ECOLOGICAL FEATURES OF MOOSE (*Alces alces andersoni*) WINTER HABITAT IN THE BOREAL WHITE AND BLACK SPRUCE ZONE OF NORTHEASTERN BRITISH COLUMBIA

by

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to the required standard

THE UNIVERSITY OF BRITISH COLUMBIA

September, 1976

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Abstract

A study of the dispersion patterns of moose in winter habitats was conducted from June 1972 to May 1974 in a wildlife reserve in north-eastern British Columbia. Major factors affecting the patterns were examined in an attempt to determine their relative importance.

Data from eight representative vegetation plots indicated productive browse in deciduous forests and open habitats. In coniferous forest there was very little shrub development.

Moose were well adapted to low winter temperatures which often followed warm winter temperatures associated with chinook winds. Snow cover rarely exceeded 76 cm. Canopies of mature coniferous forest profoundly influenced the depth of snow on the ground, but, because the snow depth in open areas was not restrictive, moose did not extensively use coniferous forest.

Willow, aspen and bog birch were the most important forage species. Rumen analyses and trailing methods supported these observations. Instances of moose cratering (pawing) and debarking were observed.

Winter forages (probably a limited sample) were very low in crude protein.

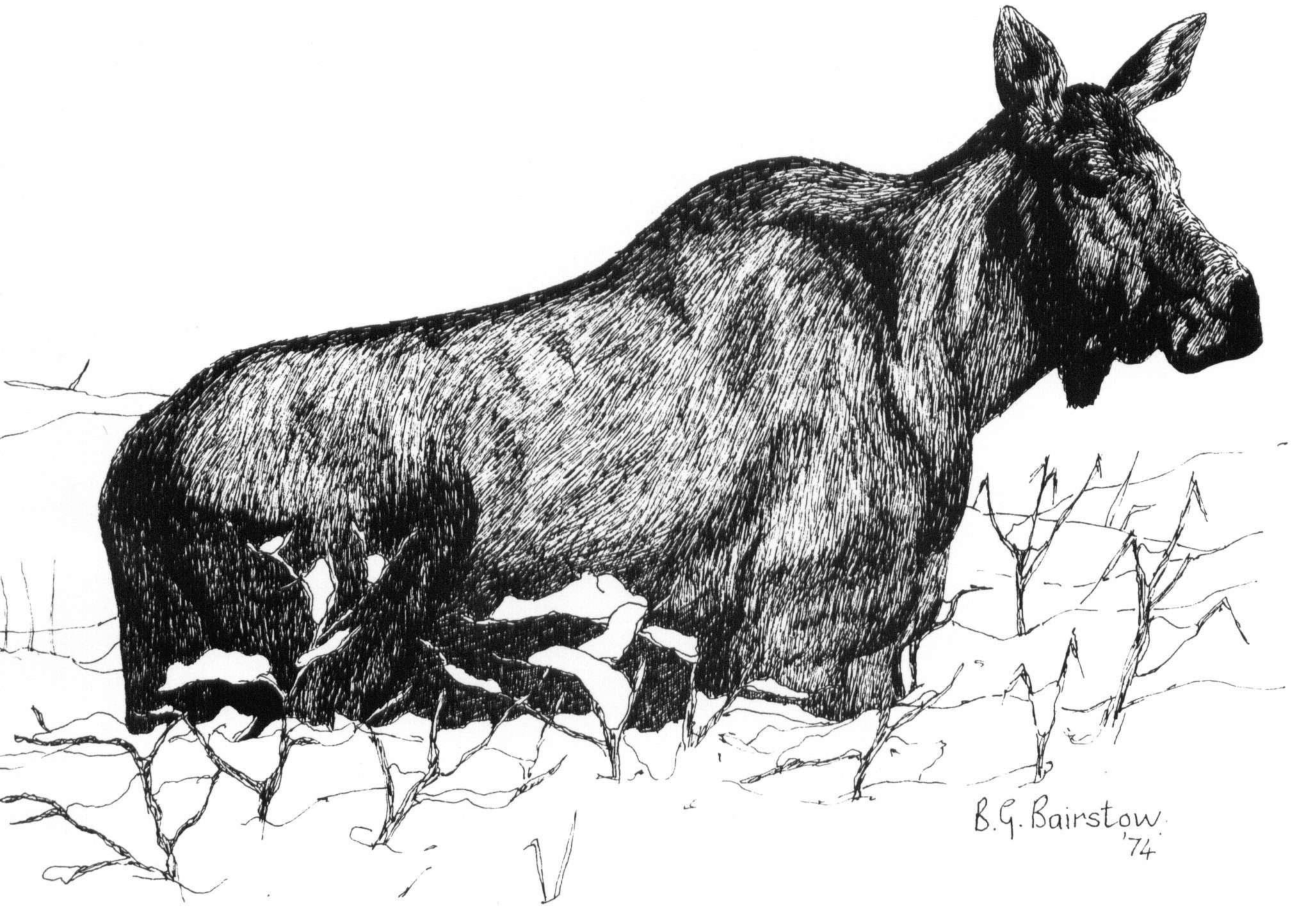
Open shrubland, agricultural land, and deciduous forest were preferred winter habitat. Several variables, quantified during ground and aerial observations, were used in a model to predict moose dispersion, but the model was applied with limited success.

Future management of habitat for moose should include logging and prescribed burning to enhance the forage resource. The purchase of alienated lands to ensure control of the land base is also recommended.

FRONTISPIECE

moose in winter

a
pen and ink
drawing by
hudson's hope
artist
b.g. bairstow


B.G. Bairstow
'74

ADKNOWLEDGEMENTS

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Drs. V. C. Brink and J. Sawitski identified most of the plant specimens gathered and mosses and willows were identified by Drs. W. Schofield and T. C. Brayshaw respectively. Ms. M. Larkin and I. Derics analyzed plant samples for crude protein and lignin content.

The effects of bitter cold temperatures and howling north winds associated with extensive fieldwork, were more than compensated for by the hospitality and services of Mr. and Mrs. J. Warren (mile 136, A.H.) and Mr. F. Ruttan (mile 147, A.H.).

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1. INTRODUCTION

The moose (Alces alces andersoni), one of three subspecies of the largest member of the deer family in British Columbia, is an important wildlife species in the province. This ungulate is a valued source of wild meat, a unique and magnificent trophy, a quarry providing many hours of recreation and an unforgettable sight. Moose are distributed throughout most of mainland British Columbia. The central and northern regions support the greatest densities where the preferred habitats of riparian vegetation and burned areas (brule) are common components of the boreal and sub-boreal biogeoclimatic zones.

Historically, a limited number of moose studies in British Columbia have focussed on the winter habitats of specific areas (Hatter, 1946; Ritcey, 1965; Sumanik, 1972(b)). A recent study by Eastman (1974) has documented the requirements for moose in the Sub-Boreal Spruce zone of central British Columbia. However, detailed information is lacking for most of northern B.C. To document the dispersion of moose in representative Peace River area habitats and to examine the habitat and animal components of an important wildlife reserve, were the main objectives of this study. A broad, holistic approach was employed. Working objectives were designed to:

1. provide an inventory of moose dispersion in available winter habitats;
2. define the vegetative characteristics of representative habitats;
3. document the consumptive use of the moose resource;

4. estimate the size of the moose population;
5. develop a strategy for future habitat protection and enhancement programs.

2. THE STUDY AREA

THE CAMERON RIVER RESERVE

2-1 LOCATION

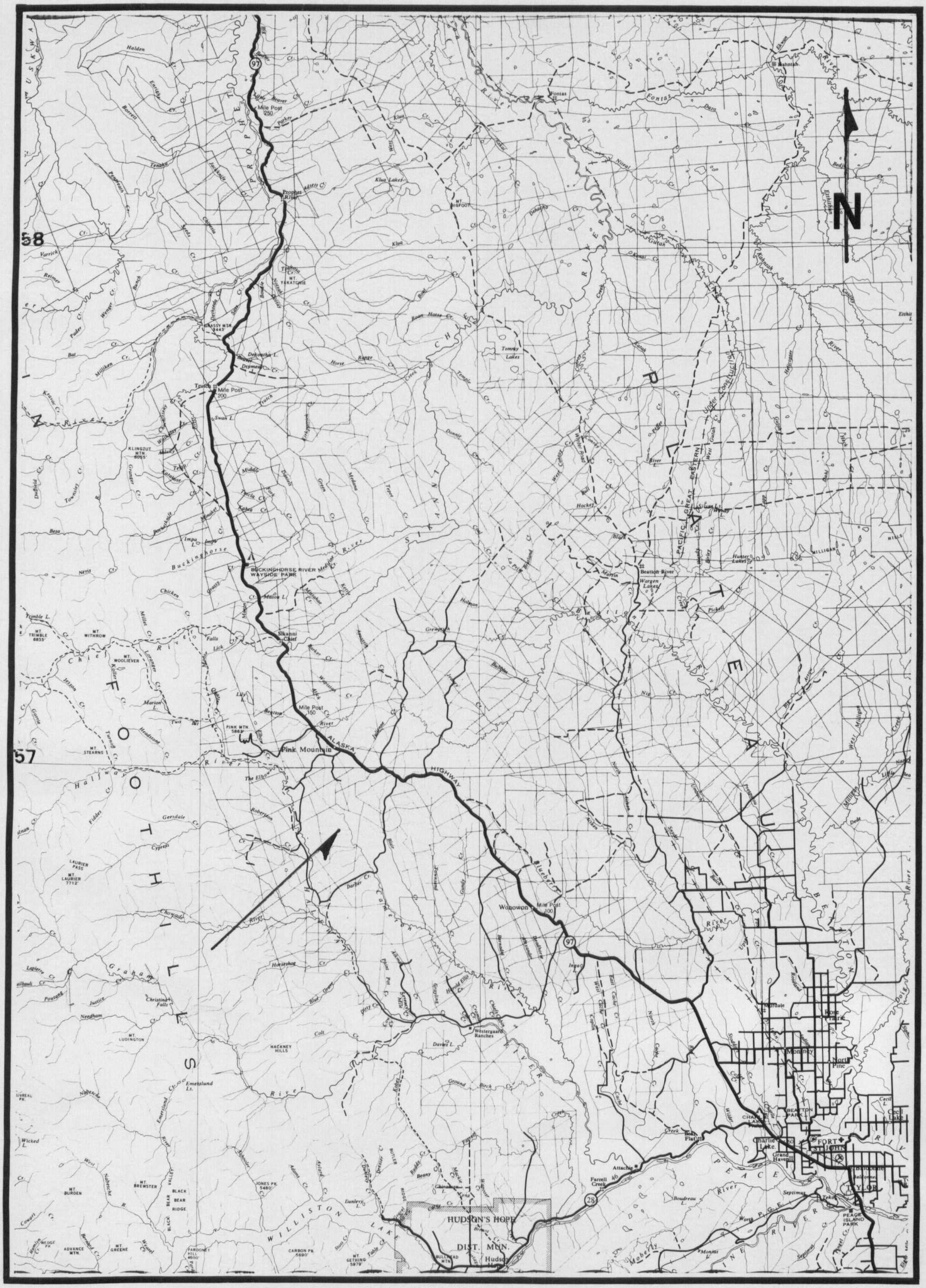
The Cameron River Reserve, the area in which this study was undertaken, is situated on the Alberta Plateau of northeastern British Columbia some 153 km northwest of Fort St. John (latitude 57°00', longitude 122°22'). The map reserve (Figures 1 and 2) was established in 1969 by the British Columbia Land Management Branch (Appendix 1). The purposes of the 925 km^2 reserve are primarily to protect land, having a high capability for wildlife, from alienation for arable agriculture, and secondly to provide grazing lands for existing ranches. A total of 5,126 hectares, or 5 percent of the area, was alienated prior to establishment of the reserve.

2-2 TOPOGRAPHY

The Cameron River Reserve occurs on the Alberta Plateau area of northeastern British Columbia, immediately east of the Rocky Mountain foothills. A series of narrow valleys, separated by rolling and sharp ridges running north-south, characterize the study area. Valley bottoms, originally resulting from drainage from the Rocky Mountains and glacial actions, comprise most of the area below the 915 m elevation (Figure 3).

FIGURE 1

Northeastern British Columbia



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58
57
ALASKA HIGHWAY
97
Mile Post 250
Mile Post 200
Mile Post 150
Prophet River
Trutch
Pink Mountain
Wonowon
BUCKINGHORSE RIVER WAYSIDE PARK
Sikanni Chief
F O O T H I L L S
P L A T E A U
PACIFIC GREAT EASTERN
Beatton River
Rose Prairie
Montney
North Pine
Charlie Lake
FORT ST. JOHN
TAYLOR
PEACE
WILLISTON LAKE
HUDSON'S HOPE
DIST. MUN.
Westergaard Ranches
Farrell Creek
Attachie
28
PEACE ISLAND PARK

