Deciduous vegetation type is a post-fire successional forest resulting from a burn approximately 30 to 40 years ago. This vegetation type has the highest percentage cover in the tree layer (Figure 4), which consists of birch, alder, willow and lesser amounts of spruce and pine. The effect of this heavy tree canopy is to reduce the reproduction of shade intolerant deciduous species and promote a return of the shade tolerant black spruce.

Browse species in order of forage abundance are Alnus crispa, Salix scouleriana, Betula nana, Rosa acicularis, Vaccinium edule, Populus tremuloides, Populus balsamifera, Pinus contorta and Betula papyrifera. Browse species in order of utilization ranks are Salix scouleriana, Alnus crispa, Betula papyrifera and Rosa acicularis (Table 17).

A total of 9 moose pellet groups were counted along the transect within this site.

Unit 6: Pine Parkland - Sample Site 10 - Table 18

The Pine Parkland is another fire generated vegetation type, but the presence of regenerating pine in the herb layer suggests it is more stable than the Mixed Coniferous / Deciduous vegetation type. The well drained nature of the landforms associated with pine suggest an edaphic disclimax of pine instead of the true black spruce parkland climax found on wetter sites.

Browse species ranked in order of forage abundance are: Betula nana, Salix scouleriana, Pinus banksiana, and Salix arbusculoides. Browse species in order of utilization ranks are: Salix scouleriana, Betula nana, Salix arbusculoides and Pinus Banksiana (Table 18).

A total of 9 moose pellet groups were observed both within and outside of plots.

Unit 7: Black Spruce Parkland - Sample Site 9 - Table 19

The Black Spruce Parkland represents the climax forest type which will develop on most lowland areas in the absence of disturbance over a long period of time. The most apparent characteristic of this vegetation type is the extremely low plant species diversity. Tree, shrub and herb percentage covers are among the lowest, while the percentage cover of moss and terrestrial lichens are the highest among the units measured (Figure 4).

Only Betula nana and Salix glauca showed evidence of browse utilization. Betula nana was available at 28% cover compared to Salix glauca with 3% available cover for forage. Both species were browsed approximately equally at trace (1-5%) levels (Table 19).

A total of three moose pellet groups were observed along the transect.

4.2.2 Analysis & Comparison of Browse Utilization, Forage Abundance, Pellet Density and Plant Species Diversity Among Lowland Vegetation Types

Results of the browse utilization survey presented in Tables 14 through 19 are summarized per transect in Table 20. Table 21 contains the lowland transect data on forage abundance, browse utilization indexes, browse abundance/utilization index, plot distance from road, pellet group counts, and plant species diversity which will be used in subsequent analyses. The purpose of Table 21 is to determine if any correlations exist which might explain the pattern of moose browsing observed and sampled in the lowland section of the study area. Moose were the predominant ungulate species utilizing the lowland habitats in sample transects 9 through 14, as determined by pellet group counts (Table 21).

Combining the six transects (n = 30 plots) revealed a significant positive correlation ($p \leq 0.05$) between forage abundance and current browse utilization using Kendall's coefficient of rank correlation (Hollander and Wolfe, 1973). The same analysis determined a significant positive correlation ($p \leq 0.05$) between forage abundance and historic browse utilization. There were no significant correlations within each vegetation type (n = 5).

There are three possible explanations for significant correlations among vegetation types, but not within vegetation types:

1. the sample size (n = 5) was insufficient to measure within transect browse variance;

2. browse behaviour of moose on a small scale (10 x 10 m) is random, not selective, due to an abundance of forage above caloric needs; and

3. the effect of the distance from the road could interfere with the abundance - utilization correlations.

The effect of the road on the distribution of browsing intensity (Browse Index, Table 21) was also tested using Kendall's coefficient of rank correlation (Hollander and Wolfe, 1973). A weak positive correlation (p = 0.09) indicates that browsing intensity increased further away from the road. This phenomenon is complicated by the fact that one of the closest plots (40 m) exhibited maximum browsing and the two furtherest plots scored lowest on the Browse Index. The heavy browsing close to the road (40 m) in Grainger Flats may indicate use of the road as a travel corridor by caribou or moose. Numerous moose tracks were observed in July along the road in the fire affected vegetation types (Pine Parkland and Mixed Coniferous / Deciduous). In both transects maximum browse use was evident in the furthest plots, while the plots closest to the road ranked second. The impact of the road on ungulate distributions is uncertain at this point.

Values of forage abundance, browsing, pellet group counts and plant species diversity which represent transect sums or means in Table 21 are presented in summary on Table 22 (graphed in Figure 6).

The purpose of this summary is to allow a tentative ranking of actual and potential ungulate use among the six lowland vegetation types which were sampled. The positive correlation between forage abundance and browse utilization pointed out previously is apparent in comparing Graphs 4, 5 and 6 to Graph 7 (Figure 6). The total number of pellet groups sighted along the transect (Graph 2) also appears to correlate with browsing and forage abundance. Pellet groups censused within plots (Graph 3) do not appear to correlate as well with the other parameters. Plant species diversity (Graph 1) exhibits a positive correlation among measurements of browse, forage abundance and pellet density. This relationship is to be expected since moose populations are known to respond favourably to the early successional stages of vegetation which are generally more diverse in structure (Kelsall et al, 1977).

4.2.3 Wildlife Utilization of Lowland Vegetation Types

Unit 1: Aspen - Liard Floodplain - Sample Site 14

Our observations of forage abundance, browse utilization, pellet group density and plant species diversity, show little evidence of ungulate use in this unit. However, this unit has been classified as important winter range for moose because of its low elevation and rich alluvial deposits which support dense shrub layers in the open canopy (Watson et al, 1973).

Unit 3: Grainger Tillplain - Sample Site 13

From our data, the Grainger Tillplain showed the highest capability to support ungulates. This vegetation type has the greatest forage abundance, browse utilization, and plant species diversity (Table 22, Figure 6). Total pellet groups found on this site ranked third of all sites, and indicated this type supports both woodland caribou and moose.

Unit 4: Black Spruce Muskeg - Sample Site 12

The transect in the Black Spruce Muskeg vegetation type did not show a great deal of use by ungulates. The total number of pellet groups observed rank fifth among the lowland vegetation transects, and browsing index for this type ranked sixth. These two factors are indicative of ungulate use and are relatively low. Forage abundance and plant species diversity ranked fifth and fourth respectively.

Unit 5: Mixed Coniferous / Deciduous - Sample Site 11

The Mixed Coniferous / Deciduous vegetation type is a post-fire successional forest approximately 30 to 40 years old. The sample transect ranks third in plant species diversity and second in forage abundance. Both of these indices show a capability to support ungulates. This transect also showed the highest number of pellet groups and the second highest browse utilization, indicating a high utilization by ungulates.

Evidence that black spruce was returning to this site as a result of heavy tree canopy shading indicate that a natural succession to Spruce Parkland is taking place. Thus while moose habitat is rated high at present, its capacity to support moose populations will decrease unless the area is burned again.

Unit 6: Pine Parkland - Sample Site 10

The Pine Parkland vegetation type shows almost as high a capacity to support ungulates as the Mixed Coniferous /Deciduous vegetation type. The Pine Parkland ranks third in both forage abundance and second in plant species diversity. The browse utilization and pellet group counts (ranked third and first respectively) indicate a high use by ungulates. Moose is the predominant ungulate species in this vegetation type.

Unit 7: Black Spruce Parkland - Sample Site 9

This unit, although ranking fourth as moose habitat, does not approach the level of the Grainger Tillplain, Mixed Coniferous / Deciduous, or Pine Parkland vegetation types. The sample transect in the Black Spruce Parkland ranks fourth in forage abundance and browse utilization, fifth in pellet groups censused, and sixth in plant species diversity (Table 22, Figure 6). This vegetation type may be important winter range for woodland caribou because of the abundant terrestrial and arboreal lichens and the presence of extensive alpine plateaus immediately to the south, just outside the study area.

4.2.4 Wildlife Utilization of Highland Vegetation Map Units

Unit 9: Spruce / Lichen - Sample Sites 7 & 8

The Spruce / Lichen vegetation type ranks as the best woodland caribou habitat in the study area as determined from botanical composition and reference to pertinent literature (Bergerud, 1978). This is a climax forest community, the result of hundreds of years of natural succession. As a result of this, and the thin regosolic soils which predominate at higher elevations, this habitat is very sensitive to disturbance.

Two sample sites were located on south-facing aspects at elevations of 980 metres (Site 8) and 1,280 metres (Site 7). Browse species utilized in order of forage abundance are, Betula nana (trace to light browsing), Salix glauca (trace to light browsing), and Shepherdia canadensis (trace browsing), (Table 23).

Pellet group analysis indicated a high concentration of grouse or ptarmigan at Site 7. An average of 8.5 groups of grouse droppings were censused in two 10 x 10 meter plots. A few hare pellet groups were the only other droppings observed. It is possible that the trace and light browsing of birch and willow in Site 7 is the result of grouse, ptarmigan, snowshoe hares and rodents.

At Site 8, located immediately above the gravel crusher, some trace historic browsing of birch and willow was recorded. Two Dall's sheep pellet groups were within one of the two 10 x 10 m plots, with an additional pellet group found away from the plot. Woodland caribou use of the area was evidenced by 2 sets of tracks which ran down a ridge towards Prairie Creek. A number of distinct game trails in the moss-lichen mat were observed.

The Spruce / Lichen type has a low tree cover, moderate densities of shrub and herb cover, and a high cover of terrestrial lichens and mosses (Figure 4).

Unit 10: Subalpine Shrub - Sample Sites 5 and 6

The Subalpine Shrub vegetation type is found in an elevational transition between the Spruce / Lichen and Alpine Tundra types. It is dominated by a 53% cover of Betula nana and a 9% cover of Salix glauca (Table 11). Figure 4 indicates this type has a total shrub cover comparable to the Grainger Tillplain type, a relatively low herb cover, and a high cover of moss and lichen characteristic of the climax vegetation types.

Trace historic browsing of equal intensity was observed on Betula nana, Salix glauca and Hedysarum alpinum (Table 24). Salix glauca is the only species to show evidence of recent browsing (trace).

A total of 4 Dall's sheep pellet groups were found in Site 6, none of which occurred within sample plots. Three of the four groups were found along 50 metres of a game trail that bisected one of the plots. At Site 5 sheep pellets were more numerous in the general area, and 6 groups were found along 50 metres of a game trail. Again none of the pellet groups occurred within the sample plots.

Salix sp. and Cladonia sp. are two examples of plant species that are preferred as forage by caribou primarily in spring and summer (Bloomfield, 1979). This indicates that some species in this habitat type are suitable and even preferred forage and browse species for caribou. While caribou pellets were not observed at the sample sites, a single caribou and other sign were found (Photos 13 and 14 respectively).

Unit II: Alpine Tundra - Sample Sites 1-4

The Alpine Tundra vegetation type has quite high plant species diversity (a total of 28 species, 18 of which are over 1% cover). At the same time it appears there is little variation between sites in terms of species coverage (results of Cluster Analysis, Figure 5).

Buttrick (1978) stated that the distribution of alpine communities was primarily controlled by topography, snow duration and moisture. His division of the alpine tundra into four types has partial bearing on this study area. Type I, fellfields and blockfields, occur on the exposed part of the mountain where snow is blown off. This type is characterized by severe winds, extremes of temperature and xeric (dry) conditions year round. It was this type of alpine tundra which was most utilized by Dall's sheep and woodland caribou, and which was most intensively sampled during the July field work.

Table 12 gives the percent frequency and percent cover of species in the Alpine Tundra type. The Alpine Tundra consists of 36.7% lichen, 29.9% shrub, 21.3% herb, 7.0% sedge, and 5.1% moss.

The results of cratering were found on all four sample sites. Both Dall's sheep and woodland caribou are known to crater during the winter months. The greatest intensity of cratering was observed on a windswept ridge at Site 1 in the Headless Range, with 1-2% of the vegetative cover being removed. Cratering occurred to a lesser extent (less than 1% cover removed) in the other three sample sites. Only sample Site 4 in the Nahanni Range showed both cratering and browsing activity. Browse species, in order of percent cover are Betula nana, Vaccinium uliginosum and Carex albo-nigra (Table 25). Vaccinium uliginosum appeared to be the most browsed, followed by Betula nana and Carex albo-nigra.

Pellet groups were found in the Alpine Tundra type using random 4 x 4 m plots. The greatest density of pellet groups was found at Site 4 in the Nahanni Range (average of 4.7 Dall's sheep pellet groups/plot, n = 3). Next is Site 1 in the Headless Range (average of 2.5 Dall's sheep pellet groups/plot, n = 2). Sample Site 2 (Photos 15 and 16) east of Caribou Flats and west of Prairie Creek respectively had moderate numbers of woodland caribou pellet groups (average of 1.0 pellet groups/plot, n = 3) and additional caribou pellet groups were observed along several game trails which were present in the area. Few Dall's sheep pellet groups (average of 0.3 pellet groups/plot, n = 3) were found at Sample Site 3 (Photo 17), but browsing on Salix commutata on the talus slope (Photo 20) near where pellet plots were located indicate significant use of the area by ungulates (Table 26).

The distribution of willow (Salix spp.) in the various vegetation types is presented in Table 27. Nine of the Salix species occur in only one vegetation type, while three (S. glauca, S. scouleriana, and S. polaris) occur on two or more vegetation types. Salix glauca occurs on three climax vegetation types, Spruce Parkland, Spruce/Lichen and Subalpine Shrub. The Salix alaxensis of the Spruce/Lichen forest is found as an invading species on areas disturbed by road construction in the vicinity of the minesite. Salix alaxensis near the mineral lick at the minesite was heavily browsed by Dall's sheep.

The greatest diversity of willow (5 species) is found on the sparsely vegetated south-facing talus slope at Sample Site 3 in the Alpine Tundra. Light browse utilization of Salix commutata occurs on this slope (Table 26). The mat of vegetation on the ridge-tops of the Alpine Tundra (Sites 1, 2, 3 and 4) is characterized by just two species of willow.

Willow, along with dwarf birch, is an important forage species for ungulates in the study area. This, coupled with willows' apparent site specificity, indicate willow could be an important indicator of wildlife habitat. Future ecological investigations should attempt to sample willow at the species rather than genus level.

4.2.5 Preliminary Wildlife Habitat Classification

DALL'S SHEEP (*Ovis dalli dalli*)

Habitat classification for this study follows a rating scale developed for the Canada Land Inventory, and is presented in the form of habitat units based on the following classifications:

Class 1: Good winter range: windswept ridges which reduce snow depth and offer sufficient adjacent escape terrain and abundant alpine tundra forage.

Class 2: Moderate winter range: windswept ridges which reduce snow depth, but limitations include either lack of forage or lack of precipitous escape terrain.

Class 3: Fair sheep range: spruce - lichen forests below good sheep habitat. Excessive snow depths and lack of escape terrain precludes extensive use of this habitat by Dall's sheep.

Class 4: Poor or nil habitat for Dall's sheep.

Description of Habitat Units (Figure 7).

Unit 4[A]: This unit includes almost all the lowland vegetation types of the boreal forest within the study area. As mountain sheep are, for the most part, totally confined to mountainous areas because of their need for precipitous escape terrain, this unit is considered as unsuitable sheep habitat.

Unit 1[B]: The Nahanni Range of the Franklin Mountains represents some of the best Dall's sheep habitat in the study area. The vegetation type is Alpine Tundra and Subalpine Shrub which provide abundant forage for sheep in summer and winter. The critical nature of this habitat is due to its importance as winter range. Reduced snow depth, as a result of exposure to prevailing winds, makes alpine tundra forage available to wintering sheep along ridges and slopes (Photo 18). Escape terrain, an important requirement of mountain sheep habitat, is abundant in the unit in the form of talus slopes and rocky cliffs. Forage may be somewhat limited in that a significant proportion of the Alpine Tundra in this unit consists of rock and talus. The highest concentration of Dall's sheep pellet groups in the study area was found in this unit at Sample Site 4.

Unit 1[C]: This unit has all the attributes of good Dall's sheep winter range, and is located immediately adjacent to the study area. Vegetation consists of Alpine Tundra and Subalpine Shrub types. The topography is such that large areas of wind-blown plateaus and gentle slopes provide decreased snow depth and access to winter forage. There is sufficient escape terrain between plateaus to support sheep populations. The vegetative cover is sparse to moderate.

Unit 2[D]: This unit, which has an indefinite boundary with unit 1[E], has all the criteria for good Dall's sheep winter range, except for abundant forage. This unit includes the highest peaks of Mackenzie Mountains that are found in the study area. It is rated only as moderate winter range because the xeric status of the general area results in sparse to very sparse vegetative cover (Photo 17).

An investigation of Sample Site 3 in this unit revealed few sheep pellet groups. Browsing of <u>Salix commutata</u> on a south facing talus slope (Table 26) did, however, indicate significant sheep use of this unit. It is believed that low forage abundance limits the use of this unit by large numbers of Dall's sheep.

Unit 1^E: This unit is classified as good Dall's sheep winter range based on topography and vegetative cover. The vegetation types of this unit are Subalpine Shrub and Alpine Tundra. Forage abundance is rated as moderate. The presence of many wind-swept ridges and plateaus reduces snow depth and permits freedom of movement and access to forage.

Escape terrain in this unit is abundant, and is not thought to limit sheep populations. Rugged south-facing cliffs and slopes in the vicinity of Folded Mountain (Photo 21) are potential Dall's sheep lambing range. These cliffs and talus slopes fit the classic description of mountain sheep lambing range in that they incorporate: 1) fairly low elevation; 2) abundant forage resources immediately adjacent; 3) south-facing aspect; and 4) very rugged topography for protection from predators.

Unit 2^F: This unit is made up of the Subalpine Shrub and Alpine Tundra vegetation types of the Headless Range. It is classified as moderate Dall's sheep winter range. Forage abundance is rated as moderate, and is probably not a limiting factor. Escape terrain is probably sufficient, but is not as abundant as Units 1^B, 1^C, 2^D and 1^E. The main limiting factor appears to be snow depth. In March 1981, snow depths at the Cadillac Explorations mine (Photo 19) were reported as greater than usual and no sheep were observed on this unit. This has influenced our designation.

Ground investigation of Sample Site 1 in this unit (July 1981) revealed a moderate density of sheep pellet groups, and much evidence of cratering. The ridges and plateaus of this unit are not as rugged as some of the other Dall's sheep habitats, but its capability as summer range is rated as high based on this habitat evaluation and sightings of sheep in July 1980 (Ker, Priestman and Associates, 1980c) and June 1981.

Unit 2^G: This unit is classified as moderate Dall's sheep winter range because of a lack of escape terrain. This area of Subalpine Shrub and Alpine Tundra on the western extremity of the study area is characterized by a more rolling topography than other alpine regions. Forage abundance is rated very high and ground investigations at Sample Site 2 revealed almost 100% cover of vegetation (Photo 15 and 16). Pellet group counts at Site 2 indicated only the presence of woodland caribou.

Unit 3^{H}: This unit is classified as fair Dall's sheep range. The dominant vegetation type is Spruce / Lichen open forest (Photo 12). It is probable that this unit gets some sheep use, but excessive snow depths and lack of escape terrain precludes extensive use of this habitat during winter.

Unit 4^{I}: This unit is classified as poor sheep habitat because of the lack of suitable forage along the canyon. The Spruce /Lichen forests above the canyon walls may get a limited amount of sheep use.

Unit 3^{J}: This habitat unit of fair sheep range is made up of Spruce / Lichen and Pine Parkland forests. The generally southern aspect of this unit, and its proximity to good sheep range, suggest some use of this habitat. Usually sheep avoid forested areas where they are more vulnerable to predation.

Unit 3^{K}: The Spruce Parkland vegetation type of this unit may get some Dall's sheep use due to its proximity to good alpine sheep range immediately to the south. The major limitation to sheep use is the lack of escape terrain except along its interface with Unit 1^{C}.

Unit 3^{L}: The Pine Parkland vegetation type of this unit may get some Dall's sheep use due to its proximity to good alpine sheep range immediately to the north in the Nahanni Range. This unit, like Unit 3^{K}, lacks escape terrain except along its interface with Unit 1^{D}.

WOODLAND CARIBOU (Rangifer tarandus caribou)

Very little information was accumulated during field studies regarding present use by caribou, and as this was a major limitation in classifying habitat. The classification scheme used is thus based more heavily on the literature and the symbols infer no ranking.

The habitats for woodland caribou are classified as follows:

W: Winter range: climax spruce - lichen forests in the Mackenzie Mountains, tillplain / floodplain lowland east of Nahanni Range.

C & S: Summer range with potential for calving: extensive alpine tundra plateaus with more than 50% vegetative cover. Fairly gentle rolling topography.

S: Summer range: alpine tundra areas with less vegetative cover than potential calving habitat.

N: Little capacity as summer or winter range.

Description of Habitat Units (Figure 8)

Unit W^A: This is part of the winter range of the Martin Hills Caribou herd as described in Watson et al, 1973. Caribou are thought to winter in the black spruce forests within this unit. Significant use of the Grainger Tillplain (Site 13) is documented by ground surveys, but the season of use is unknown. Caribou wintering in this area have been documented migrating to the alpine tundra areas of the Nahanni Range (Watson et al, 1973).

Unit S^B: The Alpine Tundra of the Nahanni Range represents summer range for at least some of the woodland caribou that winter east of this range. Abundant forage in the form of lichens, shrubs, forbs and sedges, makes this area attractive to caribou as summer range. Relief from insect harassment may be another reason caribou utilize alpine tundra habitats in summer.

Unit W^C: This unit represents potential winter range for woodland caribou utilizing the alpine plateaus immediately to the south just outside the study area. Although caribou have not been documented in the area, the Spruce Parkland forest has abundant corticolous lichens to support wintering caribou.