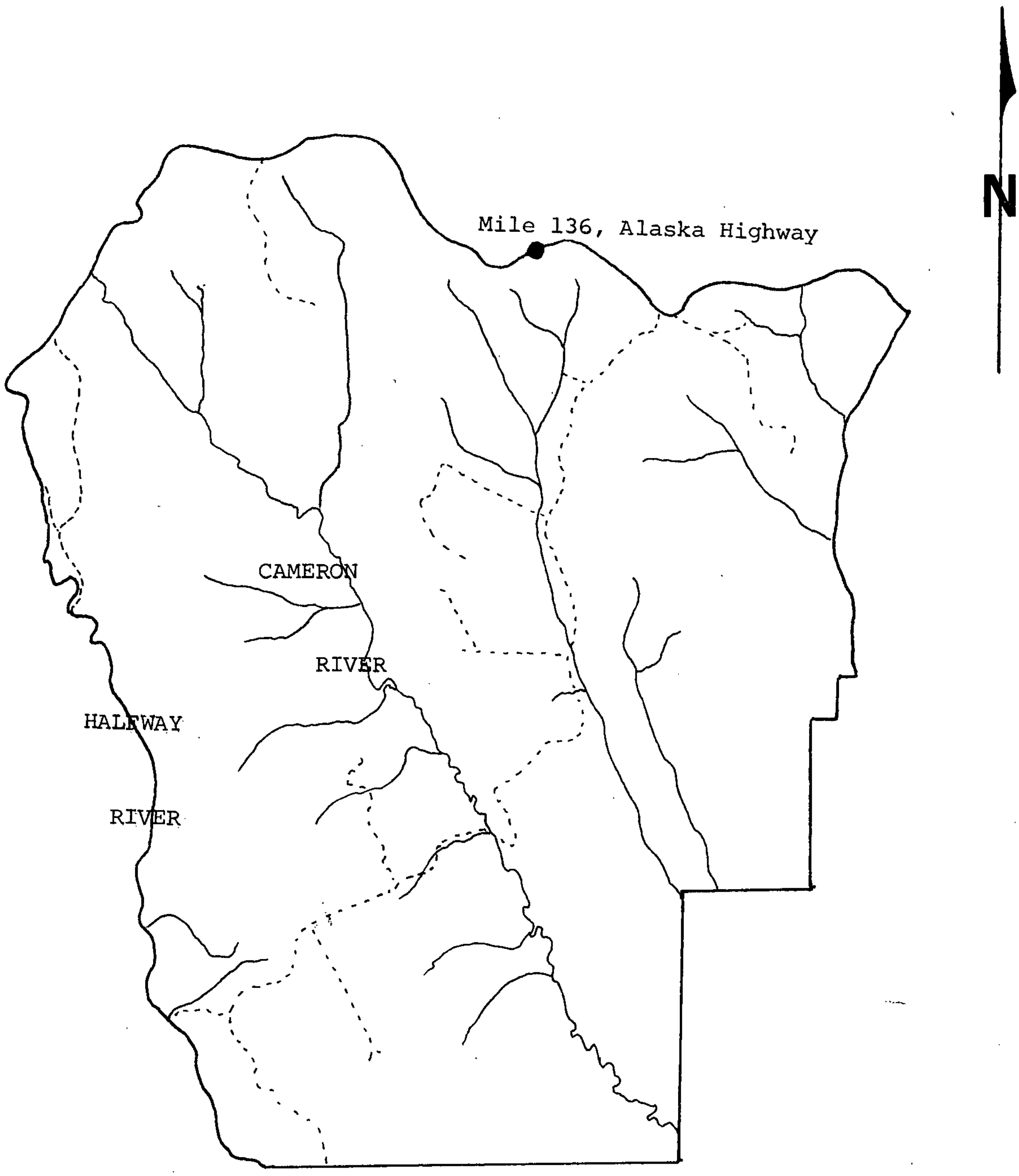

Figure 2. The Cameron River Reserve

Figure 3. Topography

2-3 GEOLOGY

The geology of the reserve area is reported on by Irish (1970). The lower elevation drainages (Halfway River, Cameron River, Blair Creek and Townsend Creek) are characterized by glacial gravels, sands and silts of the Cenozoic. The upland of the western part of the Cameron River Reserve is dominated by the Sikanni Formation (Lower Cretaceous) which consists of three thick sandstones separated by three shale units covered by a thick shale unit (the Sully Formation of Stott (1960)). Localized occurrences of the Dunvegan (Upper Cretaceous) and Buckinghorse Formations (Lower Cretaceous) are associated with the Sikanni Formation. The Buckinghorse Formation is exposed in the Darber Creek area between the Halfway and Cameron Rivers. This formation is characterized by thin layers of easily eroded grey shales in areas of low relief. The Dunvegan Formation, predominent in the eastern inter-stream ridges of the study area, consists of sandstone and shale originating as sediments of deltaic and near shore environments (Irish, 1970). The Dunvegan Formation is the youngest consolidated stratum in the area.

Ice sheets over the Alberta Plateau during the Pleistocene moved south-westerly and left a veneer of till containing distinctive Keewatin boulders (Holland, 1964).

2-4 CLIMATE

The Dfe Climate (Köppen*) is characteristic of the Boreal White

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*See Appendix 2 for Köppen climate notations.

and Black Spruce biogeoclimatic zone (Krajina, 1965). This cold continental climate is distinguished by long, cold winters and cool, short summers. Mean temperatures, based on twenty-nine years of records at Fort St. John, show January and July to be the coldest and warmest months respectively, with readings of -17°C and 16°C. July is also the month having the greatest accumulation of rainfall (6.4 cm) and the most amount of sunshine (300 hours). January is the month of greatest snowfall and February is the month with greatest accumulated snow.

Calm air is infrequent giving significance to the winds, particularly to the prevailing west winds. Chinooks (foehn winds), caused by warm Pacific air rapidly descending in the lee of the Rocky Mountains, are responsible for sudden temperature increases during the winter period. These strong, warm, dry winds result in the rapid disappearance of snow, especially from exposed areas. Occasional north winds are strong, turbulent and cold and are associated with arctic air mass movement along the eastern slopes of the Rockies and Foothills.

The frost free period varies from year to year and site to site but at Fort St. John it averages 111 days. Slope, exposure and type of vegetation are important determinants of the frost free period at any one site. Appendix 2 describes the climate of northeastern British Columbia.

2-5 SOILS

Gray Luvisol soils (Gray Wooded) occupy the undulating till plains of the Alberta Plateau east of the Rocky Mountains (Lord et al., 1973). The soils of the study area are Gray Luvisols with associated Eutric Brunisols. In the Cameron River Reserve, Luvisols occupy the extensive upland area between the major drainage basins. The Brunisols (Brown wooded) occur most widely in the Halfway and Cameron River valleys. Lord (1972, unpublished) noted that organic soil associations were generally lacking in the study area but they occur in the foothills to the west. Localized patches of organic soil occur within the study area but are not recognized at the soil association level. The characteristics of the soil associations of the study area as documented by Lord (1972, unpublished) are presented in Appendix 3.

2-6 FLORA

The Cameron River Reserve lies in the Boreal White and Black Spruce biogeoclimatic zone. White spruce (Picea glauca*) is considered to be the climatic climax dominent on fine textured upland soils while black spruce (Picea mariana) is an edaphic climax species on poorly drained sites. Moss (1955) suggested periodic burning, with the removal of organic material, may contribute to the maintenance of black spruce stands in poorly drained shallow basins. Certainly fire plays a very important role in the ecology of all forest land in the area. Aspen (Populus tremuloides), lodgepole pine (Pinus cortorta), birch (Betula papyrifera) and willow (Salix spp), species which occupy much of the study area uplands, represent pyroclimax vegetation.

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* See Appendix 4 for scientific names of the plant species.

Moist valley bottoms often support a shrub cover (bog birch (Betula glandulosa), willow (Salix spp) and shrubby cinquefoil (Potentilla fruiticosa) on poorly drained sites. The better drained sites support productive stands of black poplar (Populus balsamifera) and white spruce (Picea glauca).

A wide variety of herbaceous plants are associated with boreal forest types. Exposed river breaks are established to herbaceous species such as needle and thread (Stipa comata), junegrass (Koeleria cristata) and wheatgrasses (Agropyron spp) with bluejoint (Calamagrostis canadensis), fireweed (Epilobium angustifolium). Roses (Rosa spp) and vetch (Vicia spp) are major components of the lush herbaceous and shrub cover common in recently burned areas frequently established to aspen. Maturing coniferous forest has a poorly developed ground layer of mosses, Pleurozium schreberi, Hylocomium splendens or Dicranum spp. Bulrush (Scirpus spp), sedges (Carex spp) and cotton-grass (Eriophorum spp) are common in moist and swampy locations. Oats, barley and other Graminaceous species, are planted for green feed in the cultivated fields of the valley bottoms.

2-7 FAUNA

A wide variety of animals, native to the boreal forest, frequent the study area. Moose (Alces alces*) are the most abundant ungulate; while mule deer (Odocoileus hemionus) are common and caribou (Rangifer tarandus) and elk (Cervus canadensis) occur occasionally.

*See Appendix 5 for scientific names of the animal species.

Black bear (Ursus americanus) are common in the Alberta Plateau and grizzly bear (Ursus arctos) are limited by a lack of suitable habitat and by man's industrial and recreational intrusion into the wilderness.

Wolves (Canis lupus) and coyotes (Canis latrans) are the most common predators and cougar (Felis concolor) occur only rarely (Ruttan personal communication; Rand, 1944).

Common furbearers include the red fox (Vulpus fulva), pine martin (Martes americana), lynx (Lynx canadensis), wolverine (Gulo luscus) and beaver (Castor canadensis).

A wide variety of birds frequent the Cameron River Reserve. Gallinaceous birds such as spruce grouse (Canachites canadensis), ruffed grouse (Bonasa umbellus) and blue grouse (Dendragapus obscurus), raptors such as the great-horned owl (Bubo virginianus) and snowy owl (Nyctea scandiaca), and a variety of Passerine birds, are common.

Domestic horses and cattle have utilized the grazing areas of the study area for many years and a privately introduced herd of bison frequent the area.

Accounts of the fauna of the Alberta Plateau can be found in Williams (1932), Raup (1934), Cowan (1939), Rand (1944) and Cowan and Guiget (1965).

2-8 HISTORY

The Peace River area of northern British Columbia has a colourful history. Since the famed expedition through the area by explorer

Alexander MacKenzie in 1783 and the establishment of trading posts by Simon Fraser in 1805, this section of British Columbia has provided a challenge to white settlement and activity.

Following the Klondike gold rush of 1897, the designation of the Peace River Block in 1907 resulted in the first agricultural settlement bordering the Block. Previously, the federal government had prohibited settlement, as Bowes (1952) reported:

> Land surveyors and settlers entered the Peace River region of British Columbia only a few years prior to the First World War. Until that time, the area from the Rockies east to the Alberta boundary had been kept under a provincial government reserve which prohibited homesteading. The purpose of this reserve was to permit the federal government to select 3,500,000 acres of unalienated arable land (The Peace River Block) in return for aid given earlier by Ottawa for railway construction elsewhere in the province. The long-delayed choice of the Block was announced in 1907, and Ottawa threw open some of the lands for homesteading in 1912.

Further settlement was stimulated by the arrival at Dawson Creek in 1931 of the Northern Alberta Railway line (Peace River and Dunvegan), from Edmonton. In the study area, agricultural activity dates back to 1912.

Prior to 1912 and up until the early 1940's, Northwest Mounted Police trails, which provided access for ranchers, trappers, hunters, land surveyors (Umbach, 1929) and phytogeographic surveyors (Raup, 1934), followed the Halfway River drainage bordering the study area. Motorized travel was first attempted just south of the study area by the ill-fated Bedeaux Expedition of 1934. The Alaska Highway was constructed after 1941 as a defence measure in World War II, and now constitutes the northern boundary of the Reserve.

Natural gas and petroleum exploration, originating in a successful commercial well near Fort St. John in 1951, is manifest in seismic lines, oil and gas wells, and transmission lines in and around the Reserve.

Bowes (1952), Wilson (1965), Stacey (1973) and Ventress et al. (1973) have documented much of the history and development of the Peace River area of British Columbia.

2-9 LAND USE

2-9.1 Agriculture

Agriculture was practised in the study area even prior to the expansion of homesteading in the 1960's. As a matter of interest, areas of the Halfway River Valley were settled before locations in the Peace River Block were released by the federal government. Within the Cameron River Reserve, the Halfway Valley is the most developed area for ranching but minor developments occur in the Cameron River and Blair Creek drainages. Cattle-oriented operations are favoured over cereal production, as climatic conditions place severe limitations on cereal production. Forage for pasture, and hay, are grown with limited success. The long distance to markets places serious economic constraints on hay and grain marketing possibilities.

Native summer range is very restricted. Open grassland in the area is minimal and occurs almost exclusively on warm exposures of breaks along the major streams. Aspen encroachment is common. Burning of forest and bush to create range for livestock and wildlife has been a common practice in northeastern British Columbia, but this has been curtailed by recent British Columbia Forest Service fire suppression policies. Periodic wildfire is a natural agent and the prohibitive and suppressive policies have already seriously reduced the quality and quantity of range for domestic stock and wildlife alike. Future utilization of the woody species may provide a substitute for fire in the more productive forested areas, but low productivity forest and shrubland areas will require periodic fire if forage and browse production is to be maintained (Also see 2-9.2).

2-9.2 Fire

Fire has been the dominant force in the evolution of the current forest cover of the Cameron River Reserve. Heinselman (1971) concluded that fire was a prime influence in the succession, species composition and compartment ages of the northern forest. Dasmann (1964) categorized the moose as a mid-successional species and recognized the constant need of the species for succulent deciduous browse associated with post-fire habitats. Fire in the Boreal White and Black Spruce biogeoclimatic zone, as in most zones, alters the tree canopy and renews and improves the quantity and quality of available browse Cowan *et al.*, 1950).

Though documentation of older forest fires in the Cameron River Reserve is lacking or scanty, the recent burns and the nature of the present vegetation, provide ample evidence of fire as a major ecological factor. Lightning strikes have, no doubt, been responsible for a majority of the burn areas. However, fires initiated by man's activities including grazing land maintenance, land clearing, road building, logging, petroleum exploration, recreation and tourism, have been common in recent decades. Large areas of favourable moose habitat were thus created. Man has deliberately set fires. Raup (1934) cited numerous references to the setting of range fires by Indians. Vince (personal communication) reported extensive burning of areas of the Blueberry River breaks by Indians as a method of rejuvenating forage for horses. Elk numbers in the Tuchodi drainage have recently increased as a direct result of fires initiated by man. Harper (personal communication) noted that several residents of the now flooded Gold Bar area on the Peace River often culminated their spring trip east to Hudson Hope to replenish supplies, by progressively burning the vegetation of the river breaks to create grazing areas. Fire is recognized as a dominant and necessary factor in the maintenance of quality habitat for both wildlife and domestic livestock.

2-9.3 The Oil and Gas Industry

Northeastern British Columbia is one of the few areas of the province underlain by sedimentary rocks and the only area apparently rich in petroleum resources. In recent years, the demand for petroleum products has resulted in sizeable expenditures in exploration and production activities. Westcoast Transmission Company Limited and Pacific Petroleums Limited, major companies in the Peace River area, have established collecting networks for natural gas and oil respectively, and share ownership of the McMahan Oil Refinery at Taylor, B.C., 16 km southeast of Fort St. John.

The study area is characterized by a network of seismic lines. Numerous well sites occur in the area though no wells are currently producing (Appendix 6). The mainline Westcoast Transmission Line, an underground 76 cm steel natural gas line, bisects the Cameron River Reserve. It originates in Fort Nelson and its corridor across the provincial terrain is about 36.6 m wide and 1,280 km long. Constructed in 1957, the system terminates in Huntingdon, near Abbotsford, B.C., where it connects with the Colorado Interstate Pipeline Company and the El Paso Natural Gas Company lines which distribute Canadian gas to the western United States.

The compressor station N4, located near the centre of the study area, is one of seventeen stations located at intervals along the mainline. Natural gas driven turbines move the vaporous gas through the pressurized pipeline system. Operational data such as volumes of gas, are measured at each station and, by a sophisticated computer electronic supervisory system, provide continuous data analysis for the entire system. The turbines force a daily average of one billion cubic feet of natural gas through the mainline, about seven and one half percent of which is fuel for the turbines.

2-9.4 Forestry

The capability of the land for the production of trees is high in portions of the Cameron River Reserve; particularly in parts of the Halfway River valley. However, a history of extensive and frequent fire and clearing for agricultural activities, has resulted in few remaining sizeable tracts of merchantable coniferous timber. At the present time, the long distance to mills and markets seriously reduces the possibility of profitable logging operations. There have only been six small timber sales within the study area, totalling a mere 84 hectares (Appendix 7).

In recent years, the forest industry in northeastern British Columbia has experienced major changes. Small seasonal lumbering operations have expanded and become less seasonal with increased road and rail access.

2-9.5 Guiding and Trapping

The Cameron River Reserve is one of the few areas of northeastern British Columbia where the guiding of non-resident hunters is not permitted. However, the study area is surrounded by profitable guiding enterprises which cater mainly to sportsmen from the United States.