Unit C & S^D: Although this unit occurs just outside the study area, it was included because it is relevant to potential wintering habitat (W^C) within the study area. This unit consists of Subalpine Shrub and Alpine Tundra vegetation types on wind blown plateaus and gentle slopes. The fairly gentle topography and abundant alpine forage resources indicate that there is considerable potential for use of this unit by caribou for calving and summer range.

Unit S^E: This unit consists of Subalpine Shrub and Alpine Tundra vegetation types on moderately precipitous relief interspersed with plateaus. In the western part of the unit vegetative cover is moderate, but becomes quite sparse towards the eastern section of this unit. This combination of forage and topography indicates moderate summer range capability.

Unit S^F: This unit is classified as summer range, but probably does not get as much use as Unit S^E. Unit S^F has less potential as caribou summer range because of very precipitous relief and sparse vegetative cover.

Unit W^H: This unit is classified as potential winter range. The Spruce / Lichen forests above the Prairie Creek canyon have some limitations as winter range because of steep topography. Caribou use of this unit is not expected to be as great as in Unit W^K during the winter.

Unit W^I: This unit is classified as potential winter range. Higher elevations in this unit are dominated by Spruce / Lichen forest, while closer to the Nahanni River Pine Parkland forest predominates.

Unit S^J: This unit in the Headless Range is classified as summer range. Vegetation types are Subalpine Shrub and Alpine Tundra of moderately dense cover. The moderate relief of this unit contributes to its capacity to support caribou.

Unit W^K: The unit in which the mine/mill complex is located is classified as good caribou winter range. An abundance of terrestrial lichens and climax forests of black and white spruce provide winter forage and thermal cover for wintering caribou. It has yet to be determined whether the spruce forest adjacent to the subalpine zone gets more caribou use during winter than the valley bottom spruce forests. Woodland caribou herds in more southern latitudes use the spruce - fir forests during the midwinter months and utilize the arboreal lichens associated with these forests when snow depths preclude use of shrubs and forbes (Freddy, 1974, Edwards and Ritcey, 1959; Bloomfield, 1979).

Unit C & S^L: This unit is classified as potential calving and summer range. The Subalpine Shrub and Alpine Tundra vegetation types of moderate density provide sufficient forage resources. The plateaus and ridges of moderately rolling topography offer protection from predators by providing clear views. The potential of this unit as calving habitat is probably not as great as unit C & S^M to the north.

Unit C & S^M: This unit is probably the best woodland caribou calving and summer range in the study area. The Alpine Tundra and Subalpine Shrub vegetation types cover up to 100% of the tops of some plateaus. Plateaus are level and extensive, providing visual panoramas for protection from predators. The terrain is the most rolling and non-precipitous of the highland vegetation types in the study area.

Ground investigations at Sample Site 2 in this unit revealed the presence of feeding craters and a moderate density of caribou pellet groups. The evidence of cratering also indicates that this area is used in the winter by caribou.

MOOSE (Alces alces andersoni)

Habitat classification for moose is based on the work by Watson et al (1973) on habitat capability for ungulates along the Mackenzie Pipeline Corridor. Modifications of this basic system were necessary to incorporate results from ground investigations.

The moose habitats within the study area are classified as follows:

Class I: Important winter range: good combination of forage and shelter. Low elevation makes this habitat especially important during severe winters with heavy snowfalls.

Class 2: Moderate winter range: good combination of forage and shelter. This habitat will get significant use during mild winters and also represents good summer range.

Class 3: Fair moose habitat: limitations include low forage and high elevations.

Class 4: Insignificant or nil moose habitat.

Description of Habitat Units (Figure 9)

Unit I^A: This unit is classified as important moose winter range based on its low elevation and proximity to the Liard River. Two vegetation types are represented in this unit, Aspen - Liard Floodplain and the Tillplain - Floodplain mosaic. The forest cover along the Liard River is dominated by a mature trembling aspen forest, while along the Grainger River stands of white spruce predominate.

Ground investigation at Sample Site 14 indicate relatively low use of moose along the transect. However, litter fall was sufficiently heavy to obscure pellet groups greater than one year old. Shrub cover under the monoculture aspen forest was sufficient to support considerable densities of moose. The main limitation of this habitat unit was its lack of plant diversity and edge effect. Insect harassement was greater than on other lowland transects sampled.

Unit I^B: This unit is rated as important moose range, and is limited to the valley bottoms of Tetcela River and Fishtrap Creek, containing meander floodplains which have been burned extensively. The vegetation type of this unit, Mixed Coniferous /Deciduous, ranked highest of the six lowland transects in moose production capacity.

The value of this habitat unit is most apparent during severe winters with heavy snowpacks when it may be critical to moose survival. Low elevation valley bottoms become areas of high moose concentrations because of lower snowfalls.

Unit 2^C: This unit is confined to the Grainger Tillplain vegetation type, and is classified as moderate winter range and good summer range for moose. A high degree of habitat and plant diversity exists in this unit because of the topographic sequence of the drumlinized tillplain (Photo 3). Ground investigation within this unit (Sample Site 13) indicated high browse forage abundance and light browse utilization (6-25%) by moose and caribou. The Grainger Tillplain is ranked the highest of lowland transects in ability to produce ungulates (Figure 6).

Unit 2^D: This unit is classified as moderate winter range and good summer range. A Mixed Coniferous / Deciduous vegetation type covers the Silent Hills in this unit as a result of extensive forest fires. This diverse successional plant community provides abundant browse forage for moose during summers and mild winters.

Unit 2^E: This unit is classified as moderate winter range and good summer range. It is made up of Pine Parkland forest which occurs on well-drained sites below the western slopes of the Nahanni Range. Ground investigations of the Pine Parkland vegetation type in 2^G (Site 10) indicate this type to have high potential to support moose populations.

Unit 2^F: This unit is classified as moderate winter range and good summer range. The Mixed Coniferous / Deciduous vegetation in this unit is the result of botanical succession after a recent forest fire.

The results of a sample transect in this unit (Site 11) indicate relatively high moose densities and some of the greatest browse utilization and browse forage abundance measured among the lowland transects (Table 22).

Unit 2^G: This unit is classified as moderate winter range and good summer range. Pine Parkland is the predominant vegetation type present, although Black Spruce Parkland occurs in wet depressions. A sample transect in this unit (Site 10) indicated relatively high moose densities and abundant browse forage resources (Table 22).

Unit 2^H: This unit is classified as moderate winter range and good summer range. The unit consists of the Riparian Alluvial vegetation type and the spruce forest immediately adjacent. The abundance of shrubs, especially Salix sp., in the braided stream channels provide sufficient winter forage in all but the most severe winters.

Unit 2^I: This unit is classified as moderate winter range and good summer range. It occurs in a Pine Parkland vegetation type up to 762 m in elevation above the Nahanni River.

Unit 3^J: This unit is classified as fair moose habitat. It occurs entirely within the Tillplain /Floodplain mosaic vegetation type. The high proportion of Spruce Muskeg in this unit limits the production of moose because of low forage abundance.

Unit 3^K: This unit is classified as fair moose habitat. The vegetation type of this unit is entirely Spruce Muskeg. A sample transect in this unit (Site 12) indicates low forage abundance and utilization. Moose pellet groups were not abundant along the transect.

Unit 3^L: This unit is classified as fair moose range. It is defined by the boundaries of the Spruce Parkland vegetation type. A sample transect (Site 9) within this unit indicates there is very low plant diversity, low browse forage utilization, and a low density of moose pellet groups. This unit encompasses a climax forest community, and as such has limited potential as moose range.

Unit 3^M: This unit is classified as fair moose range. It consists of the Spruce /Lichen boreal forest which occurs above the Pine Parkland type, but below the Subalpine Shrub type. Limited use of this unit by moose is expected because the Spruce / Lichen type has the characteristics of a climax forest type.

Unit 3^N: This unit is classified as fair moose range. The Spruce / Lichen vegetation type along the bottom of Prairie Creek valley is expected to get a limited amount of moose use. The riparian vegetation along the braided stream bed is probably of great importance to the few moose that winter in this unit.

Unit 4^O: This unit is classified as nil or insignificant moose habitat. The Alpine Tundra and Subalpine Shrub types of the Nahanni Range is expected to get little, if any, moose use.

Unit 4^P: This unit is classified as nil or insignificant moose habitat. The Alpine Tundra and Subalpine Shrub types of the Mackenzie Mountains are expected to get very little use by moose.

4.3 Wildlife Distribution and Abundance

Cumulative information on numbers of ungulates observed during the four field programs is provided in Table 28 and locations of all observations, by survey, are given in Figures 10-13. Data relevant to age-sex class, habitat, elevation and the distance from the road/mine site that sightings were made, are given in Tables 29-32. Findings specific to each field program were as follows:

January Field Program

The January field program consisted solely of aerial surveys within the mine/mill study area. Observations are shown in Figure 10.

All of the Dall's sheep observations were made well away from the immediate vicinity of the camp. Sheep sightings were noted between 0.8 and 7.8 km from either the mine site or the road (Table 29). East of Prairie Creek there were extensive alpine areas with little or no snow cover and it was here on these bare areas that 14 of the 17 Dall's sheep were sighted.

The five caribou were observed in a group about 7.8 km from the mine site. In addition to the animals there was a high density of tracks and some cratering nearby.

The moose was observed west of Caribou Flats, about 9.5 km north of the road.

March Field Program

The March field program consisted of aerial surveys both within the mine/mill study area and throughout the winter road. Observations are shown in Figure 11.

The herd of 13 caribou were seen during the transect survey north of the Grainger River, east of the Grainger River Pass, and within 2.5 km of the winter road (Table 30). Three bulls were noted in this herd; the remaining 10 animals were female.

Of the 77 Dall's sheep seen, 7 were rams, 64 were ewes, 3 were lambs and 3 were unidentified with respect to age-sex class. The observation recorded closest to the mine site was of 7 sheep (2 rams and 5 ewes) made 4.4 km east of the mine. As with caribou, sheep were generally absent from the road corridor, with only 2 sightings being made nearby: one of 8 sheep (1 ram and 7 ewes) 1.5 km north of the road, and another observation of 3 unclassified sheep seen within 1.0 km of the road. Of the total of 77 sheep observed, 32 were recorded in the Nahanni Range (26 north and 6 south of the Grainger River Pass).

With one exception, all moose were observed east of the South Pass. The single exception was recorded at an elevation of 1,127 m in the Mackenzie Mountains, west of Caribou Flats and more than 9 km from the nearest portion of the mine/road facility. The remaining 16 moose noted during this study were observed at elevations ranging from 183-945 m. Twelve of these animals were observed between the Grainger River Pass and a point approximately 20 km east of the Mackenzie Mountains. None were found more than 2.4 km from the road alignment, and 8 were less than 1 km from it.

June Field Program

More ungulates were recorded during the June survey than during the January and Marsh surveys. Seventy-four woodland caribou and 45 Dall's sheep were observed. Of those caribou noted, 5 were males, 39 were females and 19 were calves. Eleven caribou were unclassified with respect to age-sex. Sheep observations included 4 rams, 26 ewes, and 15 lambs. Compared with results from January and March surveys, the June data showed that both species displayed substantial increases in numbers in the western (mine site) portion of the study area (Figure 12). Since this considerable increase in numbers could not be attributed solely to changes in observability, it is assumed that there was considerable influx of animals into the area during the spring.

All caribou sightings were made between 1,112 and 1,585 m and ranged between 1.4 and 16.4 km straight-line distance from the mine/road development (Table 31). Caribou calving appeared to be generally distributed throughout the study area. Females with calves were observed to the east and west of Caribou Flats, in the vicinity of Folded Mountain, east of the mine site, and on both the north and south sides of the winter road by the eastern flank of the Mackenzie Mountains. Most cow-calf cohorts were observed on open ridge tops or in other non-forested habitat types. All were found between 1.4 and 12.5 km from the mine or road.

Generally, Dall's sheep were observed closer to the mine site than were woodland caribou. Of all age-sex classes, only adult rams were notably absent from the immediate vicinity of the mine site and the road corridor. Of the 4 rams observed, the closest to the facility was 6.0 km away. Notably, ewes with lambs were observed immediately to the west and east of the mine site (in one case within 0.3 km of the airfield), and one sighting of a ewe with 2 lambs was recorded directly below Adit #3 (above Harrison Creek) within the mine site itself. Of particular importance was the fact that the above 3 animals were using a mineral lick formed by materials mined from Adit #3 and placed downslope.

During these surveys, alpine areas, particularly those with a south or southeast exposure, were examined closely for evidence of grizzly bear denning. Based on information provided by S. Miller (pers. comm.), the time of our surveys should have been ideal for this purpose, coinciding with the emergence of the last bears and generally prior to the collapse of the dens. Diggings were observed in one area (Figure 12), and this site was examined closely for a possible den. None was found. One grizzly bear was spotted near these diggings and another east of the Caribou Flats along Tundra Ridge. In July 1980 a sow and two cubs, believed to be grizzlies, were observed west of the mine (Ker, Priestman and Associates, 1980c).

July Field Program

Incidental observations of ungulates were made during vegetation/habitat studies conducted 9-17 July 1981. During these investigations 3 woodland caribou, 18 Dall's sheep and 1 moose were observed (Figure 13). Two of the three caribou observed were seen within 1.8 km of the development (1 animal just south of the mine; the other east of the Grainger River Pass). The third animal was located to the west of Caribou Flats, 16 km from the road (Table 32).

Dall's sheep were sighted in the Nahanni Range north of the Grainger River Pass (1 animal), east of Caribou Flats (5 animals in 2 herds of 1 and 4). Two groups of 5 and 4 sheep were seen more than 8 km south of the camp. In addition, 2 sightings of 1 and 2 lambs were made at the mineral lick above Harrison Creek, within the immediate vicinity of the mine.

A single moose observation was made within 0.5 km of the winter road near the Tetcela River.

5.0 DISCUSSION

5.1 Vegetation

5.1.1 Introduction

The presentation of the complex of vegetative cover in a study area of over 200,000 hectares is best comprehended in terms of the environment under which it has developed, since this, along with history (fire has in this case been especially important), is a major influence upon vegetation. A reasonable description of the environmental conditions of the study area can be achieved by consideration of three generalized headings, "climate", "terrain" and "fire".

5.1.2 Climate

The study area varies between 600 and 6,534 feet (183 - 1,993 metres) above sea level. Inherent in this topographic gradient is a certain degree of variation in climatic conditions within the area. Meteorological data is available for approximately one year in 1970 for the Cadillac mine site (elevation 2,850 ft. - 869 m), and more complete information (over 8 years) has been recorded at Fort Simpson (elevation 422 ft. - 129 m). Table 13 shows monthly and annual means of temperature, rainfall and total precipitation for these two locations (Ker Priestman & Associates, 1980c).

Jeffrey (1961) reports the average date when the mean temperature at Fort Simpson reaches 42°F (5.5°C) is May 10. The average growing season is 138 days, mean temperature during the growing season is 55°F (12.8°C), and mean rainfall during the growing season is 6.8 inches (173 mm). The data shown in Table 13 confirms this trend for Fort Simpson. The estimated data for the Cadillac site indicates a much shorter and wetter growing season than Fort Simpson, since the May - September average temperature is 48°F (8.9°C) and the total rainfall for that period is 12.4 inches (315 mm). Thus a difference in vegetation would be expected from the beginning of the winter road at the Cadillac mine site and the terminus at the Liard River (approximately 160 km southwest of Fort Simpson and at a similar elevation), based solely on climatic differences. However the absence of maximum and minimum temperatures, and the extrapolated nature of Table 13, may be misleading. The average midday temperature during the 1981 field studies was 80°F (26.7°C) from July 8-17.

A major feature of the climate of the entire study area from a botanical standpoint is the low annual precipitation. Such a low precipitation in a southern climate would be concomitant of desert conditions, but in the study region there is no apparent lack of available moisture in the soil. Raup (1947) presumed that the moisture source is the predominantly frozen subsoil, and that the availability of moisture is dependent upon summer temperatures sufficiently high to release it. He felt that the climatic values which limit vegetation in the southwestern Mackenzie region are probably temperature rather than precipitation.

To summarize in general terms, the climate of the study area is northern continental, characterized by short, dry growing seasons and long, cold winters.

5.1.3 Terrain

Most of the soils and minor topographic features of the study area are products of erosion and deposition during the Glacial Period, of lacustrine deposition during the retreat of the ice, or of strictly post-glacial stream cutting and alluvial sedimentation. Most of the soils are youthful (since the last ice retreat) and immature so far as the development of profiles is concerned, due in part to their youth and in part to the subarctic climate. The predominance of limestones, dolomites and calcareous seams in the slates has allowed the growth of calcicolous plants throughout much of the highland region.

The winter road crosses a number of distinct types of geological formations, landforms and soils. From its eastern-most point at the Liard River, the major geological features are the Interior Plain, Nahanni Range, the Mackenzie Plain and the Mackenzie Mountains (Nahanni Plateau). Each of these sections have distinctive geomorphology and surficial geology characteristics. The following description is adapted from information reported by Ker Priestman and Associates (1980a).

The Interior Plains section varies from 550 to 1,500 ft. (168-458 m) in elevation. The terrain is heavily wooded and consists of muskegs for the most part, interspersed by numerous shallow lakes. The principal streams in the area are the Liard River and its tributary, the Grainger River.

In the vicinity of its eastern terminus, the proposed route crosses the floodplain of the Liard River and the lower reaches of the Grainger River near its confluence with the Liard. The deposits are fine silts and silty sands that are between 1.5 and 30.5 m thick in this area. The topography of the landform is relatively flat, with between 1 and 5 m of relief. Peat cover is negligible on the active floodplain, but abandoned channels may have deposits up to 5 m thick. Much of the floodplain is wet with numerous marshy areas. Bogs with more than 1.8 m of peat may support permafrost, and ground ice may be present in the fine-grained materials of the floodplain.

Lake deposits are present between the Liard and Grainger River flood plains. These are silts and clays, often with a covering of sand or silty sand and a discontinuous organic cover. The terrain is flat to gently sloping, has a deranged drainage pattern and has permafrost in some of the bogs.

The remainder of the Interior Plains portion of the proposed route is a till plain. The surficial material is a clayey to silty Laurentide till which forms a veneer over bedrock. Thicknesses are as great as 6 m. The terrain is a sloping to rolling bedrock controlled plain, with a discontinuous peat cover. Water is often present in depressions and localized permafrost with a moderate ground ice content is present.

The Interior Plains terminate abruptly against the eastern scarp of the Nahanni Range. The Nahanni Range is the southernmost range of the Franklin Mountains. Its width in the study area is between 3 and 5 km, with elevations ranging from 2,000 to 5,000 ft. (610 - 1,525 m). It is formed of hard, massive and resistant carbonates. The winter road crosses the Nahanni Range through the Grainger River Pass.

At the Grainger River Pass, coarse-grained river deposits can be found. These are indicative of the high energy streams emerging from the mountains. The materials consist of between 3 and 23 metres of gravels and sands, commonly with a veneer of silt. The topography is level to gently sloping and local relief is up to 3 m. The surface is dry for the most part, and permafrost is probably absent.

West of the Nahanni Range, the winter road crosses the Mackenzie Plain. The area may have been part of the Interior Plains at one time, but has been separated from them by the emergence of the Nahanni Range. In the Study Area, the Mackenzie Plain is a north-south trending valley about 48 km wide, and is carved in soft shales and sandstones. This plain is dissected by the Silent Hills and the Tetcela Plateau. Elevations along the route vary from 1,000 to 3,500 ft. (305 - 1,068 m). The Silent Hills rise about 1,300 ft. (397 m) above the poorly drained plains, while the Tetcela Plateau, an informal name for the area south of the Ram Plateau, exhibits relief of about 1,000 ft. (305 m). The principal streams in the Mackenzie Plain are Fishtrap Creek, west of the Silent Hills, Tetcela River on the Tetcela Plateau, and a tributary to Sundog Creek on the western side of the Plain.

The terrain between Grainger River Pass and the Silent Hills includes till plain and hummocky till, gravel-sand hills and ridges with some mountainous and rocky areas. The hummocky till is clayey to gravelly-sandy with local gravel lenses. The topography is characterized by individual and coalescent hummocks with slopes between 5° and 30°. Small areas of organics are also present. Drainage varies between well-drained hills and poorly-drained depressions. Localized areas of permafrost with moderate ice contents are present, chiefly on north-facing or shaded areas, higher elevations, poorly-drained areas and areas with thick organic cover.

Areas of gravel-sand hills and ridges consist of deposits between 15 and 23 m thick and relief up to 9 m. These coarse-grained deposits are dry, for the most part, and within these hills permafrost is present only in organic deposits.

The mountainous and rocky areas consist of rock outcrop or rock thinly covered by rubble or till. Slopes are moderate to steep and the ground is dry. Permafrost may be present in some fine-grained colluvium.

The Silent Hills are composed of mountainous and rocky terrain. West of the hills is an area of lake deposits, followed by gravel-sand hills and mountainous, rocky areas.

The terrain west of the Tetcela River has not yet been mapped for surficial deposits. However it is expected to consist of till, lake deposits and gravel-sand hills to the eastern scarp of the Mackenzie Mountains.

The final portion of the route crosses the Mackenzie Mountains, which range in elevation from 3,000 to 6,534 feet (915 - 1,993 m). The easternmost range of the mountains (Nahanni Plateau) is crossed through the informally named South Pass, with the road reaching its western terminus at the camp, located on Prairie Creek. Nearly flat lying rocks of dolomite, limestone and shale underlie the Plateau, and variations in the physical nature of these rocks contribute greatly to variations in the physiography of the region. In general, most of the plateau is deeply dissected by stream cutting, which has produced valleys that are steep and canyon-like. The ease with which limestone and shale are broken up by frost action has produced bare rock outcrops with screes on steep slopes and contributes to the general instability of the regosolic soils.

A knowledge of the diversity of the landscape in the study area facilitates a more comprehensive understanding of the vegetation types which cover it. The relationship between them is illustrated in the winter road profile (Figure 3).

5.1.4 Fire

The third element needed to provide an overall cohesion to the vegetative cover of the study area is that of fire history. Fire has been noted as one major factor in the development of the aspen stands at the Liard River (Unit 1), the coniferous /deciduous mosaic on the Interior Plain (Unit 2), the coniferous / deciduous forests on the Tetcela Plateau and Silent Hills (Unit 5) and the Pine Parkland (Unit 6) found on the Tetcela Plateau and western flanks of the Nahanni Range. These cover types represent post-fire successional stages whose longeveity is dependent upon fire frequency. The black spruce muskeg (Unit 4) was seen to have been recycled by fire rather than replaced by another cover type.

Fire is a principal long-term environmental factor of influence in northern coniferous forests (Kelsall et al, 1977). In the short-term, the climatic climax stage is occasionally approached in local elements of the mosaic that have escaped fire for a long time (as in the spruce parkland, Unit 7). However the interspersion of forests of many different ages and species composition is a natural feature of post-fire succession on sites varying in other environmental characteristics such as soil development, drainage and aspect.

The common view of post-fire succession in northern boreal forest is that white and black spruce are the end products of many years of forest development and that burned stands eventually revert back to conifers (Kelsall et al, 1977). Because seed is usually not available after extensive fires, and because white spruce only produces abundant seeds approximately one in twelve years, birch and aspen (which can reproduce rapidly through vegetative suckering) tend to dominate south and west facing uplands following fire (Viereck, 1973 in Kelsall et al, 1977). This helps to explain the predominance of aspen and birch in the dense forest cover of the Silent Hills where only scattered white spruce is seen in the canopy. White spruce survives best in localities where intervals between fires are relatively long; such places typically occur on humid alluvial lowlands along rivers. This may be seen in Unit 1 where 30% of the type is comprised of pure white spruce clumps.

Black spruce is better adapted to fire than is white spruce. It is less selective with regard to site, produces seed at a younger age, and retains semi-closed cones for several years. Large quantities of black spruce seed that germinate quickly are generally present in crowns of unburned trees that have been killed by fire (as observed in Unit 5). The pattern is one of rapid replacement of the black spruce by another dense black spruce stand. This was seen to be the case in one plot of the mixed coniferous / deciduous type (Unit 5) and in the black spruce muskeg type

(Unit 4). The presence of black spruce in the understory of 3 other plots in the mixed coniferous / deciduous type is indicative of an eventual return to a spruce parkland in the absence of further burning. Repeated fires on wetter sites can result in replacement of black spruce by shrub thickets of alder, willows and dwarf birch. Evidence of this development is seen in the Grainger till plain (Unit 3) where these shrubs are seen to be interspersed with 5-15% of low height black spruce.

Jack pine forests characteristically occur on dry upland sites that have been repeatedly burned, as in Unit 6. They tend to be self-perpetuating because jack pine seed cones are resistant to fire and because there is no lack of seed. The observation that such stands are more flamable than other stands indicates that this species may have adapted to facilitate fire spread (Scotter, 1964).

Kelsall et al (1977) in their review of the effects of fire on the Boreal Forest state that the most flammable forests consist of coniferous trees and contain a high accumulation of organic litter. Spruce - lichen forests on dry upland slopes (as in Units 7 and 9) are, therefore, very flammable; the least flammable Boreal Forest types are aspen and poplar in early stages of succession.

The mode of post-fire succession in the study area depends on characteristics of individual sites. The dependent variables are:

1. type of fire (crown, heat intensity, etc.);
2. type of forest burned (black spruce, white spruce, etc.);
3. presence or absence of permafrost;
4. extent and quality of fuels on forest floor;
5. presence/absence of suitable seed for forest regeneration (wind carried seed such as willow leads to this type of shrub invading areas of extensive burn); and
6. topography / exposure (drainage aspect, etc.).

Successional development to climax will reduce both vegetational variety and ecological niches which will consequently reduce the overall capability to support wildlife species (Frissell, 1973). Moose in particular benefit from the herbaceous, shrub and deciduous seres that replace black spruce parkland cover. However before advocating prescribed fire as a wildlife management tool, caribou habitat must also be considered. The dense coverage of arboreal lichens available on the well spaced trees in the spruce and pine parkland units, which may constitute winter caribou forage, are not present in successional seres. The dense ground cover of lichen takes many years to re-establish following fire. According to the literature, 50-150 years for recovery of a full lichen mat are common (Kelsall et al, 1977). Therefore large areas of "climax" parkland forest should be protected from fire to insure sufficient winter range for caribou.

5.2 Wildlife

5.2.1 Dall's Sheep

Over the January to June period, distinct changes were noted in the distribution of sheep in the western portion of the study area. January data showed that sheep were widely scattered during this period and only 17 animals were recorded within the mine/mill study area (Figure 10). Of the 17 sheep observed, 14 were seen along the eastern fringe of the Mackenzie Mountains in windswept areas devoid of snow. Only 3 rams were found to the west of Prairie Creek in areas of considerable snow depth.

After January the number of sheep observed increased. In the mine/mill area (i.e. all sheep habitat excluding the Nahanni Range) numbers rose from 17 in January to 45 in March, and the same number was recorded again in June. The similarity between occurrence patterns in January and March was that most sheep recorded were found east of Prairie Creek. Snow depths were not systematically recorded throughout this area, but observations indicated variable accumulation patterns. For example, west of Prairie Creek moderate snow depths covered virtually all of the alpine area. East of Prairie Creek, particularly in the drainage of Sundog Creek and its tributaries, alpine ridges and slopes were virtually devoid of snow. It was here in January that groups of 7, 4 and 3 were seen and where even greater numbers were encountered in March. Outside of the study area, habitat of this quality appears to occur to the southeast (i.e. north of Lafferty Creek) and to the north of these winter sheep sightings (Sundog Creek / Ram River). Low numbers in the study area in January could be explained by movement of sheep into those areas contiguous with, but outside, the study area. Whether or not this occurred was not investigated.

There appears to be a precipitation shadow along the eastern slope of the Mackenzie Mountains at this latitude. This may be an important element in determining important winter range for sheep.

The March survey also demonstrated that the Nahanni Range constitutes an important winter range. Most sheep were observed at fairly high elevations (greater than 1,000 m) compared to the road (500 m) and most (26 of 32) were observed in that part of the range north of the road.

In June, surveys of the mine/mill area located the same number of Dall's sheep as recorded in March, but the difference was the appearance of sheep in considerable numbers (13) west of Prairie Creek, plus a further 17 immediately above camp, in an area devoid of sheep in March. In July 1980 BEAK wildlife biologists observed 44 sheep west of Prairie Creek (Ker, Priestman and Associates, 1980c).

Based on these observations of sheep during two summers and one winter, there appears to be considerable differences between winter and summer ranges. Simmons (1981) in his study of Dall's sheep in the Mackenzie Mountains pointed out that the habitat used as winter range is characteristically a contraction of the summer range. In another study, Heimer (1977) found in 1975-76 the winter range for Dall's sheep represented only one half of the summer range, while during the following winter the effective ranges represented only one quarter of the summer range. Thus, in those areas where sheep densities are greater in winter, forage abundance and availability become potential limiting factors.

Winter forage use by Dall's sheep has been documented by a number of researchers. Hoefs (1976) found that from the months of October to May the average per cent composition of forage was 51.5% grasses, 34.3% forbes and 14.5% browse. Heimer

(1978) found rumen contents of Dall's sheep ewes in early winter contain an average of 83% grass and sedges, 13% browse and 4% lichen and moss; and 78% grass and sedge, 20% browse and 2% lichen and moss in late winter. These results indicate that most sheep remain in the alpine and/or subalpine zone during the winter. The results of our vegetation studies indicate ample preferred forage is available in these zones. In the alpine sites the grasses and sedges comprised 17.6% of the total cover while Dryas comprised 12.1%. In the subalpine zone grasses and sedges comprised 4.8% of the cover and Dryas comprised 4.4% (Tables 11 and 12). Aerial surveys also show that some Dall's Sheep in the study area remain in alpine and subalpine areas during the winter months, but due to other factors (snow conditions and depth) not all areas with abundant forage are used by wintering Dall's sheep.

June surveys showed substantial increases in the number of sheep utilizing habitat in the vicinity of the mine site. Twenty-three sheep were observed in the ranges west of the mine/road development, between Folded Mountain and the camp. An additional 20 sheep were recorded within 5.2 km of the mine. Four areas were identified as being used by ewe-lamb groups: 1) on Folded Mountain north of the camp; 2 and 3) on peaks immediately east and west of the Prairie Creek airstrip; and 4) on slopes north of Harrison Creek immediately below Adit #3 (Figure 12).

The first three areas are believed to include lambing areas. Three groups of ewes with lambs were sighted on or immediately adjacent to Folded Mountain. This mountain has key attributes of lambing range: low elevation, nearby forage resources, south-facing aspect and escape terrain. Areas with similar characteristics occur on the slopes on either side of Prairie Creek, primarily north of the mine.

During the June surveys, the Dall's sheep were found in the alpine or subalpine shrub vegetation zones. Their use of these habitat types is reflected by other research. Hoefs (1976) found that the per cent forage composition in June consisted of 30.4% grasses, 24.9% forbes and 44.6% browse. The preference for browse species during this month may be indicative of the increased palatability of new growth on shrubs. It is possible that the sheep of the Mackenzie Mountains also shift into the subalpine shrub zone in the spring and take advantage of new spring growth. Our surveys did not cover this period. Our results showed that in this zone Betula sp. and Salix sp. comprise 62.6% cover (Table 11), and therefore ample forage is available. All of the June observations occurred within the alpine zone or subalpine shrub zone with the exception of those observed at the mineral lick near the mine site.

The remainder of the summer the sheep forage consisted of an average of 41.9% grasses, 53.7% forbes and 1.7% browse (Hoefs, 1976). In the Mackenzie and Nahanni Mountains the abundance of grasses is not as great, however the abundance of sedges and a variety of forbes provides a similar type of diet to that described by Hoefs (1976).

A final critical element of Dall's sheep habitat that has been identified as having considerable influence on population, is the presence of mineral licks. Heimer (1973) found that a single lick was utilized by all segments of a number of herds and that sheep movements from winter to summer ranges are punctuated by stops at mineral licks. Heimer found that both ewes and rams showed considerable fidelity to specific licks and that lactating ewes showed preferential use of licks. A single lick was found in the study area in the Harrison Creek drainage immediately below Adit #3 (Figure 3). The presence of ewe-lamb groups in this area may be indicative of the preferential use of licks by lactating ewes. There is some concern that this lick may contain heavy metals since it is thought the materials are from inside the adit. It is believed that the attraction to this lick is due to rock salt used on the road rather than any particular mineral content of the rock itself.

It is unlikely that the Harrison Creek site is a lambing area. The presence of sheep in that area is correlated with a mineral lick at the camp. On three occasions (one during June and 2 during the July habitat assessment) lambs were observed mouthing soils immediately below Adit #3. The identification of this mineral lick is significant. To date, it is the only lick found in the area, and may partially account for the use of the area by ewe-lamb cohorts. Of concern is the possibility that, because the soils of the lick come directly from the mine, they may contain heavy metals injurious to sheep in general and lambs in particular. At present, it is believed that the attraction is rock salt used for melting ice, rather than any minerals excavated during exploration or mine development.

5.2.2 Woodland Caribou

During the June 1981 survey 74 woodland caribou were sighted in the mine/mill portion of the study area. Only 5 were sighted during the January survey of the same area, and in March, 13 were observed in one herd during a survey of the entire study area. On the basis of our limited observations there is no evidence that any part of the study area might be an important winter range.

Winter range for all subspecies of caribou in the western Northwest Territories consists primarily of mature, open black spruce forest which favour lichen production (Watson et al, 1973). A similar pattern has been shown for woodland caribou wintering in more southerly areas (Freddy, 1979). Edwards and Ritcey, 1959) found that caribou movements in winter shifted altitudinally in response to receding and accumulating snow pack.

Snow depths were not measured in this study. However, our impression was that areas west of Prairie Creek had a greater snow pack than those areas to the east, and in the previous section this was offered as an explanation of Dall's sheep distribution and abundance patterns. Snow depths in the western portion of the mine/mill area may offer some explanation for the absence of woodland caribou in winter. Bloomfield (1979) found woodland caribou using lower elevation forests of cedar, hemlock and spruce during midwinter months, and as snow depths and conditions began to influence the availability of forage at lower elevations, they later moved into the subalpine zone, where wind action made more forage available. If such patterns apply to the study area one would expect to encounter wintering caribou in the low elevation winter range; designated W^C and W^A. Our observation of a herd of 13 in March is our only confirmation of this hunch (Figure 8).

The herds that inhabitat the study area are likely to be utilizing their range in a similar fashion to those herds documented by Freddy (1974), Edwards and Ritcey (1959) and Bloomfield (1979). In these studies, altitudinal migrations through the winter months, influenced by snow depth and the resultant availability of forage, were the general rule. However, it is possible that some cross country migration to different ranges may occur. Bloomfield (1979) found historical records which indicated that woodland caribou were known to range over an area of at least 48 km. Freddy (1974) suggested that traditional ranges were rotated year by year, and whether or not a herd might use a range may be dependent on the depth and type of snow.

Calving in various woodland caribou ranges in British Columbia is concentrated in June (Bloomfield, 1979; Freddy, 1974). Caribou select open alpine slopes to calve (Freddy, 1974), or semi-open muskeg or alpine areas (Bloomfield, 1979). Watson et al (1973) suggests calving occurs in open high alpine tundra habitat where predators are easily visible and insect harrassment relatively low. It is these criteria that the habitat classification for calving is based on, though no actual calving areas were identified. Of the 74 caribou sighted during the June survey 19 were calves. Though no specific "calving area" was identified, our observations indicated caribou calving is a widely occurring event in the Mackenzie Mountain portion of the study area.

5.2.3 Moose

The majority of the moose in the study area appear to be restricted to the lowlands along the eastern half of the winter haul road. This is based on the results of the March survey (Figure 11) and a survey of wetlands in July 1980 (Ker, Priestman and Associates, 1980c). In the March 1981 survey, 16 moose were observed in lowland habitats which amount to 116,843 hectares. An estimated 25% coverage of the area was obtained during aerial surveys, which represents about 5 moose per 100 square kilometres.

During the winter moose ranges tend to be restricted to areas where forage is available above the snow. Areas of particular importance are generally along rivers, where willow shrubs may be abundant (Watson et al, 1973).

During the January survey of the mine/mill portion of the study area, a single moose was observed along a ridge. Since snow depths were not restrictive, a few animals may remain within the Mackenzie Mountains.

During the March survey one moose was also observed within the Mackenzie Mountains. However, the bulk of the moose observations (16 of 17) were concentrated in lowland areas and some burned lower slopes (Figure 11). During the winter of 1981 it did not appear that moose were restricted to any specific winter range, but were dispersed over a large area. In winters with greater snowfalls it is likely that the moose in these areas would be restricted to riparian type habitat (Watson et al, 1973). For example, the floodplain of the Liard River near the mouth of the Grainger River was the area where the highest moose concentrations were found along the Liard Highway (Dekker and Mackenzie, 1979). It was classified as high quality winter range in this study (Figure 9).

In both summer and winter moose tend to utilize habitats with abundant willow. Franzmann et al (1976) described moose habitat in the Kenai Moose Research Centre as a mixture of paper birch (Betula papyrifera), white spruce (Picea glauca), black spruce (P. mariana), willow (Salix sp.) and aspen (Populous tremuloides). Generally this also describes the lowland habitats in which moose in the winter road area were found.

During the summer survey in the mine/mill study area no moose were observed. From our winter observation and summer ground survey, it is evident that the primary moose ranges within the study area lie between the Mackenzie Mountains and the Nahanni Range, and from the Nahanni Range to the Liard River. During the summer moose have been known to be less browse oriented and utilize newly emergent marsh growing forbes, sedges and horsetails (LeResche and Davis, 1973). Therefore it is likely that marsh areas along some of the rivers as well as the abundant lakes in the area may be preferred summer area. An indication of this was surveys done in July 1980 in which 8 moose were observed in a survey of 17 wetlands (Ker, Priestman and Associates, 1980c). Moose are thus considered to be residents throughout the year, and unlike caribou and sheep our evidence does not indicate any pronounced seasonal shifts in moose distribution.

5.2.4 Grizzly Bear

Studies on grizzly bear were directed primarily at denning, a vulnerable part of their annual cycle. No dens were found. Grizzly bears do occur in the Mackenzie Mountain part of the study area as indicated by our sightings in July 1980 and June 1981.

No specific habitat appears to be critical to Grizzly Bears, but rather the availability of food is considered the determining factor (Watson, et al, 1973). However it is sometimes difficult to determine if good food sources are available.

6.0 PROJECT IMPACTS AND OPPORTUNITIES FOR MITIGATION

6.1 Vegetation

Loss of vegetative cover as a direct result of winter road construction is not a significant impact in the study area. The types of vegetation removed are well represented in undisturbed areas adjacent to the road, so problems with natural regeneration patterns should not occur.

The introduction of new species to the area through seed carried by transport vehicles is a possibility, although use of the road only during the non-growing season will minimize the amount and survival of such seed.

Opportunities for mitigation exist in three categories: recreational use, fire control and reclamation.

The winter road constitutes an access route into vegetation types previously secluded from man's activity. Some of these types, especially those of the Highland section of the study area, have a low threshold to disturbance. The ground cover on the forested slopes adjacent to the Prairie Creek mine site have a low ability to support traffic due to the unstable talus substrate, and therefore recreational use by camp personnel should be controlled through use of specified trails.

An opportunity for mitigation of vegetation disturbance exists through a fire suppression policy. The proximity of the study area to Nahanni National Park makes such a policy imperative for the protection of this public use area. As discussed in Section 5.1.4, fire of natural (lightning) origin is a major factor affecting the distribution of vegetation cover types of the Lowland Corridor. The frequency of fire is important in determining the availability of seed for regeneration. The more frequent and extensive the burn, the smaller the areas of available seed sources for "climax" vegetation regeneration and the more extensive the coverge of species with wind-carried seed such as willow and fireweed. Therefore the preservation through fire suppression of the climax coniferous forest types Spruce Parkland and Spruce / Lichen may be desirable. The added significance of these types as winter range for woodland caribou makes this policy a habitat enhancement as well.

The results of a reconnaissance along the road to mine Adit #3 indicate that active reclamation of disturbed areas may be necessary to restore ground cover in the Prairie Creek mine/mill site following abandonment. The flat-lying roadbed supports scattered individuals of fireweed, black spruce seedlings, cinquefoil, yellow dryas, mountain avens, dwarf birch and willow. The slopes, which are covered by waste-rock materials removed from the mine, have less than a 1% plant cover, primarily of willow. This poor colonization of slopes may reflect the poor growth conditions such as nutrient deficiencies, inadequate fines and rapid drainage leading to plant moisture stress associated with waste rock disposal areas. Further monitoring of these areas could determine whether remedial action is necessary to re-establish vegetative cover and thereby stabilize such slopes.

6.2 Wildlife

Sightings of animals during the surveys indicate that for Dall's sheep and woodland caribou the largest number of animals use the study area in spring and summer. The greatest proportion of the populations of these species appear to be wintering outside of the study area. Although it is not possible to eliminate all concerns for wintering wildlife populations, the data provide no evidence that winter impacts on sheep and caribou would be negative and significant.

Moose sightings infer greater impact potential during winter owing to their relatively close proximity to the road and possible mortalities from truck traffic. Moose populations in this area are believed to be less sensitive to disturbance than Dall's sheep, and this may partially offset winter road considerations compared to sheep and caribou.

There is circumstantial evidence that the Mackenzie Mountains in the vicinity of the mine contain a number of Dall's sheep lambing areas. One possible lambing site was identified 0.3 km from the airstrip in July 1980 (Ker, Priestman and

Associates, 1980c) and two ewes and two lambs were again observed in this area in June 1981. Lambs and ewes were observed on Folded Mountain and in a number of other possible lambing sites. Development activities including vehicle and air traffic represent a potential disturbance to these sheep populations. It is important to recognize that exploration and development of the Cadillac Exploration property has apparently coexisted with local Dall's sheep populations to date, and recent activities at the mine have not discouraged the utilization of a lick at Adit #3.

The mineral lick at Adit #3 can be considered an important component of Dall's sheep habitat in the area. Heimer (1973) has found that lick sites are used year after year and are often a congregating area after the winter months. While this lick may be artificial and relatively new, it is possible that some conflicts may develop if more sheep begin to use this lick.

Our view is that the potential for negative impact remains and therefore the following mitigation measures are recommended to avoid direct disturbance and mortality of wildlife:

1. Avoidance by ground and aerial traffic of suspected nursery areas. Our data on sheep sightings indicates lambing areas are the alpine ridges east and west flanking Prairie Creek north of the mine site, and Folded Mountain. No caribou calving sites or grizzly bear denning sites have yet been identified within the study area.

2. Limiting aircraft activity during May and June, the critical period of lambing, calving and neonatal life. The ewes and lambs sighted within 0.3 km of the Prairie Creek airstrip on alpine ridges in June point to potential impact from aircraft disturbance. Such disturbance could lend to the abandonment of these areas by ewes, or sheep injuries occurring during avoidance behaviour.

3. Analysis of the mineral lick downslope from mine Adit #3. The possibility exists that the material taken from the mine may contain heavy metals.

Even if the mineral attraction of the site is rocksalt, such metals may be injested simultaneously by the animals. If this is the case, possible accumulation of heavy metals could have negative impact on the animals in the long term.