The wildlife reserve lies entirely between two trap lines; one held by native Indians and the other by Einar Westergaard of the pioneer Westergaard family. The intensity of trapping is influenced by fur prices, snow conditions, trapper effort and current success. Both lines have been subjected to limited harvests during recent years and are being utilized mainly on a recreational basis. Appendix 8 documents trends in fur take on Westergaard's Blair Creek - Townsend Creek line.

2-9.6 Recreation and Tourism

Moose hunting is the major consumptive form of recreation in the study area. A history of hunting success in northeastern British Columbia, particularly near Pink Mountain just north of the Cameron River Reserve, has resulted in a large number of hunters. Appendix 9 provides additional information about the resident moose hunter. Caribou, deer, black bear, and an occasional grizzly bear, are also taken by hunters.

The Halfway River supports a modest arctic grayling and dolly varden fishery. The capability of many small streams for fish production appears to be limited by large areas of muskeg in the drainage areas.

The rolling Plateau terrain is not scenically spectacular and the many moist muskeg areas discourage cross country hiking. Non-consumptive uses of wildlife occur mainly as observations of animals near the Alaska Highway. The highway, the northern boundary of the Reserve, brings many tourists and hunters to the periphery of the study area. The gravel highway is the major, and until recently, the only land route to the Yukon and Alaska. The five gasoline and service outlets, scattered along this section of the Alaska Highway, derive summer income from traffic associated with major northern petroleum projects, regular oilfield maintenance activities, hard rock mining exploration, tourism, and the local ranching and guiding community (Appendix 10). The autumn income of these businesses is augmented by resident and non-resident hunters. A smaller flow of traffic to northern British Columbia, the Yukon, and Alaska, often supplemented by petroleum industry activities, provides a small income during the adverse season.

3. LITERATURE REVIEW

Habitat

Winter habitat selection by moose varies with the vegetative composition and climatic influences of the location. Lowland physiographic sites are favoured (Sumanik and Warren, 1968; Sumanik, 1972a; Sumanik, 1972b; Peek et al., 1976), but valley sides with gentle slopes and warm exposures are also used (Prescott, 1968; Peek et al., 1976). Adequate forage and shelter sources and favourable exposures characterize important winter habitats. Hatter (1946) and LeResche et al. (1974) recognized the importance of fire in the production of winter browse. Des Meules (1962), Smith (1962), Ritcey (1965), Houston (1968), Prescott (1968), and Brass and Brassard (1974) reported heavy utilization of specific browse species in areas of winter concentrations of moose. Although deciduous species provide the bulk of the winter diet, coniferous canopies provide shelter from deep snows and penetrating winds (Peek, 1970; Eastman, 1974; Markgren, 1974; Peek et al., 1976). Selection of wintering areas may be the result of a migration from areas of deep snow to those having less snow (Edwards and Ritcey, 1956; Edwards, 1956; Ritcey, 1965; Dodds, 1974). The maintenance of productive moose populations is dependent on the manipulation of critical winter habitat utilizing fire, logging, or mechanical treatment (Stelfox, 1962; Ritcey, 1972; Telfer, 1972; Syroechkovskiy and Rogacheva, 1974; Lykke, 1974).

Food Habits and Forage Quality

A detailed analysis of food habits of the North American moose by Peek (1974) suggested the variability of the plant material observed as part of the moose diet indicates the adaptability of the ungulate to local habitat types and conditions. In western North America, willow species provide the major winter forage (Wilson, 1971; Houston, 1968; Eastman, 1974). LeResche and Davis (1973) report extensive use of nonbrowse foods by moose in Alaska. Bark peeling, considered a sign of poor range conditions during the winter period, indicates a forage preference during the spring (des Meules, 1968). As a forest approaches the climatic climax condition, the quantity and quality of forage for moose deteriorates (Cowan et al., 1950). Measurement of forage quality is rather crude as maturity of plant, location of sample on the plant, species of plant, and site growth characteristics, influence sampling (Tew, 1970; Oldemeyer, 1974).

Moose Management

The net productivity of Alces on good range is considered to be between 20 and 25 percent (Simkin, 1974). The quality of habitat available and influence of climatic variables represent major factors in the rate of moose productivity. Female moose conceiving twins may be selected for in burns as a direct response of the reproductive potential of the ungulate to the favourable ecological variables (Geist, 1974). Climatic variables affecting productivity include ungulate response to both vegetation (Peek, 1962) and winter conditions (Ling, 1973).

Wildlife managers have developed a number of techniques for moose management. Robinson (1962) described a management method utilizing sex ratios and Mitchell et al (1964) applied the sex ratio methodology in distinct geographic locations. A high level of productivity was reported in Simkin's (1964) study. The mean age of moose harvested by hunters was lower in heavily hunted areas than in lightly hunted areas. Ritcey (1974) and Cumming (1974) provided histories of moose management programs in both Canada and Ontario respectively. Season length, season closures, differential seasons for sexes and licence number restrictions controlled moose harvests. Long range planning and public education were also necessary to maintain the management programs. The value of regulations with sound biological inputs is often jeopardized by emotional and political pressures (Rausch et al., 1974).

4. PROCEDURES AND METHODS

4-1 Approaches to the Study of the Cameron River Reserve Moose Population

The nature of the forest habitat limits the opportunities to observe moose. In the study area, observations were further handicapped by a rolling terrain with very few vantage points. Data on moose dispersion patterns and other characteristics were gathered by several means. Since funding and time were very limited, no one of these methods offers complete data.

4-2 Road Checks and Hunter Sample Returns

The Fish and Wildlife Branch data collected at the Cache Creek Hunter Check Station in south central British Columbia and the provincial Hunter Sample returns, were used in the analysis of the moose population of the Peace River district of northeastern British Columbia (old Game Management Area 28, currently management units 7-19 to 22, 31 to 36 and 46 to 46). The Cache Creek data provided the age structure of a sample of the moose kill as aged using the method of Sergeant and Pimlott (1959). These data represent only moose killed by non-locals as the Cache Creek station is located at the junction of Highways 1 and 97, 1100 km south of the study area. Life tables and survivorship curves were developed according to the method of Eberhardt (1969).

Estimates of moose hunter numbers and hunter success were obtained from the Hunter Sample returns but these data are for the whole Peace River area of which the study area is but a part.

4-3.1 Aerial Surveys and Local Office Records

The moose population of the Cameron River Reserve per se was examined using completed aerial census reports and aerial reconnaissance. Aerial survey reports provided sex ratios for moose in several areas of the Peace River and also provided a basis for sex ratio comparisons between different locations for different years. During the aerial reconnaissance flights, moose population features were recorded, and at the same time, moose habitat characteristics were described. These flights consisted of rough north-south oriented air searches using either a Cessna 172 fixed wing or a Bell Jet Ranger 206 B helicopter. Fixed wing aircraft flew at an altitude of 31 to 92 meters at approximately 130-160 kilometers per hour. The maneuverability of the helicopter during animal classification activities resulted in a variety of elevations and speeds (10-91.2 meters at an average speed of 110-225 kilometers per hour). Mitchell's (1970) moose classification methods were used to establish the sex of moose observed during the aerial surveys. Observations of moose and habitat were recorded by cassette recorder and plotted on 1:63360 gas exploration (seismic) maps. General spring and winter dispersion patterns of moose were established from aerial survey data.

4-3.2 Ground Surveys, Personal Checks and Local Information

Ground reconnaissance, associated with other research activities and limited to a few miles of useable road, provided additional data for the general spring and winter dispersion patterns established through aerial surveys. Moose dispersion patterns during summer, a period when thick foliage hinders the observer, were obtained using a limited number of animal and track observations. Autumn dispersion of moose in the habitats of the study area was determined through contact with hunters and local resident businessmen. The location of known moose harvests were marked on a 1:63360 seismic map. The age of each moose harvested was determined by sectioning the first incisor (Sergeant and Pimlott, 1959) (Appendix 9).

4-4 Measurement of Some Representative Forest Cover Types

The vegetative cover of the Boreal White and Black Spruce biogeoclimatic zone of northeastern British Columbia, has been studied by Raup (1934), Jeffrey (1964), Wareing (1971), Annas (1971, 1973 and 1974) and Annas (unpublished). Variations in edaphic and climatic conditions and firing of the forests have created a mosaic of forest canopy types in the study area. Representative forest cover types, selected from aerial photographs on the basis of homogeneity, were quantitatively analyzed by methods modified from Ohmann and Ream (1971a) viz:

1. Ten sample points were systematically located in two groups of five parallel to the contour.
2. The coverage class system of Daubenmire (1968) was employed to estimate ground cover.

The 18 m distance between sample point was paced rather than measured. Tree seedlings were treated as tall shrubs. Representative canopy types were examined using the following data collected at each of the ten sample points during August, 1973 (Figure 4):

1. GROUND COVER (.3 x .6 m frame)

   Species occurring in the herb layer (viz. mosses, lichens grasses, herbaceous plants and small shrubs), not ordinarily available to moose during winter, were ocularly assigned a coverage class ranking of 1-6 (Daubenmire, 1968).

2. TALL SHRUB COVER (Circular)

   The number of stems by species, diameter of stems and total estimated area occupied by species were recorded. A browsing index (U.S.D.A. Handbook, 1969) was utilized for all shrubs and the presence of pellet groups was noted.

3. SAPLING COVER (point - centered quarter)

   Saplings were defined as woody plants having a diameter at breast height (dbh) of 2.5-10 cm. The distance to the nearest sapling in each of four quadrants from the sample point was measured to the nearest .2 m. Species and dbh of the nearest live and dead sapling were noted.

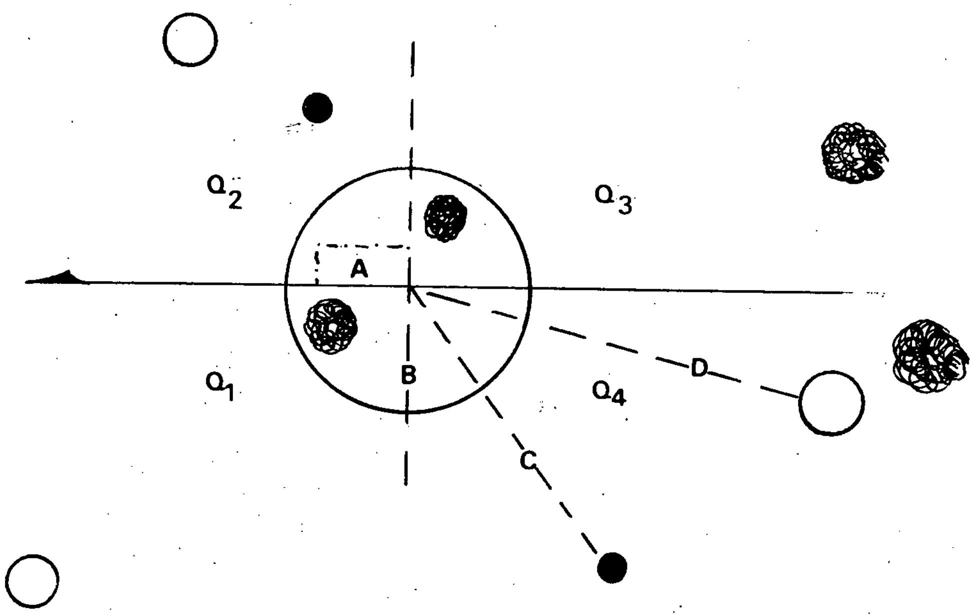
4. TREE COVER (point - centered quarter)

   The tree cover of selected habitats was examined using the point - centered quarter method as described for saplings (Cottam and Curtis, 1956, In Ohmann and Ream (1971a)). Tree age and height were recorded for the nearest tree in quadrant four. A tree was considered any woody plant having a diameter of at least 10 cm at breast height.

Summary computer programs, developed by Ohmann and Ream (1971a, 1971b) were used in the analysis of the sample plot data.

4-5 Some Abiotic Components of Winter Habitat in the Cameron River Reserve

4-5.1 Winter Air Climate



A 1' x 2' Frame, Herbaceous Cover

B Milacre plot, Shrub Cover

C Distance to nearest Sapling

D Distance to nearest Tree

Figure 4. Vegetation Analysis Methods at Each of Ten Sample Points (from Ohmann and Ream, 1971a)

The winter air climate (Dfc Köppen) of the study area is characterized by a wide range of air temperatures and wind speeds. The Canada Department of the Environment stations of Wonowon, Fort St. John and the Pink Mountain station located at mile 136, Alaska Highway, provide records which characterize the regional climate. Temperatures recorded at these stations during the study period were compared to the temperature normals for the Fort St. John station for period from 1942-1970. Hygrothermographs were established at three locations in the study area; however, with access uncertain and performance and maintenance erratic, the incomplete data were of questionable value.

4-5.2 Snow Cover Measurements

Snow cover data were obtained from several sources, viz:

1. The Canada Department of the Environment, Fort St. John Station (1942-present).
2. The newly-established Canada Department of the Environment Stations at nearby Wonowon (mile 101 A.H.) to the south, and Pink Mountain (mile 136 A.H.) to the north of the study area.
3. Snow stakes established in several forest sites.

The Canada Department of the Environment records provided estimates of occurrence, nature and monthly totals of precipitation, and facilitated the development of a winter severity index useful for moose ethology in northeastern British Columbia. The effect of forest canopy on snow depth was assessed at ten sites in selected habitat types by using snow stakes. Paired 2.5 x 7.6 cm x 1.2 m wooden stakes, painted at 15 cm areas of contrasting colours, were situated in representative forest types. The snow stakes were positioned to face east and readings were made with minimal disturbance. Subtraction of the length of the stake exposed from the total stake length of 1.2 m gave the depth of snow. Observations were made monthly during the winter of 1972-1973 and bimonthly during 1973-1974. Qualitative aspects of snow cover such as texture, load on stems and branches, and disturbance by falling snow were noted.

The forest canopy cover at these sites was estimated using a dot grid analysis of black and white photographs taken with a Konica Autoreflex T camera equipped with a Pentax fisheye lens.

4-6 Measurement of Forage

4-6.1 Measurement of Forage Abundance and Availability

The relative abundance of shrub forage was estimated in selected forage communities using the Wilderness Ecology methods of Ohmann and Ream (1971a) (see 4-4). Detailed forage abundance and availability measurements were considered to be beyond the scope of this study; variability created by seismic line cuts and by differential snow depth and ablation and other factors is manifest in the area's vegetational mosaic.

4-6.2 Measurement of Forage Quality

Selected forage species were sampled to broadly define browse quality and its change with season. The species, chosen on the basis of abundance and documented importance to moose, were two willows, lodgepole pine, white spruce, aspen, bog birch, alder, and an arboreal lichen (Alectoria spp.). Randomly selected plants were chosen from representative forest and ecotone areas which could be easily reached during the winter. Sampling occurred in May (Spring), November (Autumn) of 1973, and monthly during the adverse period (December - March) of 1973-1974. The forage samples were systematically collected within the same 12 hour period and air dried. The browse consisted of current year's growth and any plant material attached to the current year's growth at the time of sampling. That is, leaves were not separately sampled. Forage samples were oven dried at 85°C for 24 hours and ground to a fine texture using a Wiley mill. Two analyses undertaken were:

1. Crude Protein Determination

   Crude protein, usually the most important nutrient to wild ungulates, includes both true protein and nonprotein nitrogen. Rumen function is impaired by low levels of protein. The modified semi-micro Kjeldahl method of Nelson and Sommers (1973) was used to evaluate crude protein duplicate samples of selected forages utilized by moose.