4. Restricting public access of the winter road by means of a guard controlled gate at the Liard Highway entrance. This will facilitate mitigation implementation since only designated operators who are instructed in wildlife policy will utilize the road.

5. Establishment of reduced speed zones and the posting of warning signs along the Winter Road in areas of ungulate utilization.

   Caribou and sheep sign on the lower slope east of the gravel crusher indicate probable ungulate crossings of the Prairie Creek section of the road. Several sightings of Dall's sheep on ridges of the Mackenzie eastern escarpment at the mouth of South Pass identify a potential problem area.

   The Grainger River Pass area and Grainger tillplain could present possible vehicle - moose/caribou collision problems. Animal sightings and heavy browse utilization of the shrubs close to the road may mean use of this section of the road as a travel corridor.

   The road section through pure aspen stands along the lower Grainger River and Liard River represents important winter habitat for moose, two of which were sighted in March within 0.3 km of the road.

   Other possible areas of moose concern are the Silent Hills and Tetcela Plateau road sections through closed deciduous forests.

6. Prohibiting the use of firearms except by the camp manager in emergency situations. Employees and other people using the road or mine site should be educated in the policies of nonharassment and nondestruction of wildlife species.

7. Proper garbage disposal to ensure that wildlife is not attracted to the mine/mill area and that natural feeding habits are not altered. The garbage site should be fenced and refuse burned daily in accordance with suitable practices for fire control.

8. Control and suppression of fires originating from mine or vehicle activity. All internal combustion engines should be equiped with properly functioning spark arrestors or mufflers. Suitable fire fighting hand tools should be available at each work site, in sufficient numbers to equip all workmen.

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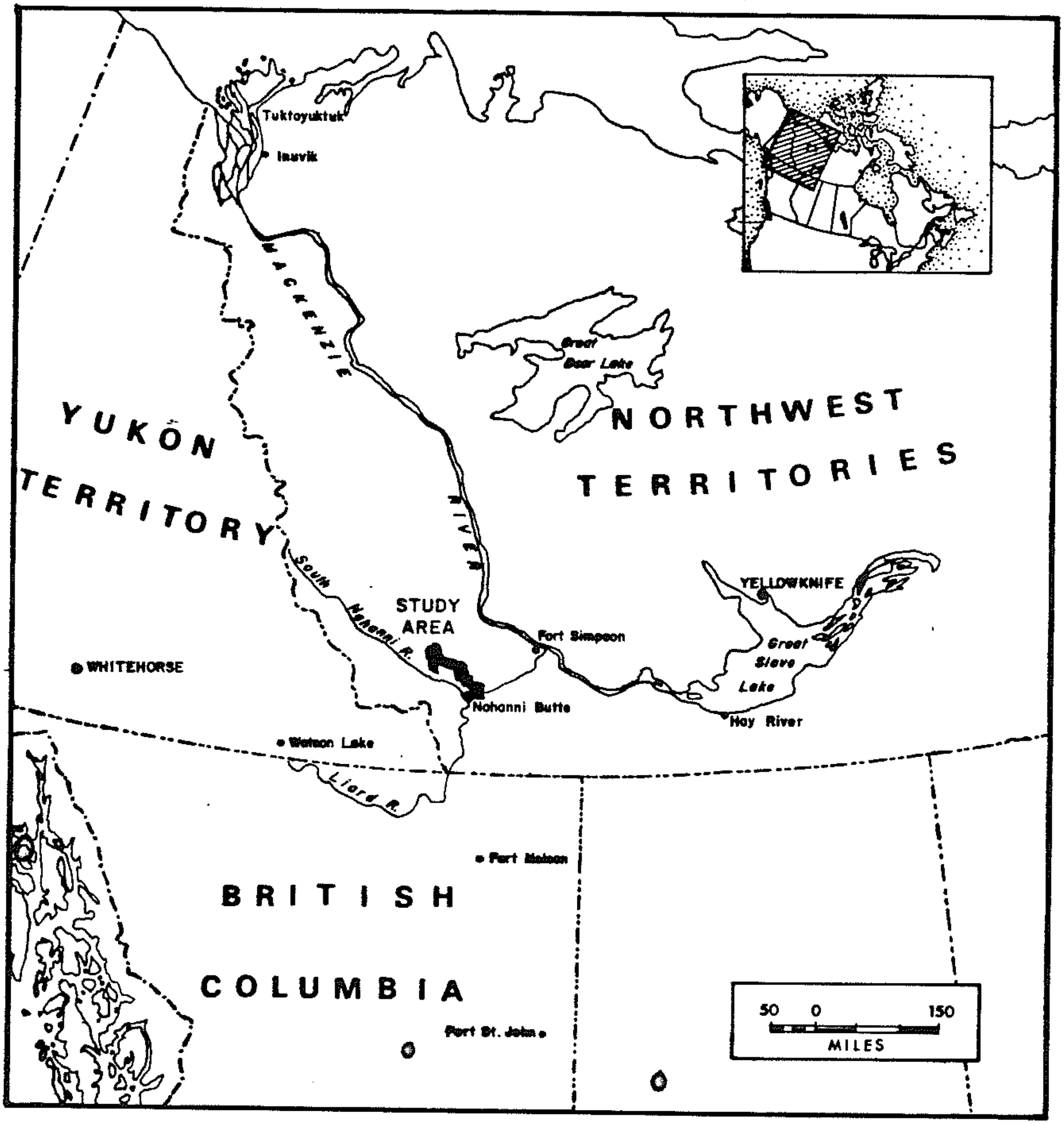

FIGURE 1: Location of Study Area.

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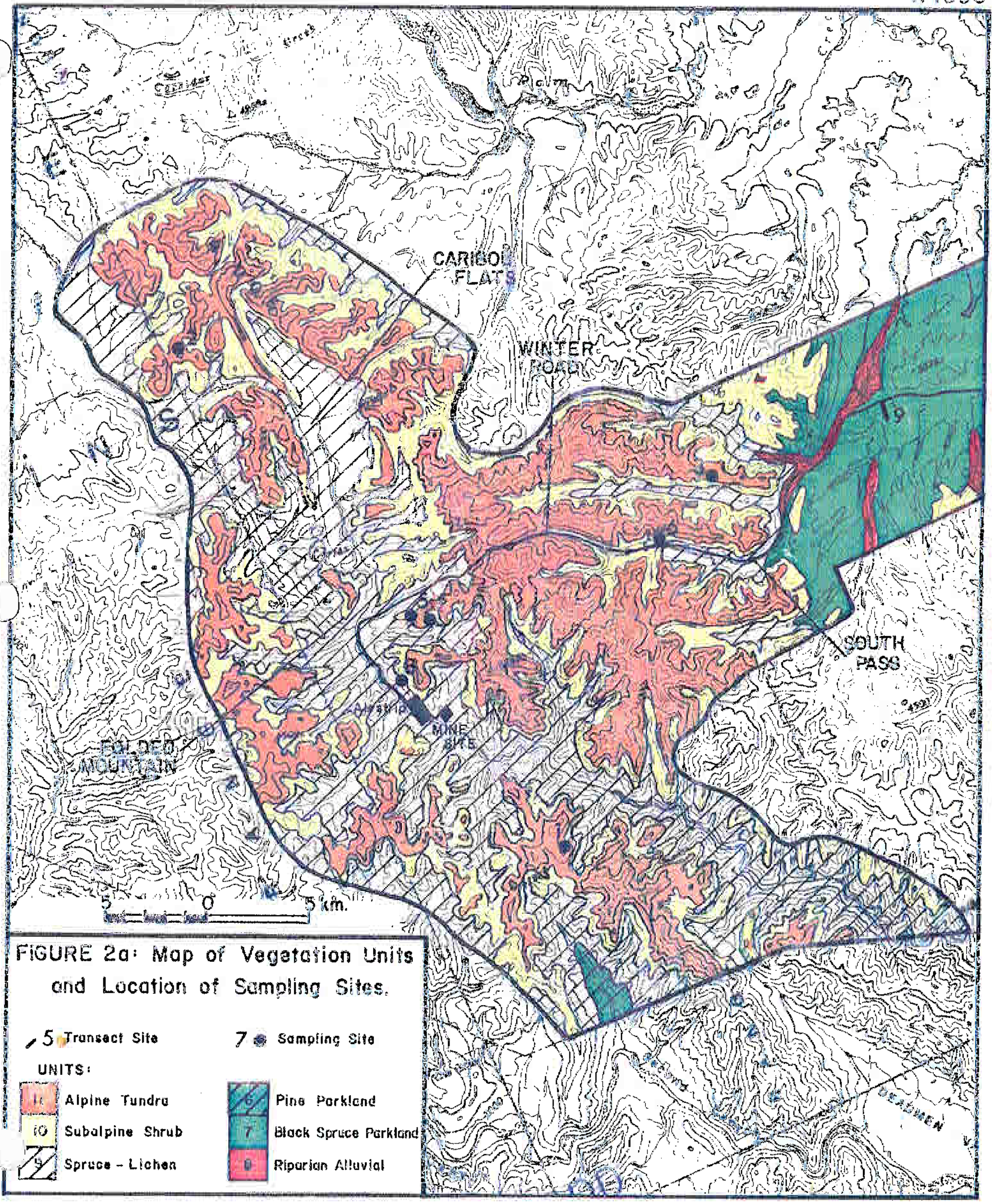


FIGURE 2a: Map of Vegetation Units and Location of Sampling Sites.

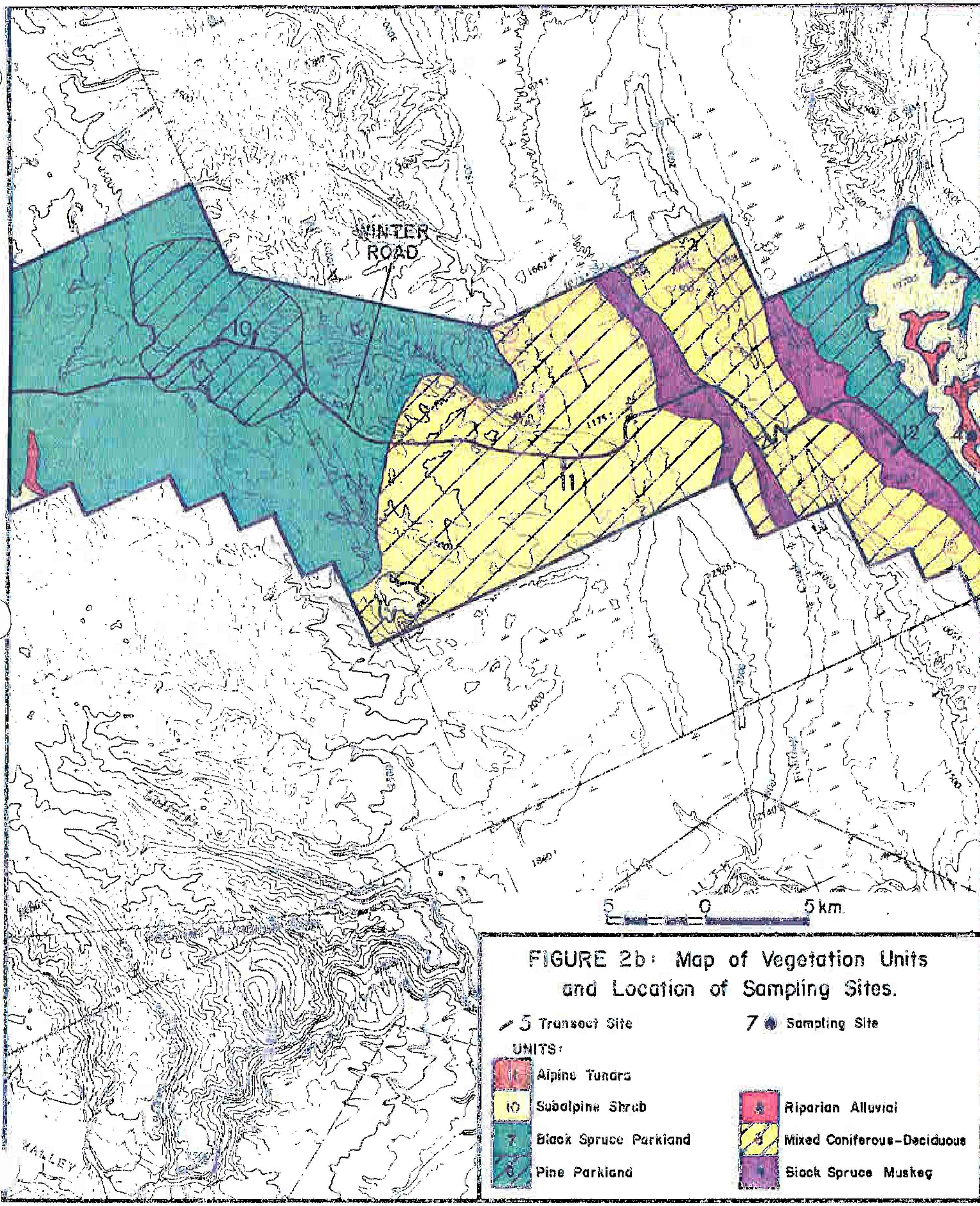


FIGURE 2b: Map of Vegetation Units and Location of Sampling Sites.

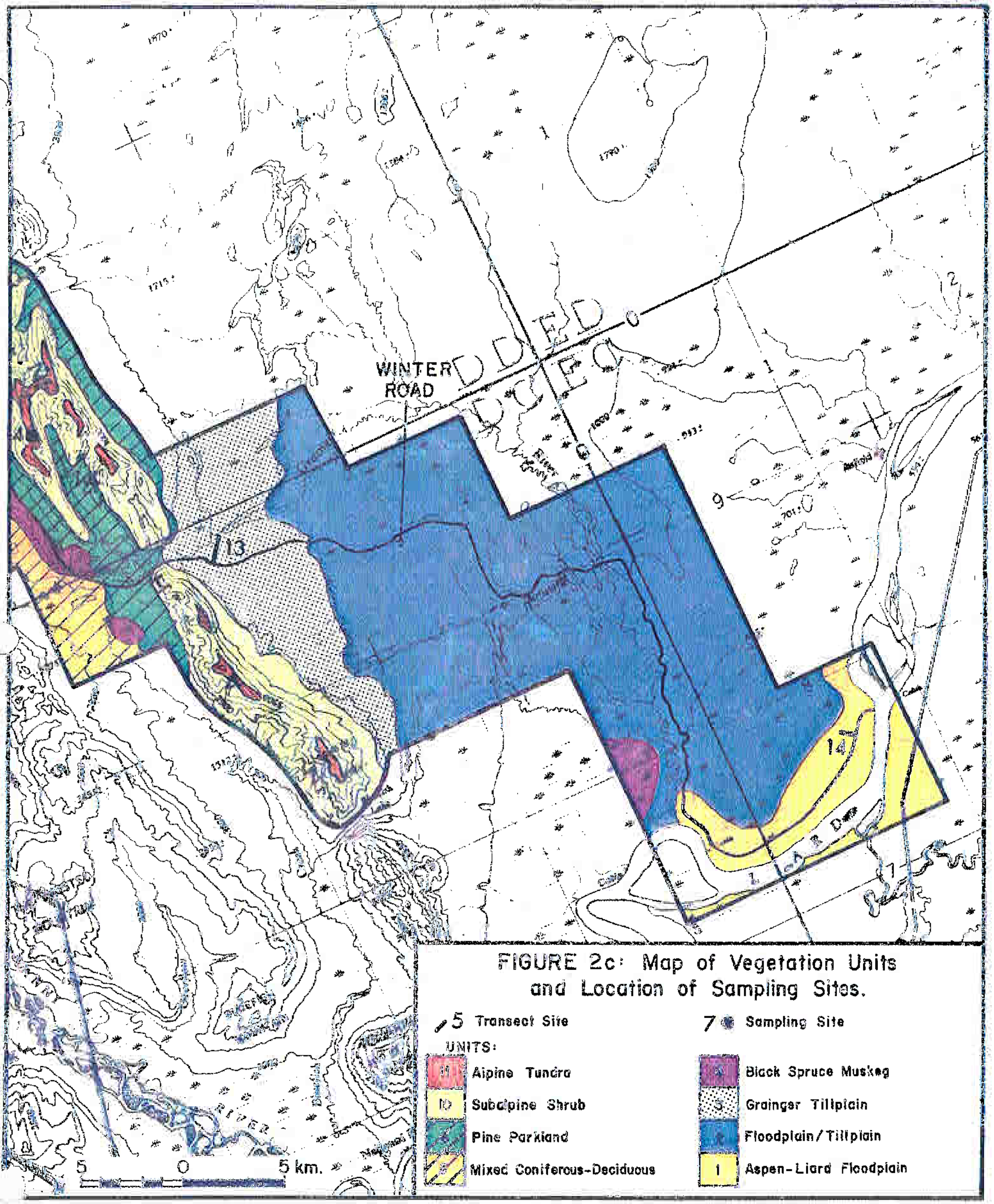
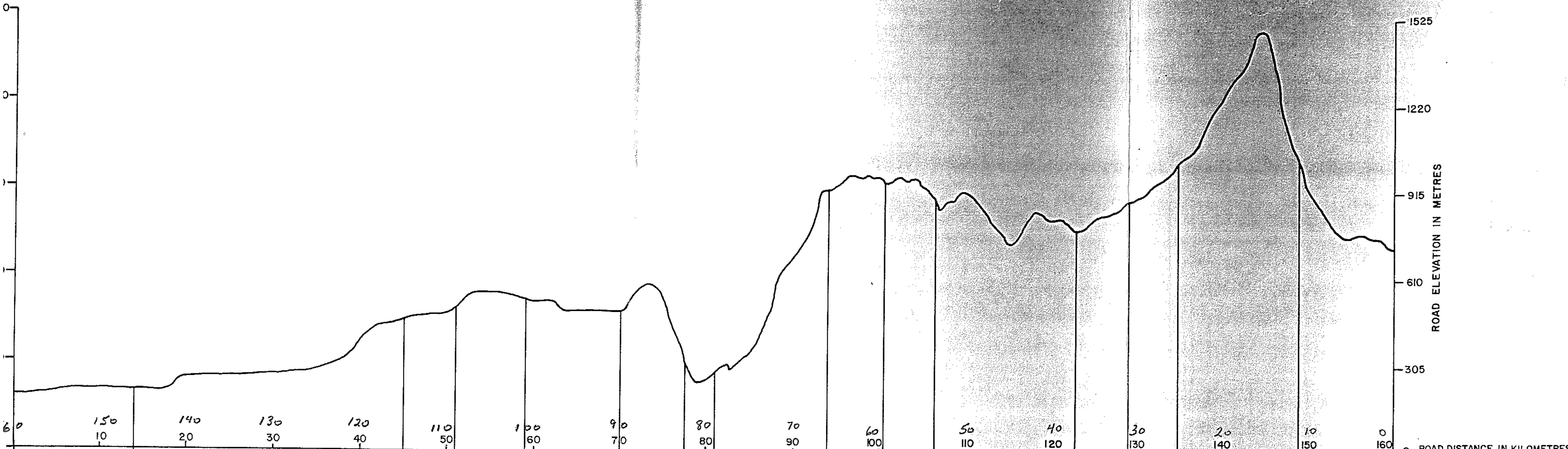


FIGURE 2c: Map of Vegetation Units and Location of Sampling Sites.

Note: Grainger Floodplain/Tillplain (Unit 2) - further mapped & broken down into 6 units as related to moose habitat & use

FIGURE 3: Profile of Winter Road.



Sites	S.S 14; Grainger River Crossing; S.S 13; Grainger Pass; S.S 12; Silent Hills; Fish-trap Ck.; Tetcela River; S.S 11; S.S 10; Sundog Tributary Crossing; CK Crossing; S.S 9; Falls S.S 6; Prairie Ck. Tributary; Mine Site
MAP UNIT	Aspen; Interior Plain Mosaic; Grainger Tillplain; Pine Parkland Mixed C/D; Black Spruce Muskeg; Mixed C/D; Muskeg; Mixed Coniferous / Deciduous; Black Spruce Parkland; Pine Parkland; Black Spruce Parkland; Riparian Alluvial; Spruce / Lichen; Subalpine Shrub; Spruce / Lichen
PHYSIOGNOMIC TYPE	Closed Forest; Closed Forest / Open Forest / Sedge Meadow / Wetlands; Closed Shrub-Open Sedge Meadow; Closed Forest-Open Shrub; Open-Closed Shrub Sedge Meadows Wetlands; Closed Forest; Open Shrub Sedge Wet-lands; Closed Forest; Open Forest; Open Forest; Open Forest; Open-Dense Shrub; Open Forest; Open - Dense Shrub; Open Forest
GEOGRAPHICAL UNIT	INTERIOR PLAINS; Nahanni Range; MACKENZIE PLAIN; MACKENZIE MOUNTAINS
GEOGRAPHICAL SUBUNIT	Liard River Floodplain; Grainger River Floodplain; –; Nahanni Range; –; Silent Hills; Tetcela Plateau; South Pass; Prairie Creek
MOOSE HABITAT	1^A; 3^J; 2^C; 2^D; 3^K; 2^F; 1^B; 2^F; 3^L; 2^G; 3^L; 2^H; 4^P; 3^N
WOODLAND CARIBOU HABITAT	N; W^A; S^B; N; W^C; S^E; W^K
DALL'S SHEEP HABITAT	4^A; 1^B; 4^A; 4^A; –; 2^D; 1^E; 3^H

PRELIMINARY CLASSIFICATION OF WILDLIFE HABITATS ALONG WINTER ROAD

UNIT (refer to text) — 2^A — CLASS — INDEFINITE BOUNDARY

MOOSE HABITAT
CLASS
1- Good winter range
2- Moderate winter range - Good summer range
3- Fair moose range
4- Nil moose range

WOODLAND CARIBOU HABITAT
CLASS
W - Winter range
C&S - Potential calving and summer range
S - Summer range
N - Nil

DALL'S SHEEP HABITAT
CLASS
1- Good winter range
2- Moderate winter range
3- Fair sheep range
4- Nil sheep range

SS = Sampling Site

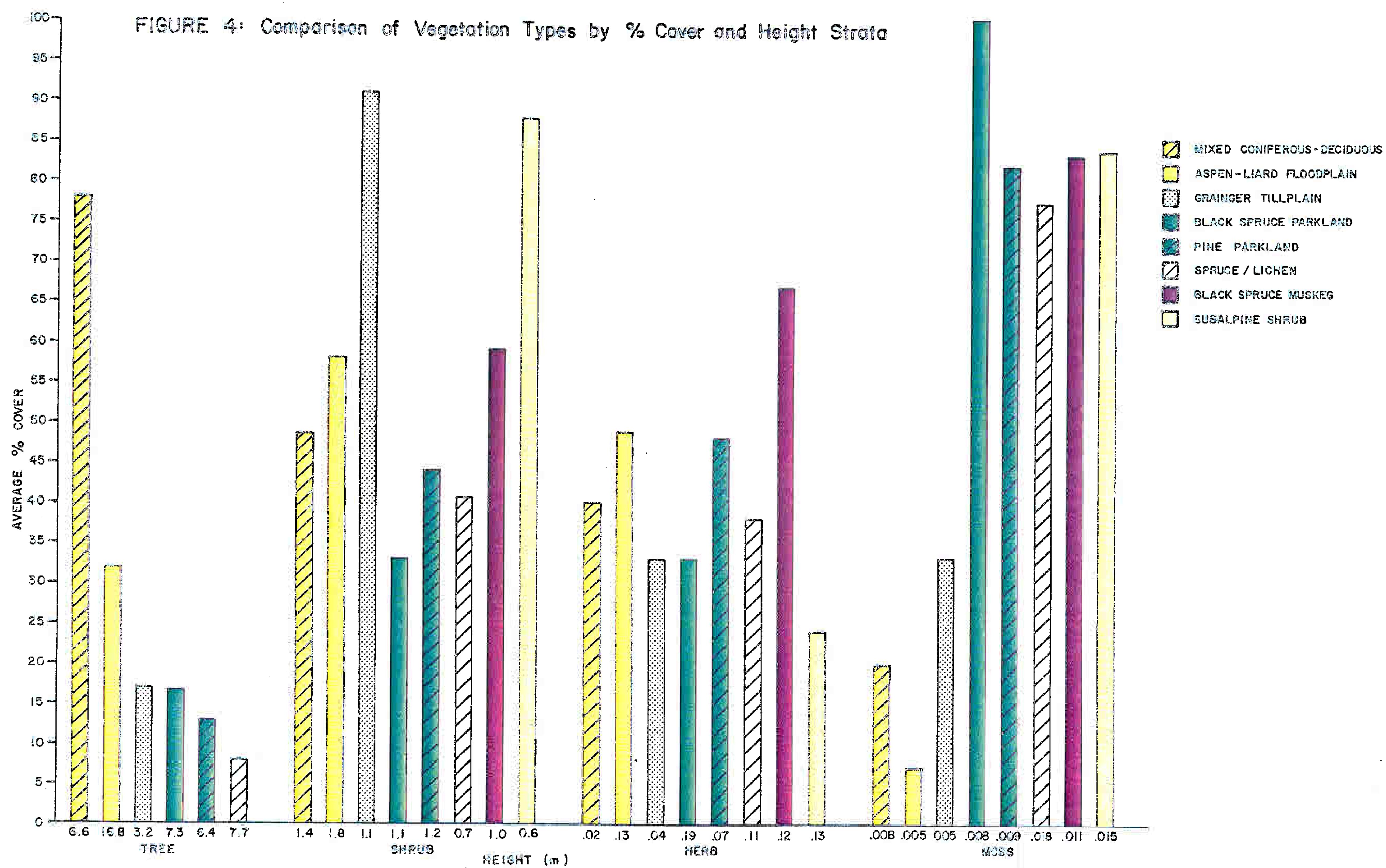
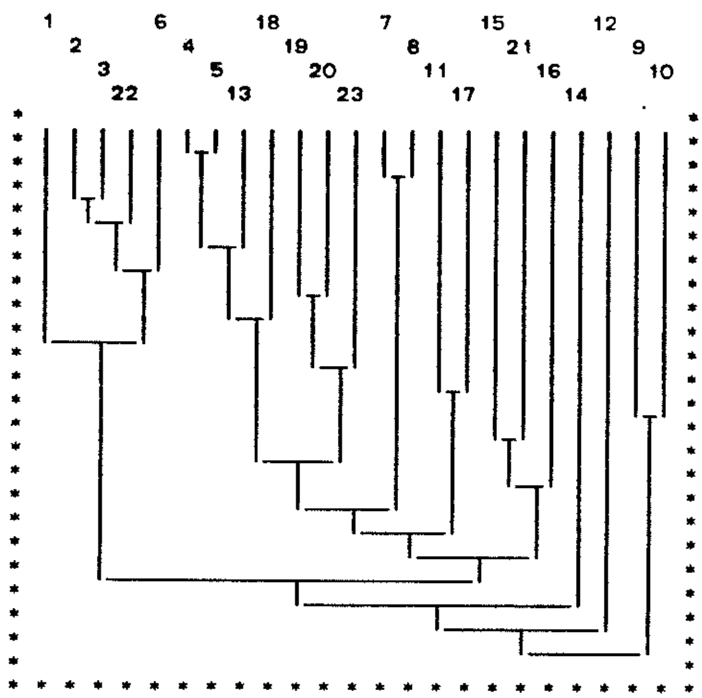


FIGURE 4: Comparison of Vegetation Types by % Cover and Height Strata
AVERAGE % COVER
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
6.6 16.8 3.2 7.3 6.4 7.7
TREE
1.4 1.8 1.1 1.1 1.2 0.7 1.0 0.6
SHRUB
.02 .13 .04 .19 .07 .11 .12 .13
HERB
.008 .005 .005 .008 .009 .018 .011 .015
MOSS
HEIGHT (m)
MIXED CONIFEROUS-DECIDUOUS
ASPEN-LIARD FLOODPLAIN
GRAINGER TILLPLAIN
BLACK SPRUCE PARKLAND
PINE PARKLAND
SPRUCE / LICHEN
BLACK SPRUCE MUSKEG
SUBALPINE SHRUB

FIGURE 5: Cluster Analysis of Alpine Vegetation Plots

STEP	I (ITEMS GROUPED)	J (ITEMS GROUPED)	ERROR
1	4	5	6.6875887
2	7	8	7.9778538
3	2	3	9.1549301
4	2	22	10.448448
5	4	13	12.989413
6	2	6	15.976105
7	19	20	17.042633
8	4	18	17.187302
9	1	2	26.479691
10	19	23	27.527191
11	11	17	28.566132
12	9	10	32.358170
13	15	21	33.026917
14	4	19	33.793900
15	15	16	37.100876
16	4	7	38.623459
17	4	11	46.136032
18	4	15	53.670151
19	1	4	58.011871
20	1	14	63.464600
21	1	12	79.051025
22	1	9	80.718018



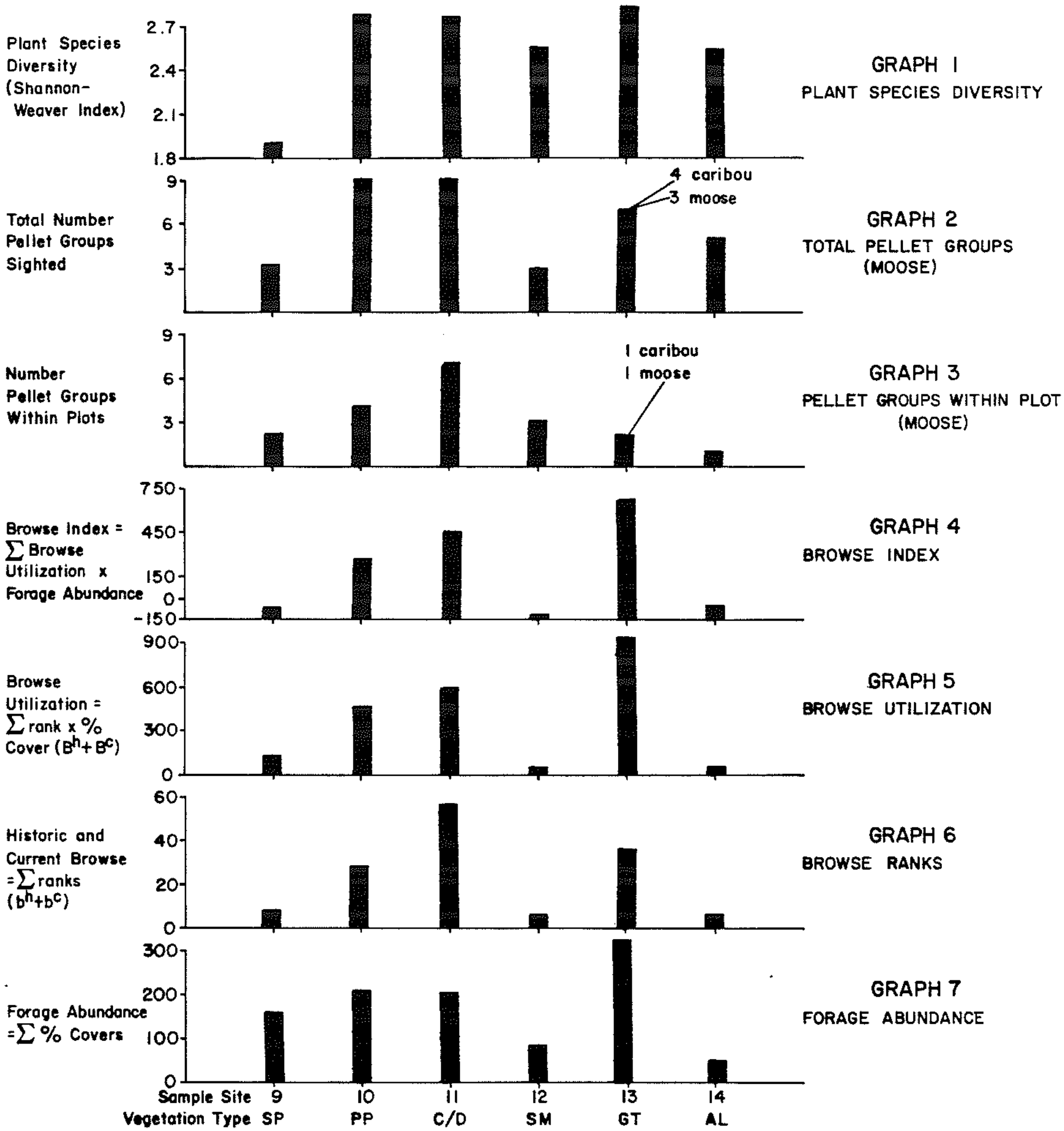


FIGURE 6: Comparitive Values for Browsing, Forage Abundance, Pellet Group Counts and Species Diversity in Lowland Vegetation Types. (Data from Table 22)

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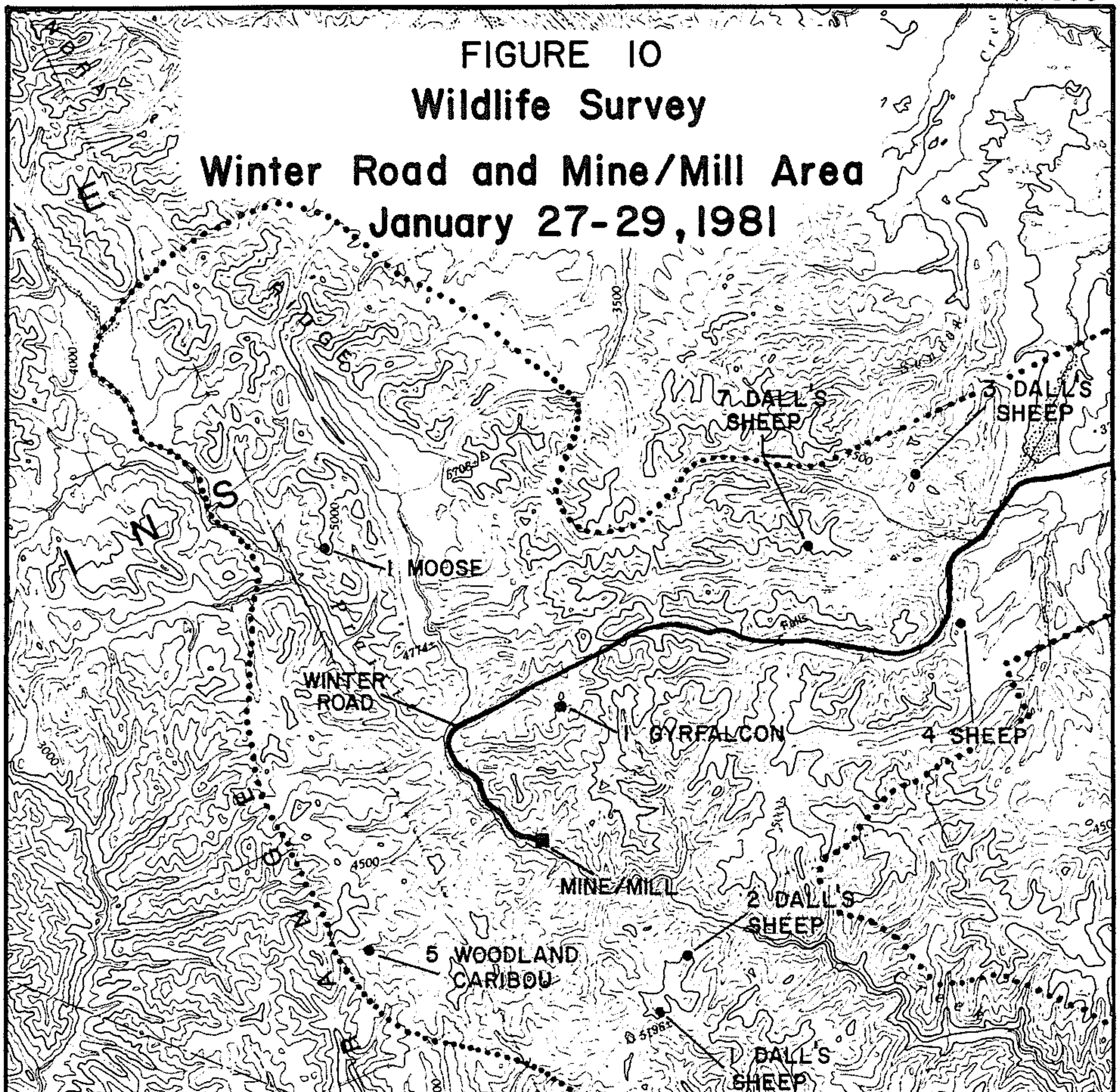
FIGURE 10
Wildlife Survey
Winter Road and Mine/Mill Area
January 27-29, 1981
7 DALL'S SHEEP
3 DALL'S SHEEP
1 MOOSE
WINTER ROAD
1 GYRFALCON
4 SHEEP
MINE/MILL
2 DALL'S SHEEP
5 WOODLAND CARIBOU
1 DALL'S SHEEP
0
5
10
15 km

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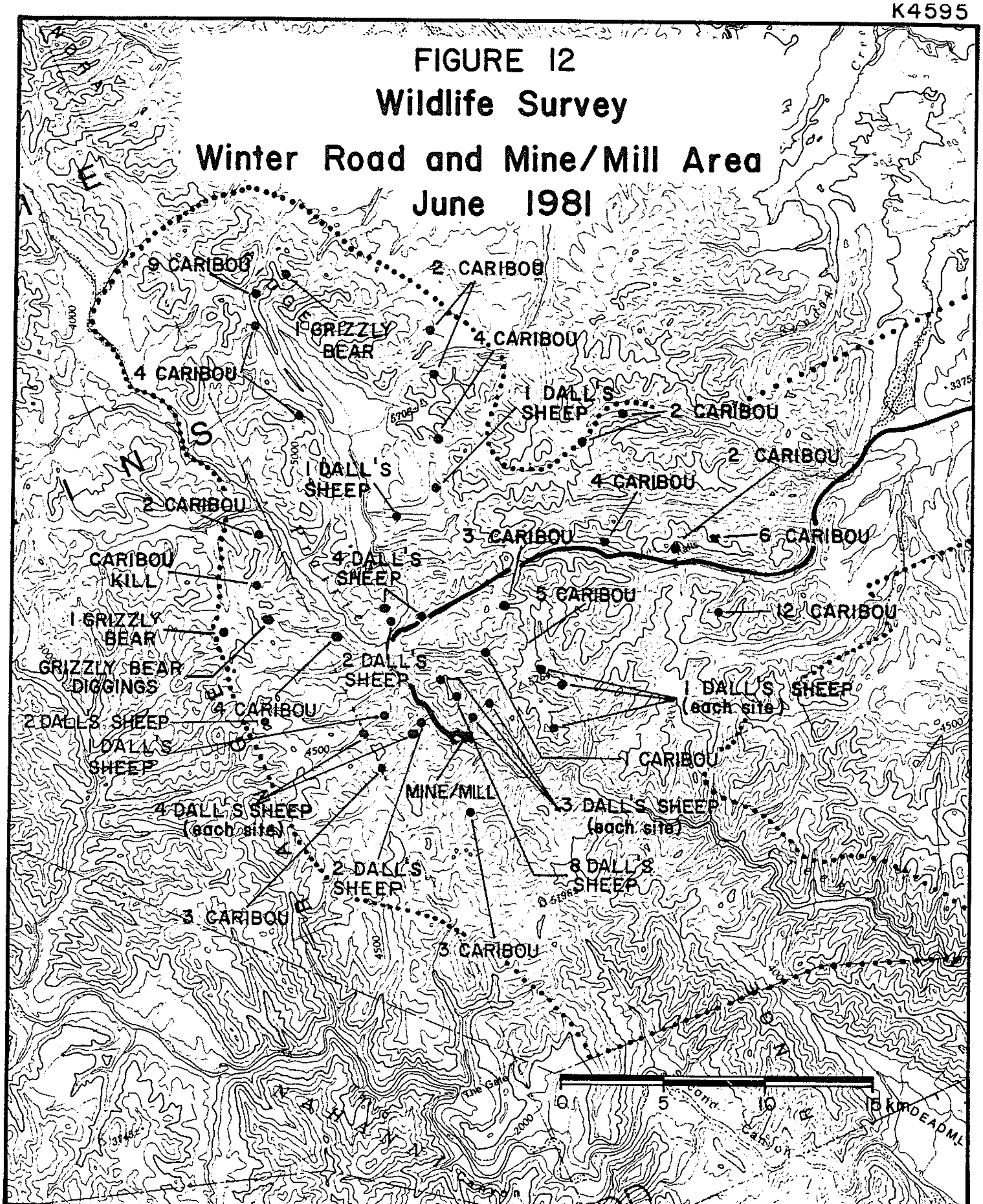
FIGURE 12
Wildlife Survey
Winter Road and Mine/Mill Area
June 1981
9 CARIBOU
2 CARIBOU
1 GRIZZLY BEAR
4 CARIBOU
4 CARIBOU
1 DALL'S SHEEP
2 CARIBOU
1 DALL'S SHEEP
2 CARIBOU
4 CARIBOU
2 CARIBOU
3 CARIBOU
6 CARIBOU
CARIBOU KILL
4 DALL'S SHEEP
5 CARIBOU
12 CARIBOU
1 GRIZZLY BEAR
GRIZZLY BEAR DIGGINGS
2 DALL'S SHEEP
1 DALL'S SHEEP (each site)
4 CARIBOU
2 DALL'S SHEEP
1 DALL'S SHEEP
1 CARIBOU
MINE/MILL
4 DALL'S SHEEP (each site)
3 DALL'S SHEEP (each site)
2 DALL'S SHEEP
8 DALL'S SHEEP
3 CARIBOU
3 CARIBOU
0
5
10
15 km
The Gate
DEADMAN

TABLE I: Sampling Intensity for Vegetation Composition at each Sample Site

Sample Site Number	Vegetation Type	Transect (T) or Random (R) Plots	$100m^2$	$16m^2$	$1m^2$	$0.1m^2$
1	Alpine Tundra	R	-	-	-	6
2	Alpine Tundra	R	-	-	-	6
3	Alpine Tundra	R	-	-	-	3
4	Alpine Tundra	R	-	-	3	8
5	Shrub	R	-	2	2	2
6	Shrub	R	-	3	6	6
7	Spruce Lichen	R	2	2	2	2
8	Spruce Lichen	R	2	2	2	2
9	Black Spruce Parkland	T	5	5	5	5
10	Pine Parkland	T	5	5	5	5
11	Mixed C/D	T	5	5	5	5
12	Spruce Muskeg	T	-	5	5	5
13	Grainger Tillplain	T	3	5	5	5
14	Aspen-Liard Floodplain	T	5	5	5	5
Total			27	39	45	65

TABLE 2: Plants Identified in the Study Area

Lifeform	Scientific Name	Common Name
Tree	*Betula papyrifera* Marsh subsp. *humilis* (Regel) Hult.	Paper Birch
	Betula papyrifera Marsh var. *commutata* (Regel) Fern.	Paper Birch
	Larix laricina (DuRoi) K. Koch	Tamarak
	Picea glauca (Moench) Voss	White Spruce
	Picea mariana (Mill.) Britt., Sterns & Pogg.	Black Spruce
	Pinus Banksiana Lamb.	Jack Pine
	Populus balsamifera L.	Balsam Poplar
	Populus tremuloides Michx.	Trembling Aspen
	Salix scouleriana Barr.	Willow
Shrub	*Alnus crispa* (Ait.) Pursh	Green Alder
	Arctostaphylos uva-ursi (L.) Spreng.	Kinnikinnick
	Arctostaphylos rubra (Rehd. & Wilson) Fern.	Red bearberry
	Betula glandulosa Michx.	Shrub birch
	Betula nana L. subsp. *exilis* (Sukatsch.) Hult.	Dwarf birch