2. Quantification of Lignin Content

   Lignin is a complex component of plants that is virtually non-digestible. The Acetyl Bromide method of Morrison (1972) was used to determine lignin values which indicate the digestibility of forages.

4-7 Forage Use by Wintering Moose

4-7.1 Rumen Analysis

Rumen samples were collected to determine the general food habitat preferences of moose in the boreal forest. A sampling bias occurred because of the ease with which autumn (hunting season) material is obtained and because out-of-season killing on a large scale was undesirable. A few winter samples were obtained from one harvested moose, road kills and poached animals. Rumen contents were thoroughly mixed *in situ* and a large sub-sample removed and stored frozen in plastic bags. Winter sampling was sometimes difficult as freezing conditions prevented thorough mixing of the rumen contents. Sub-samples (ca. 1 litre) were removed from the thoroughly mixed, thawed large samples and washed, 250 ml at a time, through a 4 mm sieve with a constant flow of water (Eastman, 1974). Identifiable plant material was separated, placed on paper towelling, and then volumetrically measured to give percentage estimates of volume.

4-7.2 Trailing Studies

Harry (1957), Knowlton (1960), Ritcey (1965), Peek (1974), Eastman (personal communication), and Peek *et al*. (1976) documented forage use by moose by employing a trailing technique. The basic method involves trailing fresh moose sign for various distances and observing instances of forage use. Peek (1974) recognized definite constraints to the method, viz:

1. Determination of what constitutes "fresh use".
2. Differential observability of use of different plants.
3. Determination of a single *bite*.
4. Definition of feeding areas (casual feeding or curious browsing *vs* preferred feeding areas).

During the 1973-1974 winter period, the fresh tracks of several moose were followed and en route their use of forage recorded; undoubtedly bias occurred in sampling as ease of access to the tracks varied greatly through the winter. The vegetation keys of Morris et al. (1962) were used to identify unknown species. Data recorded include:

1. Time during the winter.
2. Species eaten.
3. Number of bites per shrub, if applicable.
4. Height of bite above snow level as determined by visual estimate.

For the purpose of the trailing analysis, the following statements apply:

bite: An uneven but characteristic twig break assumed to be one incidence of browsing.

shrub: A stem or group of woody stems that constitute, based on visual judgement of stem proximity, a single plant. Snow accumulations precluded the use of a demarcation of a shrub as a plant having a stem completely surrounded by soil or similar definition.

Data were analyzed using n-way joint frequency distribution CROSS TABS programs and an IBM computer (Nie et al., 1970). Casual observations of moose foraging or evidence of moose foraging were recorded to provide a broad data base to quantify moose food habits. Observations of experienced northeastern British Columbia outdoorsmen were also recorded. The data obtained from the several food habit techniques were pooled and summarized. Each technique had its limitations. Moose food habit studies of other researchers are presented for comparative purposes.

4-8 Procedures for Estimating Winter Dispersion Patterns of Moose

Dispersion patterns of moose in winter habitats were difficult to determine. Snow conditions and depths in excess of 76 cm reduced mobility by both food and vehicle. Rolling forested terrain, usually devoid of outlook points, reduced ground reconnaissance efficiency. Helicopter and fixed wing surveys, completed by ground truthing, provided most of the moose dispersion information in the winter habitats. The helicopter (Bell Jet Range 206 B) flights were more or less orientated in a rough north-south direction; the fixed wing (Cessna 172) searches were more precise in north-south direction being parallel to the configurations of the terrain. Much of the aerial reconnaissance was concentrated on observing moose in winter habitats rather than observations of habitats not utilized by moose.

Harper (personal communication) suggested habitat type, as defined by dominant forest type, was a critical variable in the dispersion of moose. To test this hypothesis, the following general hypotheses were developed, viz:

Ho During the winter period, moose in the Boreal White and Black Spruce Biogeoclimatic Zone are dispersed in (a) preferred habitat type(s);

or

Hi During the winter period, moose in the Boreal White and Black Spruce Biogeoclimatic Zone are dispersed throughout all available habitat types without preference for any (one) habitat(s).

Only a single frequency statistic (viz. delineation of the habitat type in which moose are observed) is required to test these hypotheses. Though this simplistic approach provides important empirical data, other variables were also examined. All were stored in a cassette recorder, mapped on 1:63360 seismic maps, and later recorded on individual observation sheets. Data on record include:

1. Date and time of observation.
2. Position of moose on the slope.
3. Number and classification (if possible) of moose sighted.
4. Number of standing animals.
5. Estimate of the proximity of animals.
6. Simple canopy type.
7. Estimate of slope (steepness).
8. Primary direction of exposure (aspect).
9. Microtopographic direction of exposure (aspect).
10. Forage species utilized during observations (limited observations).
11. Estimated distance of moose from maturing coniferous canopy (limited observations).

In addition, the Canada Land Inventory, Forest Cover, Soil Association and transposed moose dispersion maps contributed the following information as map overlays (1:126720):

1. Recent modification of the land (if any).
2. Forest cover type (B.C. Forest Service).
3. Canada Land Inventory Wildlife Capability.
4. Canada Land Inventory Forestry Capability.
5. Canada Land Inventory Recreation Capability.
6. Soil Associations (Lord, 1972 unpublished).
7. Co-ordinates of moose observation locations (.8 km grid).

Details are appended (Appendix 11).

Data from two related studies, the aforementioned trailing analysis to determine food habits, and a study of bed site characteristics, were incorporated with these data. At a limited number of fresh moose beds, characteristics such as aspect, slope, dominant cover, browse species composition, and snow depths, were recorded.

Data for the 1973-1974 winter period were subjected to Multiple Classification Analysis (MCA) programs as documented in Le (1972) and Andrews et al. (1973). The MCA programs

> "examine the interrelationships between several predictor variables and a dependent variable within the context of an additive model". (Andrews et al., 1973).

As part of the multiple classification analysis (super vide), a multiple regression technique, summarized

> "the effect of each predictor variable on the dependent variable both before and after taking into account the effects of all variables". (Andrews et al., 1973).

For the purpose of this project, the dependent variable considered was MOOSE DISPERSION and eight predictor variables were chosen from the literature and my data (Table 1). Development of the MCA technique required several computer runs. Reported results, for the early winter (November 1 - January 15) and later winter (January 16 - April 1) periods, represent an aggregation of similar data, viz. data were summed for census cells of the systematic grid. MCA printouts presented several valuable statistics of which three are detailed. The squared multiple correlation coefficient evaluated the proportion of observed moose dispersion variance explained by

TABLE 1

A SUMMARY OF PREDICTOR VARIABLES USED IN THE MULTIPLE CLASSIFICATION ANALYSIS

Predictor Code	Predictor	Rationale for Predictor Use
CAN	Forest Canopy Type	Description of simple forest canopy type (as a habitat description)
SLP.	Slope	Indication of any topographic preference of moose. Harper (pers. comm.) theorized that mid-slope areas were important for thermal reasons in mid-winter.
ASP.	Aspect	Measurement or the orientation of the terrain to the sun.
HT.	Height of Forest Canopy	A measurement of the tree layer. The length and type of the canopy influences the degree of cover and amount of browse.
SNO.	Snow depth	Estimation of snow depth during the observation period to examine the effect of snow depth on habitat selection.
MODI.	Recent Land Modification	Definition of recently modified habitat.
EDGE.	Edge Effect	A simple measurement of edge. Cowan et al. (1950) and Eastman (1974) have documented the value of ecotones to moose.
FAGE.	Forest Canopy Age	An estimation of the age of the forest canopy. Effects shelter and forest availability.

the eight predictor variables together (multivariate analysis). The Eta-squared statistic was a one-way analysis of variance indicating the proportion of the total sum of squares explained by each predictor variable (Hudson, 1975). The Beta-squared value measured the unique ability of each predictor variable to explain the variation in the dependent variable while controlling for all other predictors (Andrews et al., 1973). The MCA coefficient for each predictor category indicated the relationship of the predictor variable category and the dependent variable MOOSE DISPERSION.

5. OBSERVATIONS AND RESULTS

5-1 Some Observations and Statistics for Moose in the Peace River District

Statistics for the Cameron River Reserve study area may be usefully set in the context of the larger physiographic area viz. the Peace River area of northeastern British Columbia. Northeastern British Columbia, especially the Peace River area, has extensive areas of choice habitat characterized by the deciduous forage species favoured by moose, a mid-successional species (Dasmann, 1964). The presence of moose in the Peace River district was first noted by Alexander MacKenzie (1801); Williams (1932), Raup (1934), Cowan (1939), and Rand (1944) have provided more detailed population and habitat information. Harper (personal communication) roughly estimated the Peace River area moose population at 50,000 animals. Although moose are distributed throughout the area, numbers in the eastern portions are few as a result of agricultural development and the occurrence of extensive muskeg. Mountain and foothill areas are extremely productive. During mild winters, moose have been observed at altitudes in excess of 1525 m, but severe winter conditions often force the ungulate to the restricted valley bottoms. Though not documented before, it is to be noted that moose in this region migrate from areas of excessive snow depth to areas of lesser snow depth. Migrations of this nature have been documented in other parts of the province (Edwards and Ritcey, 1956; Ritcey, 1965). The Canada Land Inventory has rated the capability of the land of the Peace River district to produce ungulates. Major river valleys were rating extremely "high". Harper (personal communication) suggested a moose density of 4 per km^2 for lands rated as 1W (Appendix 11 explains Canada Land Inventory symbols). A recent revision of ungulate density data suggested that a moose density of 5 per km^2 for the same lands might be estimated (Luckhurst et al., 1975). Thousands of acres of such prime moose habitat, rated 1W and 2W by the Canada Land Inventory to-day, lie beneath the reservoir created on the Peace River for hydroelectric power. The reservoir, partly covered by floating trees and debris, provides a vivid testimonial for the total disrespect shown the environment by the insatiable demands of a growth-oriented human population. Proper management and enhancement of remaining critical habitat is now required.

In the early homesteading days of the first half of the century, moose were a common source of food as the settlers sought self-sufficiency. The only ground travel routes linked the area to northern Alberta. With the construction of the John Hart Highway in 1952 and subsequent paving in 1955, a link from the Peace River district to north central British Columbia was provided. Even with access to the Peace River district, moose hunters from southern British Columbia, frequented areas north and west of Prince George in the central interior of the province. However, the construction workers who came to the Peace River following the decisions to develop the Peace River for power and to export local gas to parts of the United States and British Columbia, soon discovered the excellent moose hunting opportunities in the northeast (Table 2). Moose hunting was further encouraged by a two moose season (1967, 1968 and 1969 hunting seasons)

TABLE 2

MOOSE HARVEST IN NORTHERN BRITISH COLUMBIA
1950-1974 (HUNTER SAMPLE)
(PEACE RIVER AND NORTHERN B.C., NORTH OF 56°N)[1]

YEAR	ESTIMATED NUMBER OF MOOSE HUNTERS	ESTIMATED MOOSE HARVEST	ESTIMATES OF SUCCESS (PERCENT)
1950	1,478	340	23
1951	1,559	265	17
1952	2,012	644	32
1953	380	114	30
1954	1,552	326	21
1955	1,559	608	39
1956	2,105	821	39
1957	2,692	1,373	51
1958	3,554	2,026	57
1959	3,512	2,177	62
1960	3,706	1,779	48
1961	4,091	2,373	58
1962	4,692	3,378	72
1963	5,425	3,038	56
1964	5,943	3,292	55
1965	4,931	2,814	57
1966	5,919	3,646	62
1967	6,188	3,729	60
1968	8,402	5,726	68
1969	6,868	4,120	60
1970	9,683	5,183	54
1971	9,337	5,613	60
1972	8,302	3,410	41
1973	11,750	5,283	45
1974	9,010	3,655	41

[1] Area presently covered by Management Units 7-1 to 7-53, 6-7, 6-17B, 6-16 to 6-29 (1975). Previously Game Management Area 26, 27, 28 and portions of 21 and 25 north of 56°N latitude.

Originally Game Management Area 21

The data presented represent the sum of information for G.M.A. 26, 27 and 28 as very limited access results in insignificant resident harvests in G.M.A. 21 and 25 north of 56°.

in an attempt to utilize the thousands of moose about to be destroyed by rising waters of the Williston reservoir and to shift the hunting public from the central portion of the province. Hunting success was extremely high during this period of time and the Peace River district became known for its abundance of moose (Figure 5). To-day, local hunters constitute only slightly more than fifty percent of the British Columbia hunters in the Peace River area and hunting is largely restricted to the Alberta Plateau as the Rocky Mountain region of the northeast is accessible only by aircraft or horse. Non-resident hunters, attracted by a variety of trophy species and well publicized guiding services, take moose and other trophies almost exclusively from the habitats of the Rocky Mountain region.

The Cache Creek Hunter Check Station, provides age and sex data of wildlife harvested mainly in central and northern British Columbia by both residents and non-residents. According to the 1972 records, 18 percent of the male moose shot and 34 percent of the females harvested by resident hunters in the Peace River district, were old animals, i.e. 5.5 years or older; in 1973, the male moose proportion increased slightly to 19 percent while females decreased to 22 percent.

The British Columbia Hunter Sample, designed to estimate hunter and harvest numbers (Table 2 and Figure 5), shows that, in northern British Columbia, marked fluctuations occur in the numbers of moose hunters and in the estimates of harvests. All of the following influences may well be involved in an explanation of these variations:

1. Variations in the weather.

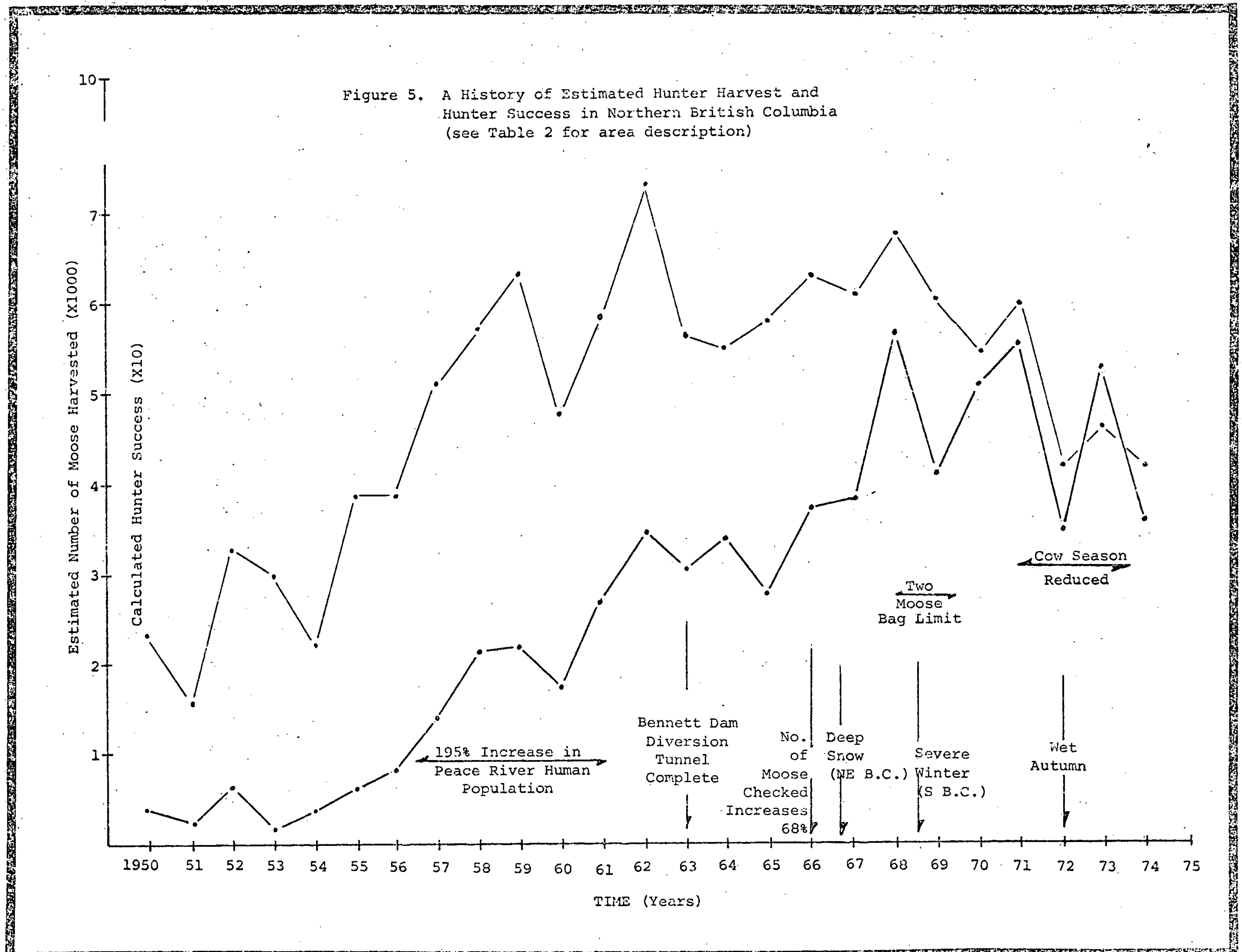


Figure 5. A History of Estimated Hunter Harvest and Hunter Success in Northern British Columbia (see Table 2 for area description)

2. Length and timing of both antlered and antlerless seasons.

3. Changes in hunter numbers and effort.

4. Shifts in hunter distribution.

Averaging the data for four hunting seasons in Game Management Area 28 (M.U.'s 7-19 to 22, 31 to 36, 43 to 46) viz. 1971-1974, about 7,109 moose hunters a year harvested 22 percent of the provincial moose harvest (i.e. about 3,305 moose) in this area alone. Comparisons with harvests of earlier years are not very meaningful as changes in hunter mobility have occurred; in 1950, for example, one half the moose known to be shot in British Columbia were from the area south of Quesnel rather than in the northern portions of the province (Ritcey, 1974).

Data presented for recent Cache Creek Hunter checks suggest a constant percentage of male moose harvested can be considered in the 5.5 year or older age category. A significant reduction in the percentage of older females harvested in 1973 may be the result of a larger aged sample size, a real decrease in female moose surviving to the 1973 season, or, more likely, the effect of a reduced cow hunting season. Life tables and survivorship curves (Eberhardt, 1969) appended, show the differences between moose survival for 1972 and 1973 (Appendix 16). Hunter preference for male moose (selection), vulnerability of the bull during the rut, a short cow season, and the sex ratio of the population, explain the difference in male and female survivorship curves; if the slopes may be taken as the level of exploitation, the 1972 and 1973 harvests may be regarded as acceptable (Larson, 1970). In 1973, the curves for both males and females are very similar. Even if the reduction in the 1973 female harvest is taken into consideration, the harvest may still be considered to be moderate because a large percentage of young moose were harvested; a heavy harvest of older moose would suggest a population of reduced productivity and one which is lightly exploited (Martin, 1956; Simkin, 1964; Lynch 1973, and Cumming, 1974).

The British Columbia Hunter Sample, designed to estimate hunter and harvest numbers, describes an increased male moose kill of 1973 and 1974. Increases in the ratio of the length of bull season to the length of cow season, may partially explain this increase. Ritcey (1974) suggested that selection against calves is strongest where moose are abundant. The juvenile:cow ratio of the kill for Game Management Area 28 (33:100) is considered to be indicative of a lightly hunted area. The juvenile component of the kill as estimated in Table 3 suggests a strong selection against juveniles in the Peace River district.

5-2 Moose Population Characteristics in the Cameron River Reserve

Aerial census reports from years prior to this study were examined to provide an estimate of the size of the moose population in the Cameron River Reserve. However, wildlife census flights have traditionally been conducted to evaluate the sex ratios of moose rather than to provide exact locations of the animal (Robinson, 1962). Only two of the early flights provided accurate moose location information. A Canada Land Inventory survey of March, 1966

TABLE 3
MOOSE CLASSIFIED ON HELICOPTER FLIGHTS
PEACE RIVER DISTRICT
1972, 1973 (B.C. Fish and Wildlife Branch Surveys)

Census Area	Observations				Sex Ratio
	males	females	juveniles	unclassified	F M J
1972					
Peace River	22	68	30	1	100:32:43
Pine River	49	53	25	0	100:92:48
Cameron River-Cache Creek	102	112	48	6	100:91:35
1973					
Peace River	9	46	32	0	100:20:70
Pine River	28	51	39	0	100:54:76
Cameron River-Cache Creek	72	210	110	0	100:34:52
West of Halfway River	34	42	25	0	100:81:60

TABLE 4
MOOSE CLASSIFIED FROM HELICOPTER SURVEYS
CAMERON RIVER RESERVE
1972, 1973, 1974

Flight Date	Observations				Sex Ratio
	males	females	juveniles	unclassifed	F M J
December 5, 1972	79	88	34	5	100:90:39
December 4, 1973	21	23	6	2	100:91:35
December 15, 1973	23	86	39	0	100:27:45
February 22, 1974	56	86	28	56	100:65:33
TOTALS (n=632)	179	283	107	63	100:63:38

included 3 east-west flight transects over the Cameron River Reserve to document dispersion patterns. A second aerial census, conducted by Regional Wildlife Biologist, F.E. Harper, on February 1, 1972, provided a healthy winter sex ratio of 100:62:39 (female:male: juvenile) for some 430 moose observed in or near the study area.

An important, but secondary objective of the study, was to obtain estimates of the size of the moose population wintering in the study area. Aerial census data, gathered mainly for the purposes of habitat use discussions, must be assessed in the light of the limitations of aerial reconnaissance methods. These are well known and have been extensively reviewed by LeResche and Rausch (1974) and Timmerman (1974) who also emphasized the need for caution in interpretation. Important variables affecting the census are the randomness of flight lines, forest cover type, weather and snow conditions, slope and aspect, observer awareness and experience, and pilot awareness and experience.

Accurate population and density estimates are difficult in the absence of known square mile plots or defined flight lines (Lungle, 1971). LeResche and Rausch (1974) found census errors in square mile quadrat sampling through habitat and observer biases. Random and rough transects were utilized here to document moose dispersion patterns in available habitats and to continue long term sex ratio comparisons. LeResche and Rausch (1974) have presented limited data on the effects of forest canopy characteristics on moose visibility in controlled plots in Alaska. Sumanik (personal communication), Eastman (personal communication), Harper (personal communication), and the author have concluded that given a constant, flat terrain with little coniferous cover, a maximum of 80 percent of the moose present are observable from the air but that over the same terrain established to trees with a well-developed canopy, the percentage observed is extremely low. Ritcey (personal communication) suggested search time (intensity), aircraft type and light conditions are important variables linked to forest type. Also, a long search time and a G3B helicopter aircraft may disturb the animals, causing them to "flush" so they can be tallied whereas a short search time with a Bell 206B Jet Ranger helicopter or fixed wing, may not have the same effect.

Wind, temperature, sunshine and cloud influence the ability or opportunity to see moose from the air. Harper (personal communication) suggested optimum Peace River district census conditions during winter exist at about -29°C under high overcast and with calm winds. Ritcey (personal communication) suggested that moose are more likely to bed in the shade on a bright day thus making observations difficult. Fresh snow is usually desirable as the presence or absence of tracks is an indication of whether moose are present. The presence of fresh tracks momentarily increase observer awareness. Ritcey (personal communication) documented reduced visibility with frozen snow or hoar frost on deciduous canopies and it is the author's experience that freshly fallen or wind blown snow on bedded moose reduces their visibility from the air. Gusty or prevailing winds can force moose to the shelter of dense conifer canopies as observed by Sumanik (personal communication) and impairs both mental concentration and physical evidence of the observers.

Variations in slope and aspect affected animal visibility in the survey area. Aircraft type, flight direction and flight speed and height may be determined by terrain types. Attempted fixed wing line transects following east-west seismic lines failed as most lines bisected the north-south trend of the ridges. Low level flight routes, while providing excellent ground visibility on the east-facing slope, were poor for west-facing slope examination as the climbing speed necessary to remain airborn was excessive. North-south flight lines, parallel to the ridges overcame this problem to some extent. Though most of the study area has been modified by fire, some unaltered sites still exist and thus slope and aspect, along with soil type, have influenced the development of the vegetation to a greater extent. Slope and nearness of flight to the slope affected observations. Observers seated in the rear of the aircraft with no forward view, were able to scan parallel slopes easier than flat terrain.

Observer awareness decreased with flight length due mainly to eye fatigue which varied with flying and sunlight conditions. Experience too in viewing moose and habitat in the correct perspective had to be acquired.

Pilot experience and awareness is a combination of knowledge of the area, awareness of animal habits, and interest in wildlife. Most pilots have considerable ability to observe animals from the air. The ability to predict the response of an animal to aircraft and its probable escape route is a desirable quality, especially when a helicopter is used. Sheep, elk, deer and moose react differently to disturbance from aircraft. These reactions may vary from habitat type to habitat type.

Tables 3 and 4 summarize moose classified during helicopter surveys. Sex ratios are affected by the time of flight, the area surveyed and possible differential habitat selection by group and sex (Peek, 1962; Peek et al., 1976). Census conditions were ideal for the December 5, 1972 flight as high overcast at a temperature of approximately -29°C. The bull:cow ratio was 90:100. Many males were observed in the preferred lowland shrub and burn habitats utilized primarily during the post rut period. Thirty-nine juveniles per 100 cows (uncorrected for non-product cows) indicate moderate productivity. A very small portion of the study area was surveyed on December 4, 1973 with male moose prominent in the bog birch - willow lowland shrub of the Cameron River headwaters area. Glare and warm, sunny weather, adversely affected the accuracy of the December 15, 1973 count. A harvest ratio of 224 males per 100 females (74 males, females actually shot) is reflected in the classified census data. The lowland shrub habitats were lightly populated at this time, perhaps due to the recent presence of hunters and use of other habitats. The 45:100 juvenile to cow ratio, represents healthy productivity. One known set of twin calves was observed on a recent burn located on a west-facing slope. The large U-shaped Halfway River valley, the western border of the study area, was intensively searched on February 22, 1974. Clear skies and deep snow conditions resulted in an excellent count. Fifty-six moose could not be classified partly because moose near groups of domestic animals were not classified for fear of disturbing these livestock. Large concentrations of moose were difficult to classify as the helicopter caused the animals to scatter. The difference between the December 15, 1973 (early winter) ratio of 100:27:45 and the February (late winter) ratio of 100:65:33 is, at least, partially explained by the difference in area surveyed, the difference in time of year, the probable difference in animal status (viz. resident versus migrant), and the difference in habitat selection by sexes. The difference in the male components from the two flights may be a result of large numbers of males migrating from an area of lower hunting pressure, i.e. where non-residents are taken on guided hunts, and perhaps differences in male habitat selection (viz. post rut versus late winter). The variations in the juvenile numbers may indicate the influence of possible lower productivity in the foothills, an early winter mortality of 21 juveniles per 100 cows, immigration or emigration of juveniles, or differential observability of cows and juveniles in December and February. However, data previously presented indicates high productivity in the foothill area. Cow: juvenile ratios obtained on the February flight are similar to those obtained by Harper in February, 1972. One hundred and seventy-six of 226 moose observed occurred in approximately 34.2 km of valley habitat. By assuming an average survey path width of .8 km (.4 km on each side of the helicopter), the moose density was calculated as 6.2 ± 1.8 moose/km^2 ($t = .05$).

Estimates of the size of the moose population in the study area may be made utilizing data secured from both aerial surveys and hunter harvest information. Calculations assume that visibility biases associated with the habitat types can be defined and that there is no repetition of survey area. Two February flights over distinct portions of the study area were combined for this estimate; a fixed wing aircraft flight over portions of the area east of the Halfway River and a helicopter survey of the Halfway River valley. Of the 316 moose observed, 187 were seen in open habitats, 90 moose were observed in deciduous forest and 39 in coniferous cover. Discussions in 5-2 have indicated that it is difficult to quantify the visibility biases for the different forest canopy types. However, using all of the information available in the literature and information of other researchers (Ritcey, pers. comm.; Harper, pers. comm.; Eastman, pers. comm.), it is assumed that 80 percent of the moose present are observed in open habitats, 60 percent observed in deciduous habitats and 20 percent in coniferous habitats. Given these assumptions, the population of moose, as determined by aerial survey, can be calculated as:

$$\frac{\text{Number of moose observed in open habitats}}{.8} \quad \text{or} \quad \frac{187}{.8} = 234$$

$$\frac{\text{Number of moose observed in deciduous habitats}}{.6} \quad \text{or} \quad \frac{90}{.6} = 150$$

$$\frac{\text{Number of moose observed in coniferous habitats}}{.2} \quad \text{or} \quad \frac{39}{.2} = 195$$

Total moose population of the census area = 579

Area of moose clumping in preferred valley locations were adequately surveyed but upland areas were only partially surveyed. Five hundred and seventy-nine moose represent a minimum population estimate.

In 1973, 94 bull moose were harvested from the study area. The spring (1974) carry-over count of juveniles was 33:100 cows. Assuming a 50:50 sex ratio for juveniles, the carry-over of bull juveniles was 16:100 cows. If 100 cows produce 16 juveniles, the number of cows required to produce 94 males is:

$$\frac{94 \times 100}{16} \quad \text{or} \quad 588 \text{ cows}$$

Based on the ratio of 100:65:33 (female:male:juvenile), the population is estimated as 588 females, 382 males, and 194 juveniles, or 1,164 moose. This estimate is influenced by unknown numbers of moose migrating to the study area during the winter. The minimum number of moose wintering in the study area ranges from 562 to 1,164 animals.