TABLE 2 Cont'd: Plants Identified in the Study Area

Lifeform	Scientific Name	Common Name
Shrub	*Betula occidentalis* Hook.	
	Cornus stolonifera Michx.	American Dogwood
	Cassiope tetragona (L.) D. Don.	Lapland Cassiope
	Empetrum nigrum L.	Crowberry
	Juniperus communis L. subsp. *nana* (Willd.) Syme	Common Mountain Juniper
	Ledum palustra L. subsp. *groenlandicum* (Oeder) Hult.	Labrador tea
	Linnaea borealis L.	Twinflower
	Myrica gale L. var. *tormentosa* C. DC.	Sweet Gale
	Phyllodoce aleutica (Spreng.) Heller subsp. *glanduliflora* (Hook.) Cov.	Mountain heather
	Potentilla fruticosa L.	Shrubby cinquefoil
	Rhododendron lapponicum (L.) Wahlenb.	Lapland Rosebay
	Rosa acicularis Lindl.	Rose
	Rubus arcticus L. subsp. *acaulis* (Michx.) Focke	
	Rubus chamaemorus L.	Cloudberry

TABLE 2 Cont'd: Plants Identified in the Study Area

Lifeform	Scientific Name	Common Name
Shrub	*Rubus pubescens* Raf.	
	Salix alaxensis (Anderss.)	Willow
	Salix arbusculoides Anderss.	Willow
	Salix commutata Bebb.	Willow
	Salix glauca L.	willow
	Salix myrtillifolia Anderss.	Willow
	Salix nivalis Hook.	Willow
	Salix phlebophylla Anderss.	Willow
	Salix planifolia Pursh.	Willow
	Salix polaris Wahl.	Willow
	Salix reticulata L.	Willow
	Salix rotundifolia Trautv.	Willow
	Shepherdia canadensis (L.) Nutt.	Soopolallie
	Spirea Beauverdiana Schneid.	Alaska Spirea
	Vaccinium uliginosum L. subsp. *alpinum* (Bigel.) Hult.	Alpine blueberry
	Vaccinium vitis-idaea L. subsp. *minus* (Lodd.)	Lingonberry
	Vaccinium sp.	
	Viburnum edule (Michx.) Raf.	High bush cranberry

TABLE 2 Cont'd: Plants Identified in the Study Area

Lifeform	Scientific Name	Common Name
Herb	*Androsace chamaejasme* Host	Rock jasmine
	Anemone parviflora Michx.	
	Arabis Drummondii Gray	Rock cress
	Artemisia arctica Less.	Wormwood
	Aquilegia brevistyla Hook.	Blue Columbine
	Delphinium glaucum S. Wats.	Larkspur
	Draba incerta Payson	
	Dryas Drummondii Richards.	Yellow Dryas
	Dryas integrifolia M. Vahl.	Mountain avens
	Epilobium sp.	
	Equisetum spp.	Horsetail
	Geum triflorum Pursh.	Old Man's Whiskers
	Galium boreale L.	Northern bedstraw
	Geocaulon lividum (Richards.) Fern.	Bastard Toad Flax
	Hedysarum alpinum L. subsp. *americanum* (Michx.) Fedtsch.	
	Lathyrus ochroleucus Hook.	Pea Vine

TABLE 2 Cont'd: Plants Identified in the Study Area

Lifeform	Scientific Name	Common Name
Herb	*Maianthemum dilatatum* (How.) Nels. & Maebr.	False Lily-of-the-Valley
	Cornus canadensis L.	Bunchberry
	Mertensia paniculata (Ait.) G. Don	Bluebell
	Moneses uniflora (L.) Gray	Single Delight
	Pedicularis labradorica Wirsing	Yellow lousewort
	Pedicularis Langsdorffii Fisch.	
	Perstemon sp.	Beardtongue
	Petasites palmatus (Ait.) Gray	Sweet coltsfoot
	Petasites sagittatus (Banks) Gray	Sweet coltsfoot
	Pinguicula vulgaris L.	Butterwort
	Plantago major L.	
	Plantanthera obtusata (Pursh.) Lindl.	Bog orchid
	Polygonum viviparum L.	Knotweed
	Potentilla biflora Willd.	
	Pyrola asarifolia Michx. var. *purpurea* (Bunge) Fern.	Wintergreen
	Pyrola grandiflora Radius	Wintergreen

TABLE 2 Cont'd: Plants Identified in the Study Area

Lifeform	Scientific Name	Common Name
Grass/Sedge	*Carex albo-nigra* Mack.	
	Carex atherodes Spreng.	
	Carex loliacea L.	
	Carex microchaeta Holm.	
	Carex rostrata Stokes	
	Carex scirpoidea Michx.	
	Carex vaginata Tausch	
	Festuca altaica Trin.	Fescue Grass
	Poa sp.	
Club Moss/Fern	*Cystopteris fragilis* (L.) Bernh.	Fragile Fern
	Lycopodium annotinum L.	Stiff Club Moss
	Lycopodium clavatum L. subsp. *monostachyon* (Grev. & Hook.) Sel.	Club Moss
	Lycopodium complanatum L.	Creeping Jenny
Moss	*Dicranum fuscens* Turn.	
	Dicranum strictum Mohr.	
	Dicranum sp.	
	Ditrichum flexicaule (Schwaegr.) Hampe.	

TABLE 2 Cont'd: Plants Identified in the Study Area

Lifeform	Scientific Name	Common Name
Herb	*Oxytropis* sp.	Locoweed
	Oxytropis sp.	Locoweed
	Saxifraga caespitosa L.	Tufted Saxifrage
	Saxifraga oppositifolia L.	Purple Saxifrage
	Senecio lugens Richards	
	Senecio resedifolius Less.	Ragwort
	Silene acaulis L. subsp. *subacaulescens* (F.N. Williams) Hult	Moss campion
	Solidago multiradiata Ait.	Goldenrod
	Spiranthes Romanzoffiana Cham.	Ladies tresses
	Veronica alpina L. var. *unalaschcensis* C. & S.	Speedwell
	Vicia sp.	Vetch
	Zygadenus elegans Pursh.	White camus
Grass/Sedge	*Agrostis scabra* Willd.	
	Agropyron boreale (Turcz.) Drobov. subsp. *hyperarcticum* (Polunin) Melderis	Wheatgrass
	Calamagrostis canadensis (Michx.) Beauv.	Bluejoint
	Calamagrostis purpurascens R.Br.	Reed bent grass

TABLE 2 Cont'd: Plants Identified in the Study Area

Lifeform	Scientific Name	Common Name
Moss	*Hypnum cupressiforme* Hedw.	
	Hypnum sp.	
	Pleurozium schreberi (Brid.) Mitt.	Feather moss
	Polytrichum commune Hedw.	
	Ptilium crista-castrensis (Hedw.) De Not.	Knight's Plume
	Rhytiadelphus triquetrus (Hedw.) Warnst.	
	Sphagnum magellanicum Brid.	
Lichen	*Alectoria nigricans* (Ach.) Nyl.	
	Alectoria ochroleuca (Hoffm.) Mass.	
	Alectoria sp.	
	Cetraria cucullata (Bell.) Ach.	
	Cetraria islandica (L.) Ach.	
	Cetraria nivalis (L.) Ach.	
	Cetraria pinastri (Scop.) S. Gray	
	Cladonia rangiferina (L.) Harm.	

TABLE 2 Cont'd: Plants Identified in the Study Area

Lifeform	Scientific Name	Common Name
Lichen	*Caldina stellaris* (Opez) Brodo	
	Cladonia cristatella Tuck.	British Soldier
	Cladonia sp.	
	Dactylina arctica (Hook.) Nyl.	
	Parmelia sulcata Tayl.	
	Parmelia sp.	
	Peltigera apthosa (L.) Willd.	
	Pertusaria sp.	
	Stereocaulon paschale (L.) Hoffm.	
	Thamnolia subuliformis (Ehrh.) Culb.	

TABLE 3: Vegetation Map Units, Coverage Area, and Coverage Area as Percentage of Study Area

Map Unit	Area in Hectares	Coverage Area as Percentage of Study Area
Aspen - Liard Floodplain	4,512	2.2
Floodplain / Tillplain Mosaic	28,731	13.7
Grainger Tillplain	6,838	3.3
Pine Parkland	12,656	6.1
Black Spruce Muskeg	5,481	2.6
Mixed Coniferous / Deciduous	26,369	12.6
Black Spruce Parkland	28,456	13.6
Spruce / Lichen	30,819	14.7
Riparian	1,012	0.5
Subalpine Shrub	29,988	14.3
Alpine Tundra	31,494	15.1
Liard River	2,788	1.3
	209,144	100.0

TABLE 4: Species Percent Frequency, Average Percent Cover and Standard Deviation by Height Strata

Aspen - Liard Floodplain: Sample Site 14

Stratum (m)	Species	% Frequency n = 5	% Cover	Standard Deviation
Tree (16.8)	*Populus tremuloides*	100	31.2	6.1
	Picea glauca	20	0.4	0.5
	Betula papyrifera	20	0.2	0.4
			31.8	
Shrub (1.8)	*Alnus crispa*	100	26.0	21.0
	Rosa acicularis	100	18.0	8.4
	Vibernum edule	40	4.8	6.0
	Picea glauca	40	2.4	3.4
	Populus tremuloides	40	2.4	4.3
	Shepherdia canadensis	20	2.0	4.5
	Cornus stolonifera	40	1.2	1.6
	Betula papyrifera	40	0.6	0.9
	Epilobium sp.	40	0.4	0.5
	Ledum groenlandicum	20	0.2	0.4
	Vaccinium sp.	20	0.2	0.4
			58.2	
Herb (0.13)	*Cornus canadensis*	100	20.0	13.2
	Rubus pubescens	100	4.6	3.2
	Rosa acicularis	60	4.0	4.2
	Lycopodium complanatum	20	4.0	8.9
	Pyrola asarifolia	100	3.6	3.7
	Linnaea borealis	60	2.4	2.5
	Ledum groenlandicum	60	2.4	4.3
	Vibernum edule	60	1.6	2.1
	Maianthemum dilatum	60	1.4	2.1
	Epilobium sp.	60	1.4	2.2
	Vaccinium vitis-idaea	40	1.2	2.2
	Plantago major	40	0.8	1.3
	Moneses uniflora	40	0.4	0.5
	Galium boreale	40	0.4	0.5
	Lathyrus ochroleucus	40	0.4	0.5
			48.6	
Moss (0.005)	*Rhytidiadelphus triquetrus*	20	4.0	8.9
	Dicranum sp.	40	3.0	4.5
			7.0	

TABLE 5: Species Percent Frequency, Average Percent Cover and Standard Deviation by Height Strata

Grainger River Tillplain: Sample Site 13

Stratum (m)	Species	% Frequency n = 5	% Cover	Standard Deviation
Tree (3.2)	*Populus balsamifera*	40	10.4	19.6
	Picea mariana	80	5.2	4.8
	Betula papyrifera subsp. *humilis*	60	1.4	1.7
			17.0	
Shrub (1.1)	*Alnus crispa*	80	29.2	23.1
	Betula nana	80	29.0	25.8
	Salix planifolia	100	10.4	19.4
	Picea mariana	80	8.6	12.2
	Ledum groenlandicum	60	4.2	8.8
	Potentilla fruticosa	40	3.0	6.2
	Myrica gale	20	2.0	4.5
	Populus balsamifera	20	2.0	4.5
	Epilobium sp.	40	1.6	2.6
	Rosa acicularis	40	0.8	1.3
			90.8	
Herb (0.04)	*Linnaea borealis*	80	9.0	8.2
	Equisetum spp.	40	4.2	8.8
	Arctostaphylos rubra	20	4.0	8.9
	Ledum groenlandicum	20	3.0	6.7
	Pyrola asarifolia	100	2.4	2.6
	Carex rostrata	20	2.0	4.5
	Carex vaginata	20	2.0	4.5
	Cornus canadensis	60	1.8	2.2
	Rubus arcticus	60	1.6	2.1
	Calamagrostis canadensis	40	1.0	1.4
	Agropyron boreale	60	0.8	0.8
	Epilobium sp.	40	0.4	0.5
	Spironthes Romanzoffiana	20	0.4	0.9
	Petasites palmatus	20	0.2	0.4
	Perstemon sp.	20	0.2	0.4
	Zygadenus elegans	20	0.2	0.4
			33.2	

TABLE 5 Cont'd: Species Percent Frequency, Average Percent Cover and Standard Deviation by Height Strata

Grainger River Tillplain: Sample Site 13

Stratum (m)	Species	% Frequency n = 5	% Cover	Standard Deviation
Moss (0.005)	*Dicranum* sp.	20	18	4.0
	Rhytidiadelphus triquetrus	80	13	16.0
	Lycopodium annotinum	20	2.0	4.5
	Cladonia cristatella	20	0.2	0.4
			33.2	

TABLE 6: Species Percent Frequency, Average Percent Cover and Standard Deviation by Height Strata

Black Spruce Muskeg: Sample Site 12

Stratum (m)	Species	% Frequency n = 5	% Cover	Standard Deviation
Shrub (1.0)	*Picea mariana*	100	31.6	8.4
	Ledum groenlandicum	100	17.0	12.5
	Betula nana	80	4.4	6.2
	Salix myrtillifolia	40	4.2	8.8
	Alnus crispa	20	1.0	2.2
	Vaccinium uliginosum	40	0.4	0.5
	Potentilla fruticosa	20	0.4	0.9
	Rosa acicularis	20	0.2	0.4
			59.2	
Herb (0.12)	*Equisetum* sp.	100	14.8	12.3
	Ledum groenlandicum	100	12.0	8.4
	Salix myrtillifolia	100	10.2	9.2
	Arctostaphylos rubra	100	9.6	11.9
	Carex atherodes	100	4.6	5.9
	Picea mariana	80	3.8	6.3
	Vaccinium vitis-idaea	100	3.4	2.3
	Carex loliacea	60	1.4	1.7
	Rubus arcticus	80	1.2	1.1
	Potentilla fruticosa	40	1.2	2.2
	Betula nana	60	1.0	1.0
	Spiranthes Romanzoffiana	40	0.8	1.1
	Senecio lugens	60	0.6	0.5
	Rubus chamaemorus	40	0.6	0.9
	Plantago major	40	0.4	0.5
	Epilobium sp.	40	0.4	0.5
	Vaccinium uliginosum	20	0.4	0.9
	Rosa acicularis	20	0.2	0.4
	Myrica gale	20	0.2	0.4
			66.8	
Moss (0.011)	*Dicranum strictum*	100	54.0	23.0
	Pleurozium schreberi	80	14.0	12.9
	Cladonia rangiferina	80	10.4	17.0
	Cladonia cristatella	40	2.2	4.4
	Cetraria pinastri	100	1.2	0.4
	Peltigera apthosa	60	0.6	0.5
	Sphagrum magellanicum	40	0.6	0.9
	Cetraria cucullata	20	0.2	0.4
			83.2	

TABLE 7: Species Percent Frequency, Average Percent Cover and Standard Deviation by Height Strata

Mixed Coniferous / Deciduous - Fire Successional Mosaic: Sample Site 11

Stratum (m)	Species	% Frequency n = 5	% Cover	Standard Deviation
Tree (6.6)	*Alnus crispa*	80	37.0	31.9
	Picea mariana	100	16.6	17.0
	Salix scouleriana	80	15.0	10.0
	Pinus Banksiana	80	5.0	8.4
	Betula papyrifera subsp. *humilis*	40	3.8	5.2
	Populus tremuloides	20	0.8	1.8
			78.2	
Shrub (1.4)	*Alnus crispa*	100	17.4	9.2
	Picea mariana	100	9.0	5.9
	Salix scouleriana	80	9.0	12.3
	Betula nana	20	4.0	8.9
	Potentilla fruticosa	20	4.0	8.9
	Vaccinium uliginosum	40	2.2	4.3
	Ledum groenlandicum	40	1.2	2.2
	Rosa acicularis	100	1.0	0
	Pinus Banksiana	20	0.2	0.4
	Geocaulon lividum	20	0.2	0.4
	Populus balsamifera	20	0.2	0.4
			48.4	
Herb (0.02)	*Vaccinium vitis-idaea*	60	16.2	32.9
	Linnaea borealis	60	13.4	28.8
	Pyrola asarifolia	60	3.2	4.3
	Ledum groenlandicum	60	1.8	2.2
	Equisetum spp.	80	1.2	0.8
	Carex vaginata	20	1.0	2.2
	Petasites palmatus	60	0.6	0.5
	Epilobium sp.	60	0.6	0.5
	Cornus canadensis	40	0.6	0.9
	Plantago major	60	0.6	0.5
	Arctostaphylos rubra	40	0.4	0.5
	Hedysarum alpinum subsp. *americanum*	20	0.2	0.4
	Pedicularis labradorica	20	0.2	0.4
			40.0	

TABLE 7 Cont'd: Species Percent Frequency, Average Percent Cover and Standard Deviation by Height Strata

Mixed Coniferous /Deciduous - Fire Successional Mosaic: Sample Site 11

Stratum (m)	Species	% Frequency n = 5	% Cover	Standard Deviation
Moss (0.008)	*Ptilium crista-castrensis*	60	15.6	25.6
	Cladonia sp.	60	1.4	1.5
	Cladonia rangiferina	20	1.0	2.2
	Hypnum sp.	20	1.0	2.2
	Peltigera apthosa	40	0.4	0.5
	Cladonia cristella	20	0.2	0.4
			19.6	

TABLE 8: Species Percent Frequency, Average Percent Cover and Standard Deviation by Height Strata

Pine Parkland - Mackenzie Plain: Sample Site 10

Stratum (m)	Species	% Frequency n = 5	% Cover	Standard Deviation
Tree (6.4)	*Picea mariana*	100	6.8	5.6
	Pinus Banksiana	60	5.0	7.0
	Picea glauca	60	1.0	1.0
	Salix arbusculoides	20	0.4	0.9
			13.2	
Shrub (1.2)	*Betula nana*	100	20.0	12.7
	Salix scouleriana	80	14.8	14.7
	Pinus Banksiana	60	3.8	4.7
	Picea mariana	60	2.8	3.1
	Ledum groenlandicum	80	1.2	1.1
	Salix arbusculoides	40	1.2	2.2
	Betula occidentalis	40	0.4	0.5
			44.2	
Herb (0.07)	*Vaccinium vitis-idaea*	100	9.0	7.3
	Linnaea borealis	40	8.2	17.8
	Lycopodium clavatum	60	7.2	9.6
	Cornus canadensis	60	5.0	5.0
	Empetrum nigrum	60	4.0	4.2
	Vaccinium uliginosum	60	3.6	6.4
	Rubus chamaemorus	40	2.4	4.3
	Equisetum sp.	60	1.6	2.1
	Agrostis scabra	40	1.6	3.0
	Petasites sagittatus	40	1.2	1.8
	Ledum groenlandicum	60	0.8	0.8
	Betula nana	40	0.8	1.1
	Pedicularis labradorica	60	0.6	0.5
	Spirea Beauverdiana	40	0.6	0.9
	Mertensia paniculata	40	0.4	0.5
	Epilobium sp.	40	0.4	0.5
	Veronica alpina	20	0.2	0.4
	Plantanthera obtusata	20	0.2	0.4
	Rosa acicularis	20	0.2	0.4
	Rubus arcticus	20	0.2	0.4
	Pyrola asarifolia	20	0.2	0.4
			48.4	

TABLE 8 Cont'd: Species Percent Frequency, Average Percent Cover and Standard Deviation by Height Strata

Pine Parkland - Mackenzie Plain: Sample Site 10

Stratum (m)	Species	% Frequency n = 5	% Cover	Standard Deviation
Moss (0.009)	*Pleurozium schreberi*	100	49.0	30.3
	Cladonia rangiferina	80	16.4	18.8
	Polytrichum commune	60	6.0	10.7
	Dicranum fuscens	40	5.2	11.1
	Sphagnum magellanicum	20	5.0	11.2
			81.6	

TABLE 9: Species Percent Frequency, Average Percent Cover and Standard Deviation by Height Strata

Black Spruce Parkland - Mackenzie Plain: Sample Site 9

Stratum (m)	Species	% Frequency n = 5	% Cover	Standard Deviation
Tree (7.3)	*Picea mariana*	100	16.6	11.4
			16.6	
Shrub (1.1)	*Betula nana*	100	26.0	12.2
	Salix glauca	60	3.2	3.3
	Picea mariana	60	2.8	4.1
	Betula glandulosa	20	0.6	1.3
	Vaccinium uliginosum	40	0.4	0.5
	Rosa acicularis	20	0.2	0.4
			33.2	
Herb (0.19)	*Ledum groenlandicum*	100	13.2	10.1
	Arctostaphylos uva-ursi	100	11.8	8.3
	Vaccinium uliginosum	60	2.2	2.6
	Betula nana	40	2.2	4.4
	Calamagrostis canadensis	60	1.4	1.3
	Cornus canadensis	80	1.2	1.1
	Equisetum sp.	20	0.6	1.3
	Petasites palmatus	20	0.2	0.4
	Rubus chamaemorus	20	0.2	0.4
			33.0	
Moss (0.008)	*Pleurozium schreberi*	100	83.4	17.3
	Cladina stellaris	100	8.8	17.4
	Cladonia sp.	100	4.0	6.1
	Peltigera apthosa	100	3.8	3.8
			100.0	