The calculated cow:juvenile ratio, established through aerial census, represents a mimumum productivity estimate as an unknown portion of females are incapable of reproduction as yearlings and two year olds. Markgren's (1969) conclusion that most females reach puberty at age two was verified in Swan Hills, Alberta by Lynch (1973). Ritcey (personal communication) suggested a small percentage of females breed as long yearlings in southern British Columbia. The cow component of the sex ratio should be adjusted to reflect true productivity. In the absence of quantified variables to develop a confident adjustment factor, sex ratios were compared assuming a constant reproductive portion of the cow moose in the population.

Aerial surveys are valuable in establishing trends in wildlife population parameters. Table 3 presents recent Peace River district moose sex ratios. Unmeasured factors which influence ungulate sex ratios include: a) hunter selection and pressure (access), b) aerial survey conditions, c) observability of moose in varying habitats, d) the area surveyed, and e) the influence of predators. The data suggest the Cameron River Reserve is as productive as anywhere in the Peace River district.

Some biologists (viz. Mitchell et al., 1964; Lynch, 1973) adjust sex ratios for productive females. Unknown factors involved in such an accurate adjustment incude: a) sex ratio of embryos and calves - Pimlott (1959) and Markgren (1969) suggested 55-58 percent of births were males, b) differential age and sex survival. Males enter the critical winter period low on fat reserves and physically exhausted from the rut. Unlike older males, young bulls do not participate strenuously in breeding activities (Markgren, 1974; Harper, pers. comm.). Ritcey (1974) documented yearling male pre-rut vulnerability to hunting in British Columbia; and c) differential grouping and habitat selection by sexes. Aerial surveys are usually undertaken in December to facilitate easy recognition of antlered males. Group age and sex composition influences habitat selection which in turn affects moose observability (Peek et al., 1976).

Considering the factors involved in adjusting for adult productivity, Harper (personal communication) utilized uncorrected sex ratios to manage Peace River district moose populations. Retention of natural population sex ratios, whether 60 percent - 40 percent in favour of cows, as documented by Cowan (1943), or 50 percent of each sex, as suggested by Peterson (1955) and Ritcey (personal communication), is the primary goal of moose management in British Columbia. Differential hunting season length is widely used to manipulate moose sex ratios. Harper (personal communication), Regional Wildlife Biologist for the area, recommended that the high proportion of males in the Peace River moose population be decreased by shortening the length of the cow hunting season in 1973. An increase in the harvest of male moose was documented by the 1973 and 1974 Hunter Samples.

5-3 Distribution of a Sample of Aged Moose

A sample of 63 incisors, 37.5 percent of the known harvest, was aged from the 1972 and 1973 hunter harvest in the Cameron River Reserve. Tables 5 and 6 document the age structure of this sample. The average age of adults harvested in 1972 was 4.9 years of age (n = 37). Over both the 1972 and 1973 seasons, the average age of male moose taken was 4.8 years (n = 40). The average age of females was 4.1 years (n = 14). Moose in the sample ranged from .5 to 12.5 years of age. The average age of moose harvested in the Cameron River Reserve is similar to recent harvests in Big Game Zone 5, Cypress Hills, St. Paul and the mountain zones of Alberta (Lynch, 1973). Lynch (1973) reported an average age of 7.2 for males and 8.2 for females in a lightly harvested moose population in northern Alberta. Cumming (1974) concluded that changes in age ratio related to overhunting were difficult to document. He suggested that an increase

TABLE 5

AGES OF ADULT MOOSE KILLED IN THE CAMERON RIVER RESERVE, 1972 AND 1973

Year	Number of Bulls Harvested	Number of Bulls Aged	Average Age	Number of Cows Harvested	Number of Cows Aged	Average Age
1972	25	11	4.1	25	6	4.3
1973	74	29	5.1	33	8	3.9
Both Years	99	40	4.8	58	14	4.1

Year	Number of Unclassified's Harvested	Number of Adults Harvested	Number of Juveniles Harvested	Total Harvest
1972	1	50	4	55
1973	1	107	5	113
Both Years	2	157	9	168

Table 6

Age Structure Of A Sample Of Moose Harvested By Hunters, 1972 and 1973

Age	1972 Number Harvested	1972 Percentage of Harvest	1973 Number Harvested	1973 Percentage of Harvest	Two Year Total Number Harvested	Two Year Total Percentage of Harvest
0-.5	4	19.0	5	11.9	9	14.2
.5-1.5	3	14.0	6	14.2	9	14.2
1.5- 2.5	2	9.5	7	16.6	9	14.2
2.5-3.5	4	19.0	5	11.9	9	14.2
3.5-4.5	3	14.0	4	9.5	7	11.1
4.5-5.5	0	0	5	11.9	5	7.9
5.5-6.5	3	14.0	2	4.7	5	7.9
6.5-7.5	2	9.5	1	2.3	3	4.7
7.5-8.5	0	0	2	4.7	2	3.1
8.5-9.5	0	0	3	7.1	3	4.7
9.5-10.5	0	0	0	0	0	0
10.5-11.5	0	0	0	0	0	0
11.5-12.5	0	0	2	4.7	2	3.1
12.5-13.5	0	0	0	0	0	0
Totals (n)	21		42		63	
Average ($\bar{x}$) (calves and adults)	3.5		4.4		4.1	
Percentage of known harvest aged	38		37		37.5	

in the percentage of yearlings harvested as a result of increased hunting intensity (20-45 percent of the kill). Simkin (1964) found 24 percent of the harvest in the five and one-half plus age category in easily accessible Ontario moose populations. In isolated populations, however, 59 percent of the harvest was in this category. Reduced pressure and selection were considered important factors in the harvest of isolated moose populations. The harvest of older animals (5.5 years plus) was 24 percent and 32 percent for 1972 and 1973 respectively in the study area. In terms of Simkin's analysis, the area is classified as accessible. The 1973 increase in the harvest of older animals can be attributed to a larger sample size, increased pressure by hunters, and the effect of dry weather on hunter access which made possible the harvest of moose normally inaccessible. Unknown animal movements may also have contributed to this increase. Harvest of yearling moose was essentially constant for both years (14 percent). Life tables developed for the Cameron River Reserve moose population are based on a very small sample size. Data collected for males were used because the sample size was much bigger than that of female moose. Female life tables are, of course, superior to tables based on statistics for males (Henny et al., 1970). Conscious of the data limitations, the life tables and survivorship curves are presented for cautious comparison with Peace River district data secured from the Cache Creek Hunter Check Station (Appendix 12). Survivorship of male moose in the study area was similar to that of the Peace River district male moose in 1972 and greater in 1973.

5-4 Analysis of Major Plant Communities Used by Moose in the Boreal White and Black Spruce Biogeoclimatic Zone

Fire and drainage are two important factors influencing the tree, shrub and herb layers of the vegetation of the Boreal White and Black Spruce Biogeoclimatic Zone. Eight sample plots, representing principal cover types (Figure 6), were selected on the basis of relative layer densities, probable importance in moose dispersion, stand homogeneity and accessibility. These plots were analyzed to define the vegetative characteristics of representative habitats. Three sites were duplicated to test the effect of reducing the 20 sample points of Ohmann and Ream (1971a) to 10 points.

Tables 7 and 8 summarize the cover types studied; summary computer printouts for each plot are appended (Appendix 13). Based on the Wilderness Ecology methods (Ohmann and Ream, 1971a), type vegetation is described as follows:

1. Birch - Willow (Betula - Salix) Lowland Shrub Community

The vegetation of the Betula - Salix lowland shrub community is dominated by thick stands of glandular birch (Betula glandulosa) and willow (Salix bebbiana var bebbiana) of the shrub layer and moss (Hylocomium splendens) and grass species (Gramineae) of the herb layer. There is no tree layer. The Betula - Salix lowland shrub community is restricted to the hydric sites (receiving) located in the headwaters of the small drainages of the Cameron River. The largest area of this community is prominent in the upper Cameron River drainage and was utilized by post-rut bull moose groups in late November and December. The valley bottom location of this community designates it as critical winter habitat though available forage may not be preferred. Domestic livestock use portions of this community under permit.

2. Willow - Alder (Salix - Alnus) Upland Shrub Community

The Salix - Alnus upland shrub community, common on ridges, represents post-fire mesic site revegetation. The tree layer, represented here and there by clumps of decadent willow (probably Salix scouleriana) and rare lodgepole pine (Pinus contorta)

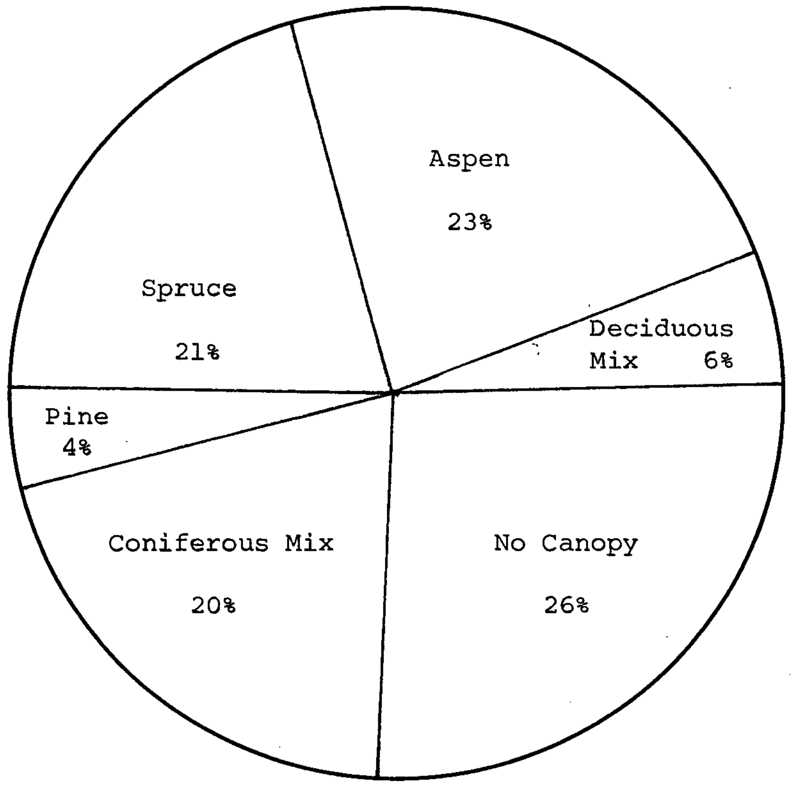


Figure 6. Forest Types of the Study Area

TABLE 7
PHYSICAL CHARACTERISTICS
OF VEGETATION PLOTS

Plot Number	Community Type	Moisture Nutrient Classification	Soil Association[1]	Altitude and Exposure	Estimated Slope ($^{\circ}$)	Average Height of Dominant Tree Canopy (meters)	Average Age of Dominant Tree Canopy (years)
1.	*Betula - Salix*	hydric	Osborn-Nig orthic gray Luvisol	3300' West	5°		
2.	*Salix - Alnus*	mesic	Fellers-Wonowon	3600' East	10°		
3.	*Populus tremuloides* (regeneration)	mesic	Wonowon-Osborn-Jedney orthic gray Luvisol	3000' West	30°		
4.	*Pinus - Populus* (regeneration)	mesic-xeric	Wonowon-Osborn-Jedney orthic gray Luvisol	3600' Southwest	10°	*Pinus contorta* 8 m (n=18)	19 (n=10)

TABLE 7 - Continued
PHYSICAL CHARACTERISTICS
OF VEGETATION PLOTS

Plot Number	Community Type	Moisture Nutrient Classification	Soil Association[1]	Altitude and Exposure	Estimated Slope (°)	Average Height of Dominant Tree Canopy (meters)	Average Age of Dominant Tree Canopy (years)
5.	*Populus tremuloides* (maturing)	mesic	Wonowon-Osborn-Jedney orthic gray Luvisol	3000' West	25°	*Populus tremuloides* 16 m (n=20)	60 (n=19)
6.	*Picea mariana*	hydric-mesic	Osborn-Nig orthic gray Luvisol	3500' East	5°		
7.	*Pinus contorta* (mature)	mesic	Wonowon-Osborn Jedney orthic gray Luvisol	3200' West	20°	*Pinus contorta* 20 m (n=19)	90 (n=16)
8.	*Pinus* - *Picea* (mixed mature)	mesic	Fellers-Osborn gray Luvisol	3100' Northwest	10°	*Pinus contorta* 20 m (n=7)	106 (n=7)

TABLE 8

DOMINANT VEGETATION OF PLOTS STUDIED

Plot Number and Name	Dominants by Layer: Tree	Sapling	Shrub	Herb
1. Lowland Shrub	absent	absent	bog birch	grass
2. Upland Shrub	absent	willow	alder	fireweed
3. Aspen	aspen	aspen	willow	fireweed
4. Pine-Aspen	pine, aspen	pine, spruce	spruce, willow	bunchberry
5. Aspen (Maturing)	aspen	spruce	soapberry	grass, fireweed
6. Black Spruce	absent	black spruce	(rare) willow	lingonberry
7. Pine (Mature)	pine	absent	(rare) high bush cranberry	mosses
8. Pine-Spruce (Mature)	pine, spruce	absent	(rare) high bush cranberry	mosses

and white spruce (Picea glauca) veterans, is extremely sparse. The patchy shrub layer is characterized by clumps of mountain alder (Alnus crispa) with scattered high bush cranberry (Viburnum edule) plants. The herb layer is extremely variable with the alder of the shrub layer a major influence in determining its composition. The herbaceous layer is made up of a decaying litter of alder, willow, and fireweed (Epilobium angustifolium) leaves. Though the willow - alder upland shrub community seems important to moose year round, greatest use of this community was observed in early winter.

3. Aspen (Populus tremuloides) Community

Recent post-fire aspen communities are characterized by thick deciduous aspen (Populus tremuloides) sapling canopies and are widespread throughout the study area especially on shedding locations on ridges. This community provides excellent year round habitat for moose. Summer forage is obtained from the lush fireweed of the herb layer or from the leaves of the dominant saplings and shrubs viz. aspen and willow respectively. Winter browse is easily reached from the preferred willow dominating the shrub layer and the lower shoots of the sapling aspen. Rare young seedlings of either balsam poplar (Populus balsamifera) or aspen - balsam poplar hybrid (Populus tremuloides x Populus balsamifera) received noteworthy winter browsing by moose along edges of roads and seismic lines.

4. Lodgepole Pine - Aspen (Pinus - Populus) Community

Recent post-fire communities located on xeric ridgetops are characterized by vegetation diversity. The fact that the two plots analyzed reflect a difference in vegetative composition indicates the necessity of 20 sample points in highly variable forests. Widely dispersed tree groves of lodgepole pine, aspen and rare white spruce veterans occur with white spruce and lodgepole pine being the main saplings. The variable dense shrub layer of mountain alder, white spruce and willow is underlain by a highly variable herb and little layer with bunchberry (Cornus canadensis), decaying wood and fallen deciduous leaves prominent. Moose were never observed in the sample plot but autumn use was established through hunter observations, known moose harvests and pellet group occurrence.

5. Maturing Aspen (Populus tremuloides) Community

The tree layer of the maturing Populus tremuloides community, identified by the prevalence of aspen, provides limited browse and shelter for wintering moose. However, a well developed shrub layer of soapberry (Shepherdia canadensis), willow and high bush cranberry provide important browse particularly in autumn and early winter. A lush herbaceous cover of grass, mainly bluejoint (Calamogrostis canadensis) and fireweed are characteristic of this community. (Foresters regard maturing stands of aspen as a cover crop for developing white spruce (climax stand) saplings).

6. Black Spruce (Picea mariana) Community

Moist receiving sites, usually located on the lower third of the ridge slopes, are characterized by dense black spruce stands. Moss (1955) suggested this community represents an edaphic climax maintained by poor drainage and periodic fires. In the absence of a tree layer, the stunted growth of the sapling layer, averaging 5.2 m (n=10), provides minimal shelter for wintering moose. In fact, snow stake data presented in 5-5.2 indicate increased snow depths in black spruce communities due to the structure of the canopy. The sparse shrub layer of this community is restricted to a few willow with lingonberry (Vaccinium vitis - idaea) and several mosses (Pleurozium schreberi and Nephroma arcticum) prevalent in the herb layer. Moose use this community as travel through or escape cover areas when they are in the neighbouring lowland shrub community of the valley bottoms and the aspen communities of the upper slopes.

7. Mature Lodgepole Pine (Pinus cortorta) Community

Averaging 19.6 m (n=19) in height, the trees of community viz. lodgepole pine provide possible winter shelter and a secluded habitat for calving. The poorly developed shrub layer consists solely of scattered high bush cranberry plants. A moss, Pleurozium schreberi dominates the herb layer but lingonberry and bunchberry are common. Observations suggest use of this community by moose is limited.

8. Mature Lodgepole Pine - White Spruce (Pinus - Picea) Mixed Community

The mature coniferous mix community of lodgepole pine and white spruce provides winter shelter from possible snow crusting conditions, seclusion and privacy for calving in the spring, escape from the summer heat and escape cover during the hunting season. The effect of the thick canopy is to produce a very patchy shrub layer of high bush cranberry and a herb layer dominated by a moss Pleurozium schreberi, bunchberry and lingonberry. A fresh summer bed and a cow moose were observed in the plot location during a relatively warm period of August, 1973, suggesting the cool reaches of coniferous canopies may be utilized during the few warm days characteristic of this northern clime.

Duplicate plot data indicate 20 sample points per plot of the Wilderness Ecology (1971a) method are desirable in heterogeneous vegetation as exemplified by the lodgepole pine - aspen recent burn community site. However, in homogeneous stands viz. aspen and lodgepole pine - aspen communities, observed variation is expected but minimal with the increased sample size. The intensity of the 10 sample point analysis is considered satisfactory for description of homogeneous communities. The methods may be too detailed and time consuming for general wildlife habitat surveys; however, there is a potential for developing modifications in methodology once the faunal requirements are better known.

Phytological development along roadsides and seismic lines is given in Appendix 14. Several plants are almost restricted to disturbed sites and are rare in communities deemed to be of prime importance to moose. Successional development on the disturbed areas is important but is a direction of study that must be pursued in future work. Because of the vigorous development of shrubs over much of the disturbed area, these areas may well have a definite impact of the suitability of the habitat to sustain a moose population. The logical next step in inventorying the vegetation of the Cameron River Reserve should include a complete analysis and classification of the vegetation resulting from disturbance and its use by moose. Knowledge of the successions in these areas may well be the foundation for moose habitat management in the future.

Oswald and Senyk (1972) documented forest cover anomalies in northeastern British Columbia by reporting black spruce on dry sites and lodgepole pine on wet sites. Stands of black spruce were observed in upland areas (mesic) of the study area but their presence is considered consistent with the soil features described by Lord (1972, unpublished).

The network of seismic lines in the Cameron River Reserve offered a unique opportunity for photographic analysis of vegetative characteristics. Brink (personal communication) suggested systematic photographs could provide a valid basis for dot grid analysis of dominant vegetation. Interception of canopy types by seismic lines is considered random. Attempts to perfect an accurate method were adversely influenced by variations in the depth of field (viz. focal length varied with stand density), development of ecotonal vegetation (impedes accuracy), and other priorities influenced by a short growing season. Lack of success in this instance, however, does not eliminate the desirability of an efficient, accurate photographic method for quantifying representative canopy types adjacent to seismic lines.

5-5 Some Abiotic Components of Winter Habitat

5-5.1 Winter Air Climate

Over 30 years of climatic data exist for the Fort St. John airport station. In northeastern British Columbia, the long winter is characterized by low temperature regimes interrupted by occasional chinooks (foehn winds; see 2-4). Table 9 compares the mean monthly temperatures for the two winters, during which the study was pursued, with the average mean monthly temperatures for the 1942-1970 period.

TABLE 9
MEAN MONTHLY TEMPERATURES FOR THE WINTERS OF THE STUDY, 1972-1973 and 1973-1974 AND WINTER NORMALS (1942-1970) COMPARED

Period	Mean Monthly Temperatures (^{O}C)				
	1942-1970 Normal (A)	1972-1973 (B)	(A-B)	1973-1974 (C)	(A-C)
December	-13	-17	+4	-14	+1
January	-17	-13	-4	-21	+4
February	-12	-11	-1	-11	-1
March	- 7	- 3	-4	-12	+5

The data show that the 1972-1973 winter was warmer than normal with only the month of December recording a mean monthly temperature below the long-term normal. The 1973-1974 winter period can be classified as colder than normal, with February as the only month with a mean monthly temperature above the normal. March 1974 was extremely cold with a markedly lower mean monthly temperature than normal. March is an important month for ungulate survival as low temperatures impede snow cover melt and vegetation development, and generally lengthen the period of winter stress.

During 1973, several new climatological stations were established in northeastern British Columbia by the Canada Department of the Environment. Two of these, Wonowon (mile 101, Alaska Highway) and Pink Mountain (mile 136, Alaska Highway), produced pertinent temperature records. The Pink Mountain station is on the northern boundary of the study area. Appendix 2 gives the mean monthly temperature for Fort St. John, Wonowon and Pink Mountain. The mean monthly temperature of Wonowon (30 seconds north and 36 seconds west of Fort. St. John) is -18°C cooler than Fort St. John, while Pink Mountain (46 seconds north and 1 degree 38 seconds west) is -16°C cooler than Fort St. John. Though topography and altitude represent important unmeasured variables, a general trend of lower air temperatures to the north is described.

Formozov (1946) concluded that moose distribution in Russia was limitely firstly by snow depth and secondly by air temperature. The presence of expanding populations of moose in northern Russia (Formozov, 1963) and the Arctic Slope in Alaska (LeResche _et al._, 1973) would indicate a tolerance for much lower temperatures than are usual for the study area; an area where fluctuation is common. The land area east of the Rocky Mountains experiences chinooks. The effects of these warm, westerly winds in general are less pronounced east of the mountain lee, but the strength of foehn winds, altitude and the presence of other systems, may modify this influence. Though localized chinook conditions often result (Peattie, 1936), mean monthly temperatures do not show the sudden temperature changes associated with foehn winds. Table 10 presents some specific data indicative of chinook conditions. On February 2 and 3, the variation between minimum and maximum Fort St. John temperature was 9°C, while, at Pink Mountain, the same statistic was 23°C. The Pink Mountain station recorded a maximum temperature of -4°C, or 15°C greater than the Fort St. John station. Variation of air temperature is attributed to the localized effect of the chinook in the Pink Mountain area. Conversely, data presented for February 13 and 14 documents temperature changes indicative of a powerful chinook influencing the entire east slope and plateau areas.

The patterns of polar outbreaks for northeastern British Columbia have been established (Tyner, 1951). Large masses of cold air move from the north and east over the Alberta Plateau creating either stormy conditions or periods of extreme cold. Strong northeast winds create large snow drifts. The general effect of winds on ungulate thermal regulation has been documented by Moen (1968). The effects of the cold winds, although not measured in this study, may be an important factor in habitat selection.

TABLE 10
COMPARISON OF AIR TEMPERATURES
DURING CHINOOK CONDITIONS
FEBRUARY, 1974

Date	Temperature by Location							
	Fort St. John				Pink Mountain			
February	Maximum Temperature °C	Maximum Temperature °F	Minimum Temperature °C	Minimum Temperature °F	Maximum Temperature °C	Maximum Temperature °F	Minimum Temperature °C	Minimum Temperature °F
1	-23	-10	-32	-26	-20	- 4	-28	-18
2	-19	- 2	-28	-18	- 7	19	-27	-16
3	-19	- 2	-29	-21	- 4	25	-22	- 7
13	-17	1	-28	-19	-23	-10	-26	-20
14	0	32	-20	- 4	- 1	30	-28	-18
15	4	40	- 6	21	2	36	- 7	20

5-5.2 Snow Cover Measurements

> The state of the snow cover and weather conditions are the most important abiotic factors which create the character of the winter regime.
>
> A.N. Formozov, 1963

Partially as a result of Formozov's classic work of 1946, characteristics of snow cover have received greater attention from wildlife biologists (Edwards, 1956; Pruitt, 1960; des Meules, 1960; Ritcey, 1965; Peek, 1970; Kelsall and Prescott, 1971; Telfer and Kelsall, 1971; Coady, 1973). Edwards and Ritcey (1956) recognized snow as "a major environmental variable affecting the survival, and hence the survival behavior" of moose. Formozov (1946) concluded that snow had a substantial influence on the formation of faunas. He considered moose as CHIONEUPHORES viz. species able to live in areas of considerable snow depth. Deep snow was considered to be a major factor in determining the distribution of moose in Russia.

Snowfall data collected by the Atmospheric Environment Branch of the Canada Department of the Environment are given in Appendix 2. The summary of monthly snowfall shows that snowfall was above average during the first four months of the 1972-1973 winter. Precipitation in the form of snow was well below normal in March and, which when coupled with the milder than average temperatures, resulted in an early spring (Table 11). The winter of 1973-1974 was characterized by near normal early winter snowfall; however, the late winter period was distinguished by excessive amounts of snow. The March snowfall of 76 cm was almost three times the normal measure of 28 cm.

TABLE 11

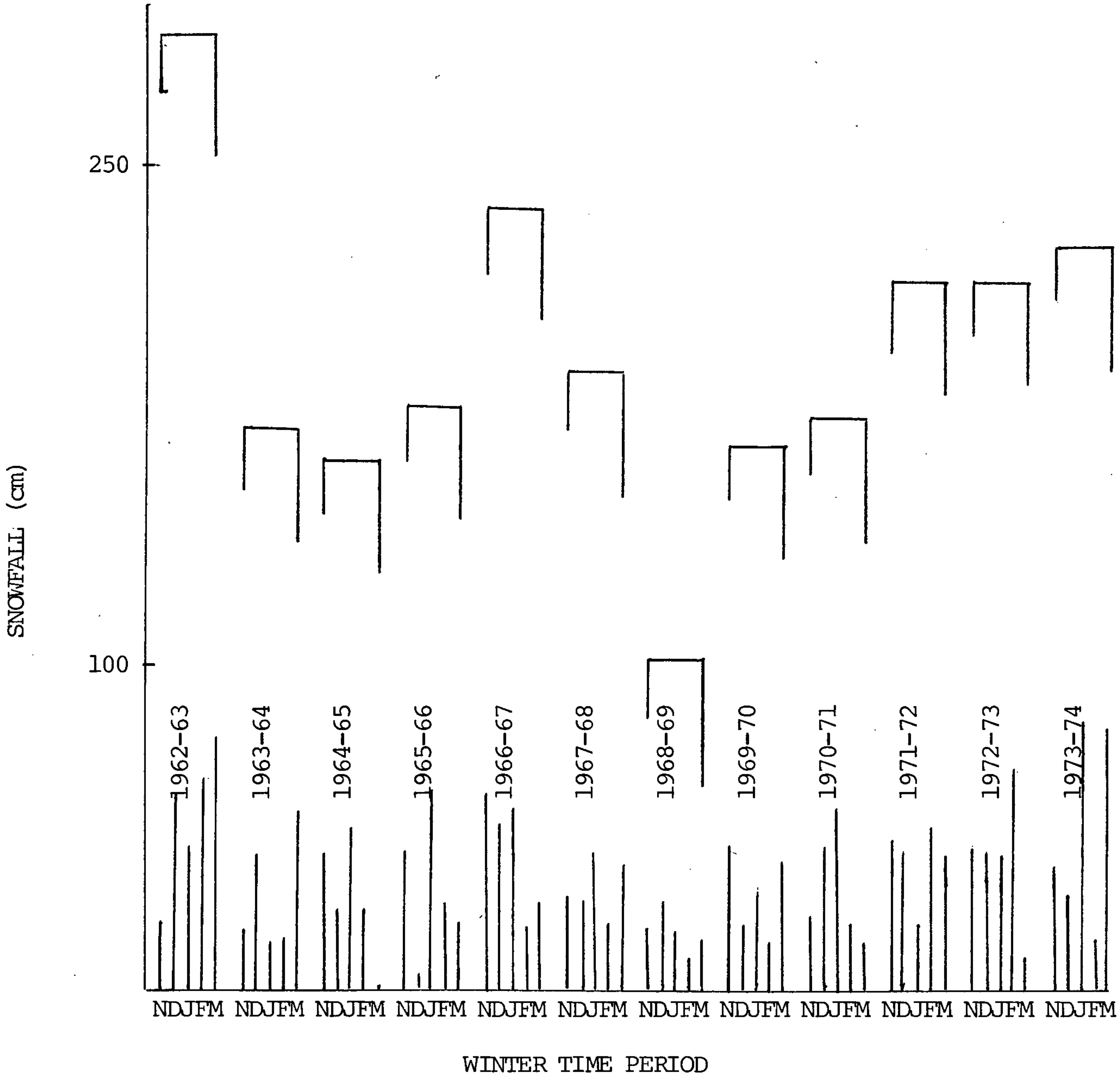
SNOWFALL FOR THE WINTER MONTHS OF 1972-1973 and 1973-1974 AT FORT ST. JOHN AND FOR THE WINTER OF 1973-1974 AT PINK MOUNTAIN COMPARED TO THE NORMALS (1942-1970) AT FORT ST. JOHN

Period	Snowfall (cm)					
	Normal 1942-1970 Fort St. John (A)	1972-1973 Fort St. John (B)	(B-A)	1973-1974 Fort St. John (C)	(C-A)	1973-1974 Pink Mountain
November	30.5	49.6	19.1	36.4	5.9	34.3
December	34.8	49.3	14.5	26.2	- 8.6	15.3
January	35.1	48.3	13.2	77.8	42.7	17.8
February	29.0	63.0	34.0	18.0	-11.0	10.2
March	28.2	8.9	-19.3	76.3	48.1	38.0

The heavy snows and low temperatures confined moose to valleys for most of March 1974. Data presented for the Pink Mountain station suggest that the study area, located in the lee of the Rocky Mountains, receives far less snowfall than the Fort St. John station where shadow effects are less. Fresh snow in March 1974 for the Pink Mountain station was one-half that measured at the Fort St. John station. Yet, because of the uncertain effects of altitude and topography on the Pink Mountain measurements, the short period of station records, and the length of the Fort St. John records, the information of the latter station is considered the best indicator of trends for the study area. The snowfall at the Fort St. John airport is given in Figure 7. The 1962-1963, 1966-1967 and 1973-1974 winters received the greatest amount of snow. Over a ten year history, the March 1974 snowfall is greatest. The late winter snowfall of 1973-1974 is the greatest for the decade.