TABLE 10: Species Percent Frequency, Average Percent Cover and Standard Deviation by Height Strata

Spruce / Lichen - Mackenzie Plain: Sample Sites 7 and 8

Stratum (m)	Species	% Frequency n = 5	% Cover	Standard Deviation
Tree (7.7)	*Picea mariana*	50	4.0	5.2
	Larix laricina	50	1.0	1.4
	Picea glauca	50	3.3	4.3
			8.3	
Shrub (0.7)	*Betula nana*	100	9.8	4.8
	Potentilla fruticosa	75	6.5	4.7
	Vaccinium uliginosum	50	6.5	12.3
	Salix glauca	100	5.3	7.8
	Rhododendron lapponicum	50	4.5	7.1
	Juniperus communis	100	3.5	4.4
	Shepherdia canadensis	50	1.5	1.9
	Picea mariana	50	1.3	1.5
	Ledum groenlandicum	25	1.3	2.5
			40.2	
Herb (0.11)	*Arctostaphylos uva-ursi*	100	6.5	3.9
	Arctostaphylos rubra	75	5.5	9.7
	Carex scirpoidea	75	5.3	5.5
	Agropyron boreale	25	5.0	10.0
	Festuca altaica	50	3.0	4.8
	Dryas integrifolia	75	2.3	2.2
	Hedysarum alpinum	100	1.5	1.0
	Potentilla fruticosa	50	1.5	1.7
	Betula nana	25	1.5	3.0
	Vaccinium uliginosum	25	1.3	2.5
	Pedicularis labradorica	50	0.5	0.6
	Zygadenus elegans	75	0.5	0.5
	Picea mariana	25	0.5	1.0
	Epilobium sp.	25	0.5	1.0
	Solidago multiradiata	25	0.3	0.5
	Artemesia arctica	25	0.3	0.5
	Galium boreale	25	0.3	0.5
	Pyrola asarifolia	25	0.3	0.5
	Polygonum viviparum	25	0.3	0.5
	Ledum groenlandicum	25	0.3	0.5
			37.2	

TABLE 10 Cont'd: Species Percent Frequency, Average Percent Cover and Standard Deviation by Height Strata

Spruce / Lichen Parkland - Mackenzie Plain: Sample Sites 7 and 8

Stratum (m)	Species	% Frequency n = 5	% Cover	Standard Deviation
Moss (0.018)	*Cladina stellaris*	100	45.2	42.5
	Dryas integrifolia	50	16.7	29.0
	Dicranum fuscens	75	5.5	7.1
	Cetraria sp.	50	4.0	7.3
	Peltigera apthosa	25	2.5	5.0
	Androsace chamaejasme	50	1.5	2.4
	Cladonia sp.	25	1.3	2.5
	Silene acaulis	25	0.3	0.5
			77.0	

TABLE 11: Species Percent Frequency, Average Percent Cover and Standard Deviation by Height Strata

Subalpine Shrub - Mackenzie Mountains: Sample Sites 5 and 6

Stratum (m)	Species	% Frequency n = 5	% Cover	Standard Deviation
Shrub (0.59)	*Betula nana*	100	53.4	30.1
	Ledum groenlandicum	40	20.0	27.4
	Salix glauca	80	9.2	10.1
	Picea mariana	40	1.6	3.0
	Potentilla fruticosa	60	1.4	1.7
	Vaccinium uliginosum	40	1.2	2.2
	Rhododendron lapponicum	20	0.8	1.8
			87.6	
Herb (0.13)	*Arctostaphylos uva-ursi*	100	7.0	5.4
	Dryas integrifolia	60	4.4	8.7
	Salix polaris	20	3.0	6.7
	Artemesia arctica	20	2.0	2.4
	Pyrola asarifolia	20	2.0	4.5
	Carex vaginata	20	2.0	4.5
	Festuca altaica	40	1.6	2.2
	Calamagrostis purpurascens	40	1.2	1.8
	Hedysorum alpinum	60	0.8	0.8
	Phyllodoce aleutica	40	0.6	0.9
	Arctostaphylos rubra	40	0.6	0.9
	Equisetum sp.	20	0.2	0.4
			24.0	
Moss (0.015)	*Cladina stellaris*	100	28.2	30.3
	Rhytiadelphus triquetrus	40	26.0	37.1
	Cladonia sp.	20	10.0	22.4
	Dicranum fuscens	40	8.0	11.0
	Peltigera apthosa	40	4.2	8.8
	Cetraria nivalis	40	3.0	4.5
	Alectoria ochroleuca	20	2.0	4.5
	Polytrichum commune	20	1.0	2.2
	Cetraria islandica	20	0.4	0.9
	Pertusaria sp.	20	0.4	0.9
	Dactylina arctica	20	0.2	0.4
			83.4	

TABLE 12: Species Percent Frequency, Average Percent Cover and Standard Deviation by Height Strata

Alpine Tundra: Sample Sites 1-4

Stratum (m)	Species	% Frequency n = 23	% Cover	Standard Deviation
Moss	*Cetraria nivalis*	91	14.3	13.5
	Dryas integrifolia	78	12.1	11.8
	Cassiope tetragona	43	11.2	17.9
	Salix nivalis	61	9.5	10.7
	Cetraria islandica	83	7.1	6.1
	Carex albo-nigra	87	6.4	6.0
	Alectoria ochroleuca	87	6.0	8.4
	Vaccinium uliginosum	26	3.5	8.2
	Dicranum fuscens	57	3.3	5.8
	Pertusaria sp.	39	2.6	5.7
	Polygonum viviparum	26	2.4	4.9
	Thamnolia subuliformis	83	1.7	1.6
	Salix phlebophylla	57	1.7	2.5
	Silene acaulis	22	1.7	3.9
	Dactylina arctica	48	1.7	4.2
	Ditrichum flexicaule	26	1.3	3.3
	Geum triflorum	17	1.1	2.9
	Rhododendron lapponicum	13	1.1	3.0
	Oxytropis sp.	30	0.8	1.5
	Hedysarum alpinum	9	0.8	3.2
	Senecio resedifolius	13	0.3	0.8
	Cladonia sp.	13	0.2	0.6
	Potentilla fruticosa	9	0.2	0.6
	Ledum decumbens	4	0.2	1.0
	Anemone parviflora	9	0.1	0.5
	Equisetum sp.	4	0.1	0.2
	Polytrichum commune	4	0.1	0.2
	Pyrola grandiflora	4	0.1	0.4
			91.6	

TABLE 13: Climatic Summaries

Station		J	F	M	A	M	J	J	A	S	O	N	D	Year
Cadillac*	T	-14	-3	8	25	40	51	55	52	41	24	2	-5	23
	R	0	0	0	0.1	1.0	2.3	3.4	2.8	1.9	0.3	0	0	11.8
	P	0.9	0.9	0.8	1.0	1.6	2.3	3.4	2.8	2.3	1.9	1.2	0.9	20.0
Fort Simpson	T	-21	-10	5	29	47	58	62	58	45	28	3	-12	24
	R	0	0	0	0.1	0.9	1.6	1.8	2.1	1.0	0.3	0	0	6.8
	P	0.8	0.7	0.7	0.6	1.2	1.6	1.8	2.1	1.2	1.1	1.0	0.8	13.6

(Month columns J–D are grouped under the printed heading "Month".)

T - Mean daily temperature (°F)
R - Monthly rainfall, inches
P - Monthly total precipitation, inches
* - Estimated or derived

SOURCE: Ker, Priestman and Associates (1980c).

TABLE 14: Browse Utilization Results

Sample Location: Site 14
Vegetative Community Type: Aspen - Liard Floodplain

Species	P1			P2			P3			P4			P5			Mean		
	HB	CB	%	HB	CB	%	HB	CB	%	HB	CB	%	HB	CB	%	HB	CB	%
Betula papyrifera	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pinus Banksiana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Populus balsamifera	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Populus tremuloides	-	-	2	-	-	10	-	-	-	2	-	1	-	-	-	.4	-	2.6
Salix scouleriana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alnus crispa	-	-	21	-	-	10	-	-	55	-	-	5	-	-	40	-	-	26.2
Betula nana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rosa acicularis	-	-	10	-	-	30	-	-	20	-	-	15	-	-	25	-	-	20
Salix arbusculoides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salix glauca	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salix myrtillifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salix planifolis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Shepherdia canadensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vaccinium uliginosum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Viburnum edule	-	-	16	-	-	-	-	-	5	3	-	3	-	-	5	.6	-	5.8
Hedysarum alpinum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex albo-nigra	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

HB = Historic Browse*
CB = Current Browse*
% = Browse Availability (% cover of species < 2.0 m in height)

* Browse Utilization: 1 = trace (1-5%); 2 = light (6-25%); 3 = moderate (26-50%); and 4 = heavy (>50%).

TABLE 15: Browse Utilization Results

Sample Location: Site 13
Vegetative Community Type: Grainger Tillplain

Species	P1 HB	P1 CB	P1 %	P2 HB	P2 CB	P2 %	P3 HB	P3 CB	P3 %	P4 HB	P4 CB	P4 %	P5 HB	P5 CB	P5 %	Mean HB	Mean CB	Mean %
Betula papyrifera	-	-	-	-	-	3	-	-	2	1	-	1	-	-	-	.2	-	1.2
Pinus Banksiana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Populus balsamifera	-	-	-	4	1	10	-	-	-	1	-	1	-	-	-	1	.2	2.2
Populus tremuloides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salix scouleriana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alnus crispa	3	2	60	1	1	25	-	-	-	-	-	43	-	-	20	.8	.6	29.6
Betula nana	3	2	60	2	1	5	1	-	45	-	-	-	-	-	35	1.2	.6	29
Rosa acicularis	-	-	5	-	-	3	-	-	-	-	-	3	-	-	-	-	-	2.2
Salix arbusculoides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salix glauca	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salix myrtillifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salix planifolis	4	3	5	2	1	45	1	-	1	2	-	1	1	-	1	2	.8	10.6
Shepherdia canadensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vaccinium uliginosum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Viburnum edule	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hedysarum alpinum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex albo-nigra	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

HB = Historic Browse*
CB = Current Browse*
% = Browse Availability (% cover of species < 2.0 m in height)

* Browse Utilization: 1 = trace (1-5%); 2 = light (6-25%); 3 = moderate (26-50%); and 4 = heavy (>50%).

TABLE 16: Browse Utilization Results

Sample Location: Site 12
Vegetative Community Type: Spruce Muskeg

	P1			P2			P3			P4			P5			Mean		
Species	HB	CB	%	HB	CB	%	HB	CB	%	HB	CB	%	HB	CB	%	HB	CB	%
Betula papyrifera	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pinus Banksiana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Populus balsamifera	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Populus tremuloides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salix scouleriana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alnus crispa	-	-	-	-	-	-	-	-	-	-	-	1	-	-	5	-	-	1.2
Betula nana	-	-	17	-	-	3	-	-	-	-	-	-	3	-	6	1.4	-	5.8
Rosa acicularis	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.2
Salix arbusculoides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salix glauca	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salix myrtillifolia	-	1	6	-	-	22	-	-	13	-	-	25	-	-	6	-	.2	14.4
Salix planifolis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Shepherdia canadensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vaccinium uliginosum	-	-	1	-	-	-	-	-	-	-	-	-	-	-	2	-	-	.6
Viburnum edule	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hedysarum alpinum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex albo-nigra	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

HB = Historic Browse*
CB = Current Browse*
% = Browse Availability (% cover of species < 2.0 m in height)

* Browse Utilization: 1 = trace (1-5%); 2 = light (6-25%); 3 = moderate (26-50%); and 4 = heavy (>50%).

TABLE 17: Browse Utilization Results

Sample Location: Site 11
Vegetative Community Type: Mixed Coniferous / Deciduous

	P1			P2			P3			P4			P5			Mean		
Species	HB	CB	%	HB	CB	%	HB	CB	%	HB	CB	%	HB	CB	%	HB	CB	%
Betula papyrifera	3	3	<1	-	-	-	-	-	-	-	-	-	-	-	-	.6	.6	1
Pinus Banksiana	-	-	-	-	-	-	-	-	-	1	-	<1	-	-	1	.2	-	1
Populus balsamifera	-	-	-	-	-	-	-	-	-	-	-	-	1	1	<1	.2	.2	1
Populus tremuloides	-	-	-	-	-	-	-	-	-	-	-	-	2	1	4	.4	.2	1
Salix scouleriana	-	-	-	4	4	3	2	2	2	1	2	10	3	2	30	2.0	2.0	9.0
Alnus crispa	3	3	20	1	1	21	2	2	10	-	1	30	2	2	7	1.6	1.8	17.6
Betula nana	-	-	-	-	-	-	-	-	-	-	-	-	2	2	20	.4	.4	4.0
Rosa acicularis	-	-	3	1	2	2	-	-	-	1	1	<1	-	-	2	.4	.6	1.6
Salix arbusculoides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salix glauca	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salix myrtillifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salix planifolis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Shepherdia canadensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vaccinium uliginosum	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-	2.0
Viburnum edule	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hedysarum alpinum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex albo-nigra	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

HB = Historic Browse*
CB = Current Browse*
% = Browse Availability (% cover of species < 2.0 m in height)

* Browse Utilization: 1 = trace (1-5%); 2 = light (6-25%); 3 = moderate (26-50%); and 4 = heavy (>50%).

TABLE 18: Browse Utilization Results

Sample Location: Site 10
Vegetative Community Type: Pine Parkland

	P1			P2			P3			P4			P5			Mean		
Species	HB	CB	%	HB	CB	%	HB	CB	%	HB	CB	%	HB	CB	%	HB	CB	%
Betula papyrifera	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pinus Banksiana	-	-	7	-	-	11	4	-	2	-	-	-	-	-	-	.8	-	4.0
Populus balsamifera	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Populus tremuloides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salix scouleriana	4	1	21	-	-	-	4	-	7	-	-	-	3	2	35	2.2	.6	12.6
Alnus crispa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Betula nana	1	-	37	-	-	20	1	-	5	-	-	12	2	1	30	.8	.2	20.8
Rosa acicularis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salix arbusculoides	2	-	2	2	-	5	-	-	-	-	-	-	-	-	-	.8	-	1.4
Salix glauca	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salix myrtillifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salix planifolis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Shepherdia canadensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vaccinium uliginosum	-	-	15	-	-	2	-	-	1	-	-	-	-	-	-	-	-	3.6
Viburnum edule	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hedysarum alpinum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex albo-nigra	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

HB = Historic Browse*
CB = Current Browse*
% = Browse Availability (% cover of species < 2.0 m in height)

* Browse Utilization: 1 = trace (1-5%); 2 = light (6-25%); 3 = moderate (26-50%); and 4 = heavy (>50%).

TABLE 19: Browse Utilization Results

Sample Location: Site 9
Vegetative Community Type: Spruce Parkland

Species	P1			P2			P3			P4			P5			Mean		
	HB	CB	%	HB	CB	%	HB	CB	%	HB	CB	%	HB	CB	%	HB	CB	%
Betula papyrifera	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pinus Banksiana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Populus balsamifera	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Populus tremuloides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salix scouleriana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alnus crispa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Betula nana	-	-	25	1	-	52	1	-	30	1	-	25	-	-	9	.6	-	28.2
Rosa acicularis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salix arbusculoides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salix glauca	-	-	6	1	1	7	1	1	3	-	-	-	-	-	-	.4	.4	3.2
Salix myrtillifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salix planifolis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Shepherdia canadensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vaccinium uliginosum	-	-	-	-	-	5	-	-	-	-	-	5	-	-	1	-	-	2.2
Viburnum edule	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hedysarum alpinum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex albo-nigra	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

HB = Historic Browse*
CB = Current Browse*
% = Browse Availability (% cover of species < 2.0 m in height)

* Browse Utilization: 1 = trace (1-5%); 2 = light (6-25%); 3 = moderate (26-50%); and 4 = heavy (>50%).

TABLE 20: Mean Browse Utilization and Percentage Cover of Available Browse for Lowland Communities

	Sample Site																	
	9			10			11			12			13			14		
Species	HB	CB	%	HB	CB	%	HB	CB	%	HB	CB	%	HB	CB	%	HB	CB	%
Betula papyrifera	-	-	-	-	-	-	.6	.6	1	-	-	-	.2	-	1	-	-	-
Pinus Banksiana	-	-	-	.8	-	4	.2	-	1	-	-	-	-	-	-	-	-	-
Populus balsamifera	-	-	-	-	-	-	.2	.2	1	-	-	-	1	.2	2	-	-	-
Populus tremuloides	-	-	-	-	-	-	.4	.2	1	-	-	-	-	-	-	.4	-	3
Salix scouleriana	-	-	-	2.2	.6	13	2	2	9	-	-	-	-	-	-	-	-	-
Alnus crispa	-	-	-	-	-	-	1.6	1.8	18	-	-	1	.8	.6	30	-	-	26
Betula nana	.6	-	28	.8	.2	21	.4	.4	4	1.4	-	6	1.2	.6	29	-	-	-
Rosa acicularis	-	-	-	-	-	-	.4	.6	2	-	-	1	-	-	2	-	-	20
Salix arbusculoides	-	-	-	.8	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Salix glauca	.4	.4	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salix myrtillifolia	-	-	-	-	-	-	-	-	-	-	.2	14	-	-	-	-	-	-
Salix planifolis	-	-	-	-	-	-	-	-	-	-	-	-	2	.8	11	-	-	-
Shepherdia canadensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vaccinium uliginosum	-	-	2	-	-	4	-	-	2	-	-	1	-	-	-	-	-	-
Viburnum edule	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.6	-	6
Hedysarum alpinum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex albo-nigra	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SUM TOTALS	1	.4	33	4.6	.8	43	5.8	5.8	39	1.4	.2	23	4.2	2.2	75	1	-	54

HB = Historic Browse*
CB = Current Browse*
% = Browse Availability (% cover of species < 2.0 m in height)

* Browse Utilization: 1 = trace (1-5%); 2 = light (6-25%); 3 = moderate (26-50%); and 4 = heavy (>50%).

TABLE 21: Summary of Forage Abundance, Browse Values, Pellet Group Counts, Distance from Road and Plant Species Diversity Index for Lowland Transects

Vegetation Type and Unit	Site - Plot	Browse Forage Abundance Σ % Cover	Σ Historic Browse Ranks b^h	Historic Browse Utiliz. Σ Rank x % Cover B^h	Σ Current Browse Rank b^c	Current Browse Utiliz. Σ Rank x % Cover B^c	Σ Historic and Current Browse Ranks $b^h + b^c$	Total Browse Utiliz. $B^H + B^C$	Browse Index BI	Distance from Road D(m)	Pellet Groups Within Plots	Total Pellet Group Censused Along Transect	Pellet Group Species	Shannon-Weaver Diversity Index for Plant Species
Spruce	9-1	31	0	0	0	0			-62	30				
Parkland	9-2	59	2	59	1	7			14	160	2			
	9-3	33	2	33	1	3			6	170				
	9-4	25	1	25	0	0			0	250				
	9-5	9	0	0	0	0			-18	900				
7	9-Sum	157	5	117	2	10	7	127	-60		2	3	M	
	9-Mean	31	1	23	0.4	2	1.4		-12					-1.9149
Pine	10-1	71	7	125	1	21			64	10	2			
Parkland	10-2	37	2	10	0	0			-59	300	2			
	10-3	14	9	41	0	0			27	360				
	10-4	14	1	2	0	0			-24	600				
	10-5	67	5	165	3	100			261	630				
6	10-Sum	203	24	343	4	121	28	464	269		4	9	M	
	10-Mean	41	4.8	69	0.8	24	5.6		54					-2.7658
Mixed	11-1	38	6	63	6	63			90	90	2			
Coniferous	11-2	28	6	35	7	37			68	140	1			
/Deciduous	11-3	20	4	24	4	24			32	200	3			
	11-4	45	3	11	4	51			22	360	1			
	11-5	78	10	153	8	119			238	540	0			
5	11-Sum	209	29	286	29	294	58	580	450		7	9	M	
	11-Mean	42	5.8	57	5.8	59	11.6		90					-2.7540
Spruce	12-1	23	0	6	1	6			-34	100				
Muskeg	12-2	5	0	0	0	0			-10	170				
	12-3	11	4	4	0	0			-18	300	2			
	12-4	25	0	0	0	0			-50	340	1			
	12-5	19	0	0	0	0			-38	600				
4	12-Sum	83	4	10	1	6	5	16	-150		3	3	M	
	12-Mean	17	0.8	2	0.2	1	1.0		-30					-2.5885
Grainger	13-1	125	10	380	7	255	17		635	40				
Tillplain	13-2	95	9	165	4	85	13		250	400	1M			
	13-3	45	2	46	0	0	2		1	630				
	13-4	43	3	3	0	0	3		-83	950	1C			
	13-5	55	1	1	0	0	1		-109	1260				
3	13-Sum	363	25	595	11	340	36	935	694		2	7	4C 3M	
	13-Mean	73	5	119	2.2	68	7.2		139					-2.8009
Aspen -	14-1	18	0	0	0	0			-36	270	1			
Liard	14-2	12	0	0	0	0			-24	450				
Floodplain	14-3	5	0	0	0	0			-10	560				
	14-4	3	5	11	0	0			8	700				
	14-5	8	0	0	0	0			-16	800				
1	14-Sum	46	5	11	0	0	5	11	-78		1	5	M	
	14-Mean	9	1	2	0	0	1.0		-16					-2.5652

TABLE 22: Comparative Values for Browsing, Forage Abundance, Pellet Group Counts and Plant Species Diversity for the Lowland Vegetation Types

Vegetation Type & Sample Site	SUM Forage Abundance	SUM $b^h + b^c$	SUM $B^h + B^c$	SUM Browse Index	SUM Pellet Groups Within Plots	Total Pellet Groups Sighted Along Transect	Vegetation Species Diversity Index
Spruce Parkland Site 9	157	7	127	-60	2	3	1.9149
Pine Parkland Site 10	203	28	464	269	4	9	2.7658
Mixed C/D Site 11	209	58	580	450	7	9	2.7540
Spruce Muskeg Site 12	83	5	16	-150	3	3	2.5885
Grainger Tillplain Site 13	363	36	935	694	2	7	2.8009
Aspen - Liard Site 14	46	5	11	-78	1	5	2.5652

TABLE 23: Browse Utilization Results - Highland

Sample Location: Sites 7 & 8
Vegetative Community Type: Spruce - Lichen

	1280 m						980 m								
	P1			P2			P3			P4			Mean		
Species	HB	CB	%	HB	CB	%	HB	CB	%	HB	CB	%	HB	CB	%
Betula papyrifera	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pinus Banksiana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Populus balsamifera	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Populus tremuloides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salix scouleriana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alnus crispa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Betula nana	3	2	3	2	1	16	0	0	12	1	0	14	1.5	-	11
Rosa acicularis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salix arbusculoides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salix glauca	2	1	1	2	1	17	0	0	2	1	0	1	1.3	0.5	5
Salix myrtillifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salix planifolis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Shepherdia canadensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vaccinium uliginosum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Viburnum edule	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hedysarum alpinum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex albo-nigra	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Shepherdia canadensis	1	0	4	0	0	2	0	0	0	0	0	0	0.3	0	1.5

HB = Historic Browse*
CB = Current Browse*
% = Browse Availability (% cover of species < 2.0 m in height)

* Browse Utilization: 1 = trace (1-5%); 2 = light (6-25%); 3 = moderate (26-50%); and 4 = heavy (>50%).

TABLE 24: Browse Utilization Results - Highland

Sample Location: Site 5 & 6
Vegetative Community Type: Subalpine Shrub

	Site 5, 4400 feet						Site 6, 3200 feet (Falls)											
	P1			P2			P3			P4			P5			Mean		
Species	HB	CB	%	HB	CB	%	HB	CB	%	HB	CB	%	HB	CB	%	HB	CB	%
Betula papyrifera	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pinus Banksiana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Populus balsamifera	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Populus tremuloides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salix scouleriana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alnus crispa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Betula nana	1	0	75	1	0	75	0	0	55	0	0	2	0	0	60	0.4	0	53
Rosa acicularis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salix arbusculoides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salix glauca	1	1	5	1	0	3	0	0	25	0	0	0	0	0	13	0.4	0.2	9
Salix myrtillifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salix planifolis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Shepherdia canadensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vaccinium uliginosum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Viburnum edule	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hedysarum alpinum	0	0	0	0	0	0	0	0	0	2	0	2	0	0	0	0.4	0	0.4
Carex albo-nigra	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

HB = Historic Browse*
CB = Current Browse*
% = Browse Availability (% cover of species < 2.0 m in height)

* Browse Utilization: 1 = trace (1-5%); 2 = light (6-25%); 3 = moderate (26-50%); and 4 = heavy (>50%).

TABLE 25: Browse Utilization Results - Highland

Sample Location: Site 4 (Nahanni Range)
Vegetative Community Type: Alpine Tundra

Species	P1			P2			P3			P4			P5			P6			Mean		
	HB	CB	%	HB	CB	%	HB	CB	%	HB	CB	%	HB	CB	%	HB	CB	%	HB	CB	%
Betula papyrifera	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pinus Banksiana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Populus balsamifera	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Populus tremuloides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salix scouleriana	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alnus crispa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Betula nana	-	-	-	-	-	-	-	-	-	2	1	70	2	1	5	2	1	15	1	0.5	15
Rosa acicularis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salix arbusculoides	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salix glauca	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salix myrtillifolia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Salix planifolis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Shepherdia canadensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vaccinium uliginosum	-	3	15	-	1	15	-	3	15	1	-	5	-	-	2	2	-	15	0.5	1.2	11
Viburnum edule	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hedysarum alpinum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carex albo-nigra	-	1	8	-	1	8	-	1	8	-	-	-	-	-	1	-	1	5	-	0.5	5

HB = Historic Browse*
CB = Current Browse*
% = Browse Availability (% cover of species < 2.0 m in height)

* Browse Utilization: 1 = trace (1-5%); 2 = light (6-25%); 3 = moderate (26-50%); and 4 = heavy (>50%).

TABLE 26: Special Browse Utilization Survey of Salix commutata on a South-facing Alpine Talus Slope

Sample Location: Site 3 (Mackenzie Mountains)
Vegetative Community Type: Alpine Tundra

Plant Number	Plant Vigor	Plant Sexual Vitality	Historic Browse*	Current Browse*
1	good	good	3	1
2	good	medium	2	0
3	good	poor	1	0
4	medium	medium	2	1
5	good	poor	2	2
6	medium	poor	2	1
7	medium	poor	4	2
8	medium	poor	2	2
9	medium	poor	2	1
10	good	poor	2	1
Mean			2.2	1.1

* Browse Utilization: 1 = trace (1-5%); 2 = light (6-25%); 3 = moderate (26-50%); and 4 = heavy (>50%).

TABLE 27: Comparison of Distribution of Willow Species and Percent Available Cover in Study Area

Vegetation Unit	Vegetation Type	Vegetation Type Code	Sample Site	Salix Species	% Cover Available	Ungulate Species on Range
1	Aspen-Liard Floodplain	AL	14	None	0	moose
3	Grainger Tillplain	GT	13	S. planifolia	10.4	caribou & moose
4	Black Spruce Muskeg	SM	12	S. myrtillifolia	14.6	a few moose
5	Mixed Coniferous/Deciduous	C/D	11	S. scouleriana	24.0	moose
6	Pine Parkland	PP	10	S. scouleriana S. arbusculoides	14.8 1.2	moose
7	Black Spruce Parkland	SP	9	S. glauca	3.2	a few moose, maybe caribou
9	Spruce/Lichen	SL	7,8	S. glauca S. alaxensis	5.3 N/A	mostly caribou & sheep
10	Subalpine Shrub	SS	5,6	S. glauca S. polaris	9.2 3.0	caribou & sheep
11	Alpine Tundra	AT	1,2,3,4	S. nivalis S. phlebophyla	9.5 1.7	caribou & sheep
11	South-facing Talus slope in Alpine Tundra	AT	3	S. commutata S. glauca S. rotundifolia S. reticulata S. polaris	greatest ↓ least	sheep

TABLE 28: Cummulative Ungulate Observations made during Four Field Investigations January - July 1981

	SPECIES											
	Woodland Caribou				Dall's Sheep				Moose			
Field Study	M	F	Y	U	M	F	Y	U	M	F	Y	U
27-29 January 1981	0	0	0	5	0	0	0	17	0	0	0	1
17-21 March 1981	3	10	0	0	7	64	3	3	0	13	3	1
9-10 June 1981	5	39	19	11	4	26	15	-	-	-	-	-
9-17 July 1981	1	0	0	2	2	9	7	0	0	0	0	1

M = male
F = female
Y = youth
U = unclassified

TABLE 29: Ungulate Observations During Field Program, 27-29 January 1981

Species	No. of Animals Observed	Age/Sex Class	Vegetation Unit	Habitat Unit	Elevation (m)	Straight-Line Distance from Facility (km)
Woodland Caribou	5	U	9 - Spruce/Lichen	W^K	1188	7.8
Dall's Sheep	1	1 M	11 - Alpine Tundra	1^F	-	7.3
	2	2 M	11 - Alpine Tundra	1^F	-	7.8
	7	5 F, 2 Y	11 - Alpine Tundra	2^D	1676	3.8
	3	2 F, 1 Y	11 - Alpine Tundra	2^D	1524	3.8
	4	1 M, 2 F	10 - Subalpine Shrub	2^D	1280	0.8
Moose	1	1 M	11 - Alpine Tundra	4^P	1188	9.5

TABLE 30: Ungulate Observations During Field Program, 17-21 March 1981

Species	No. of Animals Observed	Age/Sex Class	Vegetation Unit	Habitat Unit	Elevation (m)	Straight-Line Distance from Facility (km)
Woodland Caribou	13	3M,10F	3 - Grainger Tillplain	W[A]	485	2.6
Dall's Sheep	3	1F,2Y	10 - Subalpine Shrub	1[B]	762	2.0
	1	1M	10 - Subalpine Shrub	1[B]	1341	9.6
	5	5F	11 - Alpine Tundra	1[B]	1310	10.6
	1	1F	10 - Subalpine Shrub	1[B]	914	5.6
	5	5F	10 - Subalpine Shrub	1[B]	945	5.7
	4	4F	11 - Alpine Tundra	1[B]	1249	4.0
	4	1M,3F	11 - Alpine Tundra	1[B]	1127	2.3
	2	1F,1Y	10 - Subalpine Shrub	1[B]	823	3.1
	5	5F	11 - Alpine Tundra	1[B]	1219	4.8
	1	1F	10 - Subalpine Shrub	1[B]	1067	4.4
	1	1M	10 - Subalpine Shrub	1[B]	1219	3.6
	7	2M,5F	10 - Subalpine Shrub	2[D]	1371	4.4
	1	1F	11 - Alpine Tundra	2[D]	1193	5.3
	8	1M,7F	11 - Alpine Tundra	2[D]	1463	1.5
	4	4F	10 - Subalpine Shrub	2[D]	1219	7.3
	3	3F	11 - Alpine Tundra	2[D]	1280	4.7
	1	1F	11 - Alpine Tundra	1[E]	1097	15.8
	2	1M,1F	11 - Alpine Tundra	1[E]	1524	8.7
	16	16F	11 - Alpine Tundra	1[E]	1463	9.1
	3	U	10 - Subalpine Shrub	2[D]	945	0.6

TABLE 30 Cont'd: Ungulate Observations During Field Program, 17-21 March 1981

Species	No. of Animals Observed	Age/Sex Class	Vegetation Unit	Habitat Unit	Elevation (m)	Straight-Line Distance from Facility (km)
Moose	1	U	10 - Subalpine Shrub	4P	1127	9.2
	2	1F,1Y	1 - Aspen - Liard	1A	183	0.3
	1	1F	2 - Floodplain/Tillplain	3J	396	2.4
	1	1F	6 - Pine Parkland	2G	945	1.2
	3	1F,2Y	5 - Mixed C/D	2F	701	0.7
	1	1F	5 - Mixed C/D	2F	549	0.9
	1	1F	5 - Mixed C/D	2F	670	0.9
	1	1F	5 - Mixed C/D	2F	335	2.4
	1	1F	5 - Mixed C/D	1B	213	0.5
	1	1F	5 - Mixed C/D	2F	579	1.5
	2	2F	5 - Mixed C/D	2F	579	0.9
	1	1F	5 - Mixed C/D	2D	594	0.9
	1	1F	4 - Bl Spruce Muskeg	2D	594	0.5

TABLE 31: Ungulate Observations During Field Program, 9-10 June 1981

Species	No. of Animals Observed	Age/Sex Class	Vegetation Unit	Habitat Unit	Elevation (m)	Straight-Line Distance from Facility (km)
Woodland Caribou	4	4F	11 - Alpine Tundra	S[E]	1524	1.5
	3	3M	11 - Alpine Tundra	W[K]	1341	4.7
	3	3F	10 - Subalpine Shrub	C & S[L]	1112	5.1
	2	1F,1Y	10 - Subalpine Shrub	C & S[L]	1402	8.6
	4	2F,2Y	10 - Subalpine Shrub	C & S[L]	1280	2.6
	3	3F	10 - Subalpine Shrub	S[F]	1371	0.7
	5	4F,1Y	10 - Subalpine Shrub	S[F]	1341	8.6
	1	1F	9 - Spruce / Lichen	W[K]	1280	2.5
	4	2F,2Y	11 - Alpine Tundra	C & S[M]	1493	12.5
	4	4F	11 - Alpine Tundra	C & S[M]	1584	15.2
	9	9U	11 - Alpine Tundra	C & S[M]	1584	16.4
	2	2U	10 - Subalpine Shrub	S[E]	1219	12.9
	2	1F,1Y	11 - Alpine Tundra	S[E]	1280	11.8
	4	2F,2Y	10 - Subalpine Shrub	W[K]	1371	7.3
	2	1F,1Y	11 - Alpine Tundra	S[E]	1524	1.4
	6	3F,3Y	10 - Subalpine Shrub	S[E]	1585	1.8
	2	1M,1F	10 - Subalpine Shrub	S[E]	1371	5.5
	2	1M,1F	10 - Subalpine Shrub	S[E]	1310	9.3
	12	6F,6Y	11 - Alpine Tundra	S[F]	1463	2.6
Dall's Sheep	2	2M	11 - Alpine Tundra	2[G]	1006	8.4
	4	2F,2Y	9 - Spruce / Lichen	3[H]	1554	2.9
	1	1F	9 - Spruce / Lichen	3[H]	1219	2.3
	4	2F,2Y	9 - Spruce / Lichen	3[H]	1006	0.8

TABLE 31 Cont'd: Ungulate Observations During Field Program, 9-10 June 1981

Species	No. of Animals Observed	Age/Sex Class	Vegetation Unit	Habitat Unit	Elevation (m)	Straight-Line Distance from Facility (km)
Dall's Sheep	2	1F,1Y	9 - Spruce / Lichen	3H	1006	0.5
	1	1M	11 - Alpine Tundra	1E	1280	6.9
	1	1F	11 - Alpine Tundra	1E	1585	5.2
	3	3F	9 - Spruce / Lichen	3H	1067	1.1
	1	1F	11 - Alpine Tundra	1E	1706	4.0
	4	3F,1Y	10 - Subalpine Shrub	1E	1036	0.6
	2	1F,1Y	9 - Spruce / Lichen	3H	1036	0.4
	1	1M	9 - Spruce / Lichen	3H	1341	6.0
	1	1F	9 - Spruce / Lichen	3H	1310	5.5
	4	2F,2Y	10 - Subalpine Shrub	1E	1371	0.6
	8	5F,3Y	9 - Spruce / Lichen	3H	1173	0.3
	3	1F,2Y	9 - Spruce / Lichen	3H	945	0.0
	3	2F,1Y	9 - Spruce / Lichen	3H	1173	0.3

TABLE 32: Ungulate Observations During Field Program, 9-17 July 1981

Species	No. of Animals Observed	Age/Sex Class	Vegetation Unit	Habitat Unit	Elevation (m)	Straight-Line Distance from Facility (km)
Woodland Caribou	1	U	11 - Alpine Tundra	$C \& S^{M}$	1555	16.0
	1	U	3 - Grainger Tillplain	W^{A}	458	0.5
	1	1M	10 - Subalpine Shrub	$C \& S^{L}$	1370	1.8
Dall's Sheep	1	1F	10 - Subalpine Shrub	1^{E}	1370	15.5
	4	2F,2Y	11 - Alpine Tundra	1^{E}	1464	14.3
	2	2Y	9 - Spruce / Lichen	3^{H}	915	0.0
	1	1Y	9 - Spruce / Lichen	3^{H}	915	0.0
	1	1M	11 - Alpine Tundra	1^{B}	1220	2.8
	5	1F,4J=5F	11 - Alpine Tundra	1^{F}	1525	8.4
	4	1M,1F,2Y	11 - Alpine Tundra	1^{F}	1525	8.8
Moose	1	1U	5 - Mixed C/D	1^{B}	335	0.5

Photo 1

Aspen on the Liard River Floodplain
Sample Site 14

The winter road cuts through dense stands of aspen interspersed with shrub-dominated water-logged lands and scattered clumps of white spruce (dark green patches in photo center near the river).

Photo 2

Floodplain / Tillplain Mosaic

The winter road is shown as it crosses seasonally water-logged muskeg and black spruce patches (left foreground), deciduous forests of aspen and birch (light green) interspersed with white spruce (dark green) and patches of jack pine (centre and right foreground). A Grainger River tributary crossing is shown in the background.

Photo 3

Grainger Tillplain
Sample Site 13

East of the Nahanni Range (background), the winter road (center) crosses a rolling tillplain of low elevational change. The dark green patches are arborescent thickets of black spruce or balsam poplar on better-drained mounds. The light green sections are sedge meadows. This vegetation type has the greatest browse forage abundance in the study area and supports populations of woodland caribou and moose.

Photo 4

Grainger Tillplain

Wet sedge meadows of Carex rostrata provide good grazing areas for Woodland Caribou.

Photo 5

Grainger Tillplain

Grainger Tillplain is characterized by a rolling topography with associated vegetation changes. The low (less than 0.5 metre) shrub community in the foreground consists of dwarf birch and shrubby cinquefoil (yellow blossoms). The gentle slopes have a black spruce cover at their base which grades into a tall (1.5 - 3 metres) shrub community of alder, willow and dwarf birch. This topographic sequence is repeated across the landscape.

Photo 6

Black Spruce Muskeg

Blanched snags are evidence of the fire that destroyed the original black spruce stand. The jack pine stand in the distance (center of photo) developed following the fire on the rapidly drained east flanks of the Nahanni Range (background). This lowland vegetation type is rated as only fair moose habitat.

Photo 7

Mixed Coniferous / Deciduous

Mixed Coniferous / Deciduous cover type on the Tetcela Plateau. A dense tall shrub cover of alder (foreground) and a tree canopy dominated by birch (white trunk in background) characterize the deciduous patches. The forest floor cover is primarily deciduous litter with scattered occurrence of moss (Ptilium crista castrensis). This vegetation type is a successional stage after fire and is heavily utilized by moose.

Photo 8

The Three Highland Vegetation Types
in the Mackenzie Mountains

Lower slopes are shown to support a Spruce / Lichen cover (the light colored mat is Cladina stellaris). Upslope positions are dominated by a Subalpine Shrub cover type composed primarily of dwarf birch and willow with scattered spruce. Crests are covered with a ground carpet of Alpine Tundra vegetation. All three vegetation types are important habitats for both Woodland Caribou and Dall's Sheep.

Photo 9

The Winter Road Route Through the South Pass

The photo shows the Subalpine Shrub cover type on older creek terraces with scattered patches of black spruce. The slopes rising from the creek bed to these terraces support a herbaceous cover with a high percentage of lichen. Although some use of this habitat by sheep and caribou occurs, it does not appear to be a critical habitat.

Photo 10

Spruce / Lichen Zone

The upper south-facing slopes of the Spruce / Lichen Zone show a change from black spruce to white spruce near tree line. Shrub cover as the Subalpine Shrub Zone is approached on the upper slopes is denser than on lower slopes.

The opposite north-facing slope has a lichen ground mat with scattered black spruce. Unvegetated patches are probably the result of snow sliding. Steep creek-cut ravines support little vegetation cover. Depending on snow depths this habitat type may be important winter range for Woodland Caribou.

Photo 11

Spruce / Lichen Zone

Spruce / Lichen lower slopes are dominated by a thick mat of cream-coloured lichen (Cladina stellaris) which covers all ground debris. Footsteps produce noticeable disturbance to this lichen carpet. The herb stratum is primarily composed of sedge and kinnikinick.

Photo 12

Caribou Flats

Black Spruce / Lichen covering the gentle slopes of the Tundra Ridge depression provide winter range for Woodland Caribou.

Photo 13

Subalpine Shrub

Subalpine Shrub cover at 4,400 feet on the Funeral Range west of Prairie Creek. One adult male Woodland Caribou is shown on a mining exploratory road (photo center).

Photo 14

Black Spruce Tree used for "Bush-Thrashing"

Remnants of a black spruce tree used for "bush-thrashing" by caribou in the Subalpine Shrub type (Site 5). During the rut, male Woodland Caribou use trees such as these to remove the velvet from their antlers. The results are seen to be disasterous to black spruce survival.

Photo 15

Tundra Ridge - Sample Site 2

Alpine Tundra vegetation provides an extensive cover mat on these glacier-flattened mountain tops. The light color is caused by the yellowish lichens Cetraria nivalis and Alectoria ochroleuca. The dark patches are primarily composed of the low heath Cassiope tetragona. Talus slopes support scattered patches of alpine tundra vegetation cover. A caribou game trail is seen extending from the center toward the top of the photograph, approximately bisecting the top of the plateau. Moderate densities of caribou scats occur in this area. This area is classified as potential caribou calving range.

Photo 16

Woodland Caribou at Sample Site 2

Note the almost 100% cover of vegetation on this alpine tundra site.

Photo 17

Alpine Tundra

Sample Site 3 in the eastern Mackenzie Mountains shows a patchy Alpine Tundra cover caused by the high occurrence of frost-heaving of the bedrock substrate. The more rugged nature of these mountains with respect to Sample Site 2 holds greater potential for Dall sheep. The white bloom in the right foreground is Dryas integrifolia, a major component of the Alpine Tundra vegetation cover.

Photo 18

Dall Sheep

Five Dall's sheep on a southwest facing slope near ridge line (Nahanni Range, March 1981). Note the lack of snow cover on these wind-swept ridges compared to snow cover at the mine site at the same time. Wind swept ridges such as these are critical winter habitat to Dall's sheep in the study area. The Liard River can be seen in the distant background.

Photo 19

Prairie Creek Mine/Mill Site in March 1981

Photo 20

Talus Slopes

Talus slopes at Sample Site 3 support very scattered individuals of willow species (foreground and center) and surveyor (center right). Individual patches of Dryas Drummondi (yellow disc above willow in left foreground) grow in sheltered niches. It was on this talus slope that the special browse utilization survey of Salix commutata shown in Table 26 occurred.

Photo 21

Folded Mountain in March 1981

The snow-covered floodplain of Prairie Creek and the plowed winter road are seen in the left foreground. South-facing precipitous slopes such as these provide ideal lambing grounds for Dall sheep.

Photo 22

Dall Lamb on Access Road to Mine Addit 3

The lamb was first seen at the mineral lick below the mine entrance. The ewe was not observed.