Comparisons of winter conditions have recently been made utilizing an index comparison method. Picton and Knight (1971) developed a numerical index while studying elk responses to winter conditions in Sun River, Montana. Kohn (1972) employed maximum air temperatures and snow depth to compute "winter points". A simple index of winter severity, based solely on snow cover, was developed for northeastern British Columbia. A snow depth of 76 cm, as suggested by Ritcey (personal communication), Peterson (1955) and Rue (1968), was considered to be an impediment to the movement of moose. Assuming 76 cm of snow increases the energy required for movement or forces the animal to seek the shallower snow beneath coniferous canopies (Eastman, personal communication; Peek, 1970; Peek et al., 1976),

Figure 7. A History of Winter Snow Fall 1962-1974, Fort St. John, B.C.



the number of days in the month with a snow cover of greater than or equal to (76 cm) were computed. The winter severity index was the sum of such days over five months, November to March. Appendix 2 gives winter severity indices using data from the Fort St. John' station. The data suggest that there were only two severe winters in the last ten years, viz. 1966-1967 and 1973-1974. The 1973-1974 winter is distinguished by sixty-nine days of restrictive snow depth.

The figures presented in Appendix 2 document variations in the snow depth between years and cover types. Results are presented without taking into consideration the effects of altitude, exposure, slope, or microtopography in stand sites. Of 10 snow stake sites, data from seven are presented in some detail.

The heavy snowfall of the 1973-1974 winter period has been noted (5-5.2). Table 12 summarizes the effect of different canopies on the depth of snow. Four sites: a) lowland shrub, b) a 1956 recent burn, c) a regenerating aspen, and d) a maturing aspen, gave similar maxima and duration measurements each year. At these sites, interception of snow is minimal since the winter cover is thin. The data clearly demonstrate the inability of the deciduous cover to intercept snow and to modify, in an important way, the patterns of snow on the ground. The data for both winters indicate maximum snow depths in the black spruce sites. The height and structure of the dense black spruce canopy in effect causes snow accumulation, even though, by dot grid analysis, there is a fairly dense canopy. As the maximum height of the canopy is 6.1 m, snow known as qali often accumulates

TABLE 12
A SUMMARY OF SNOW STAKE READINGS IN SELECTED COVER TYPES, 1972 and 1973

Geographic Location	Cover	1972 Maximum Snow Depth Recorded In Periods (cm)	1972 Average Period, Snow Cover (cm)	1973 Maximum Snow Depth Recorded In Periods (cm)	1973 Average Period Snow Cover (cm)	Cover Rating, percent cover (dot grid analysis)
Townsend Creek Drainage, 3000 ft elevation	Willow-birch shrub community, no trees	56	30	75	48	0
Cameron River Drainage, 3200-3500 ft elevation	Recent burn (1956) standing coniferous snags, canopy of woody species lacking	51	28	75	52	0
Blair Creek Drainage, 2900-3400 ft elevation	Aspen regeneration recent burn (1952-1954), Age: 10-30 yrs Ht. 31-107 m	54	28	71	50	30.5
	Aspen, older burn Age: 49-68 yrs Ht. 10.9-19.8 m	53	22	80	47	41.5
	Black Spruce (edaphic climax) Age: 30-40 yrs Ht. 3.0-6.1 m	60	38	81	56	44.0
	Mature Pine Age: 91-100 yrs Ht. 20.1-33.6 m	44	28	64	43	64.0
	Maturing Spruce Age: 91-100 yrs Ht. 20.1-28.9 m	32	20	53	29	74.0

on the wide branches of the low growing trees (Figure 8); the areas immediately beneath the trees have somewhat less snow but noticeable qamaniqs, or a bowl shape depression or snow shadow about the base of a tree, are quite limited (Pruitt, 1960). As gali increases, the weight and volume of the snow load eventually forces the black spruce branches down to release the snow. Also, ablation is probably minimal.

5-6 Measurement of Forage

5-6.1 Comments on Forage Abundance and Availability

The bulk of forage for moose during the winter is browse (Cowan et al., 1950; Harry, 1957; Knowlton, 1960; Ritcey, 1965; Coady, 1973; Peek, 1973; Peek et al., 1976). However, LeResche and Davis (1973) have shown that non-woody species are important to moose in Alaska.

Measurement of useful vegetation is best undertaken during or shortly after the growing season (summer and autumn) or after the growing season viz. during the winter. Measurement of browse takes many forms including leader growth measurement (Houston, 1968), browse surveys (Harry, 1957) or plant density calculations (Ohmann and Ream, 1971a).

The abundance of shrubs and saplings within a given forest canopy is a function of the evolutionary adaptability of the species. Factors such as soils, slope, exposure and drainage combine with external forces, such as fire and man, to mold plant communities.

Figure 8. Snow accumulated on black spruce branches (Qali) often forcing them down and depositing the snow between the close-growing trees.

As plant communities develop and mature, the quantity of desirable moose forage may be reduced and important species may become over-developed to the point of being of little forage value to wintering moose. Also, varying depths and conditions of winter snow, while excluding low growing forage sources, may make taller browse species available and short statured species less available. For the purposes of this study, forage abundance was considered only in the context of the selected forest communities. The shrub analysis of 4-6.1 indicates the relative area of the shrubs in the representative communities (Table 13). The data indicate that a prominent shrub layer occurs in deciduous and mixed recent post-fire communities but is conspicuously absent in the more mature coniferous communities. However, the data, while quantifying shrub density in selected communities, fail to describe the important ecotonal vegetation on disturbed sites. Seismic lines and oil - gas roads have removed and altered vegetation on an estimated 24.4 km^2 (1214 km x 20 m) of the study area. The proliferation of browse species on these disturbed areas is influenced by seed source, soil type, drainage conditions, surrounding vegetation, and exposure. Sampling of disturbed communities is complicated by localized development, the nature of the shape of the communities viz. long narrow seismic lines, and the time the area was disturbed. The data presented describe only the shrub portions of forage in selected communities. The dynamics of shrub and tree utilization as a forage resource as influenced by snow depth and the description of the variable plant communities on disturbed sites, provide topics for further research. Mature coniferous canopies

TABLE 13
SHRUB FORAGE ABUNDANCE IN
SELECTED FOREST TYPES

Major Browse Species (Basal Area/ha^2)	COMMUNITY TYPE: Lowland Shrub	Upland Shrub	Aspen (seral)	Aspen (maturing)	Pine-Aspen (seral)	Black Spruce	White Spruce	Pine-Spruce
Bog Birch	9,989.0							
Willow	1.2		19.4	107.5	21.4	37.2	2.0	
Alder		112.7	2.8		83.6			2.8
High Bush Cranberry		18.6	1.6	1.2				
Rose		2.0	2.8	2.8	.8			
Soapberry			2.4	2.4				
Aspen					83.6			
White Spruce				3.6	44.0			
Black Spruce						13.8		

intercept snow to a lesser degree than less mature stands, perhaps as a result of thinning through competition. Data suggest mature conifer sites provide less canopy cover than similar less mature sites though interception abilities of coniferous species may vary with the characteristics of falling snow. However, as the snow stake data clearly show, relatively mature stands of spruce and pine are associated with relatively shallower snow packs; ablation from the taller canopy is no doubt a partial explanation as relative humidity is commonly very low during much of the winter.

The snow stake data presented verify the favourable winter snow cover characteristic of moose winter ranges in northeastern British Columbia. Deciduous canopies are ineffective in modifying the snow pack, while thick coniferous stands intercept snowfall and effectively reduce snow depth at ground level. The importance of coniferous canopies for moose survival has been documented by Peek (1970), Coady (1973), Peek et al. (1976) and Eastman (personal communication). The snow stake data combined with the winter snowfall regime measured outside the study area, suggest maximum snow depths seldom impede adult moose movements. As the 1973-1974 winter period is distinguished as the severest snowfall period of the last ten years, it is concluded that severe crusting conditions, absent during the two winters of study, exist as the major theoretical factor to force moose to coniferous cover. Harper (personal communication) reported moose tracks sprinkled with blood as a result of snow crust inflicted cuts to the hoof and Peek (personal communication) notes that localized crusting is common in foothill valleys of northeastern British Columbia.

Formozov (1946) and Peek (1970) described falling gali as compacting the snow cover without greatly increasing snow depth. Observations in the thick coniferous canopies of the Cameron River Reserve indicate the result of falling qali is a hard compact area usually of less depth than the prevailing level of snow cover. The observation of Formozov (1946) that the snow cover remains longer in spring under closed canopies is supported by data presented for March 1973 (Appendix 2).

Areas of severe browse hedging were not common in the study area. However, several small areas were noted where aspen and willow stems had been severely browsed. In one instance, the occurrence of a lick was associated with localized hedging of neighbouring browse species. Severe hedging may be compensated to some extent by the summer rest when rapid growth of browse species occurs. Peek et al. (1976) reported browse species could withstand removal of 50 percent of the current year's growth without severe detrimental effects. Over-browsing is site and plant community specific. Current year's growth measurements in the study area ranged from 5 to 76 cm for the preferred species of willow and aspen.

5-6.2 Winter Forage Quality

Table 14 and Appendix 15 give the analyses, for crude protein and lignin, of eight forages used by wintering moose in the study area. These forages, selected on the basis of their use and availability, include two coniferous species for comparative purposes; however, it should be noted that available literature suggests deciduous species are the preferred browse in most areas.

TABLE II-4
CHEMICAL COMPOSITION OF SELECTED
MOOSE FORAGES SAMPLED THREE TIMES
DURING THE YEAR, 1973-1974

Forage Sample	Percent Crude Protein Content (mean of duplicate samples)			Percent Lignin (mean of duplicate samples)		
	Spring (May)	Autumn (September)	Winter (January)	Spring (May)	Autumn (September)	Winter (January)
Willow (*Salix scouleriana*)	8.03	3.04	3.0[illegible]	9.30	10.20	9.6
Willow (*Salix bebbiana var bebbiana*)	7.83	3.17	3.11	7.70	10.90	7.8
Bog Birch (*Betula glandulosa*)	7.62	3.10	2.90	10.30	10.3[illegible]	7.3
Alder (*Alnus crispa var crispa*)	8.0[illegible]	4.67	4.00	7.40	8.20	10.3[illegible]
Aspen (*Populus tremuloides*)	7.04	2.71	3.1[illegible]	11.20	7.10	9.2
Pine (*Pinus contorta*)	3.6	1.8	2.8	13.4	13.2	14.0
Spruce (*Picea glauca*)	2.9	2.7	1.2	8.8	10.5	8.5
Arboreal lichen (*Alectoria spp*)	1.1	1.6	1.9	10.7	10.3	9.4

Crude Protein

The deciduous forages sampled maintained, in winter, a relatively higher crude protein content than the coniferous samples. Quality changes over the season are much as expected on a priori basis. Deciduous samples, taken during the spring and characterized by lush leaf growth and bud development, exhibited the highest crude protein values. Reduced crude protein content is evident in the autumn samples and mid-winter crude protein was extremely low. The samples of coniferous species and arboreal lichen reflect year round low protein content with minimal monthly fluctuations. The data presented, rechecked for laboratory accuracy, suggest the selected forage of the study area to be of sub-maintenance level (less than 7 percent crude protein) for wintering moose. When compared with the values of Cowan et al. (1950), Kelly (1972), Eastman (unpublished) and Oldemeyer (1974), the crude protein values are extremely low. Crude protein values are, in part, influenced by state of phenological development, part of plant sampled and growth site conditions. Gasaway and Coady (1974) suggested that forage selected by moose in winter is near the minimum required protein level. A large rumen fill was thought to

> "Compensate for poorer quality forage as microbes are provided with more substrate which leads to increased utilization of lower quality food". (Gasaway and Coady, 1974)

Tew (1970), documented a wide variation in the crude protein content of aspen over several sites in a localized area. The below normal crude protein levels presented might be explained by: a) procedural errors in collection and analysis of samples, b) dilution effect of not sampling stems and leaves separately, c) genuine low levels of crude protein in forage plants of the study area, or, d) combinations of these. Laboratory procedures were re-examined for errors but duplicate samples were extremely close to original samples. The dilution effect should only affect the spring sample where either the contribution of the leaves or buds may mask the other in determination of an overall crude protein value. The relatively high lignin values tend to suggest that c) is the case for there is a fair positive correlation between crude protein and lignin values in most browse samples (Brink, personal communication). However, relative crude protein values seem comparable to the data of Eastman (unpublished) and Oldemeyer (1974). Reported levels of crude protein should be rechecked before firm conclusions are formulated. Data presented here must be considered as preliminary results.

Lignin

White spruce, the willows and bog birch exhibited a high lignin content of 7-10 percent during the autumn sampling period. Spring and mid-winter values were considerably less. Alder values increased with time indicating very low digestibility by January. Lodgepole pine and lichen (*Alectoria* spp.) readings were constant for the three sampling dates. A spring lignin content of 11.2 percent, an autumn value of 7.1 percent and a relatively high winter reading of 9.2 percent was peculiar to aspen. The relatively low value for September suggests an increase in the digestibility of aspen. These data support the findings of the rumen analysis and the observations of feeding habits. High levels of essential oils in conifers and alder lower palatability and digestibility.

5-7 Forage Use by Wintering Moose

5-7.1 Rumen Analysis

Table 15 and Appendix 16 are summaries of the information gained from the 25 rumen samples analyzed for plant remains. Season, sex, age and behaviour of the animal, range conditions, and analytical techniques influence the kind of information obtained (Eastman, 1974). It is assumed that vegetative material occurred in similar proportions in both the identifiable and unidentifiable rumen portions. August analyses (n=2), representing the summer period, show that about 80 percent of the contents were willow and the remaining 20 percent aspen. Leaves and current year's woody growth comprised most of this material. In the samples collected during the autumn, willow and aspen fragments constituted 46 and 43 percent respectively of the identifiable material. Lignin values for this period (5-6.2) indicate relatively high digestibility of aspen browse. It should be noted that Tew (1970) suggested that differential times of leaf drop on certain trees may result in quality differences in ingested browse over quite a long period of time during autumn. Two samples examined revealed unusually large concentrations of sedges or sedge-like material; both moose, a male and a female, were harvested in a white spruce forest in the same general area. Although the sample is too small to permit a firm statement, it is interesting

TABLE 15
PREFERRED MOOSE FORAGE SPECIES
AS DETERMINED BY RUMEN ANALYSIS

Forage Type	Composition of Identified Plants (Average Percentage by Volume)			
	Summer (n=2)	Autumn (n=17)	Early Winter (n=2)	Late Winter (n=4)
Deciduous species	100	91	91	100
Willow	80	46	95	54
Aspen	20	43	5	43
others	0	11	0	3
Coniferous species	0	Tr	0	0
Forbs	0	9	9	Tr
Graminoids	0	Tr	0	0

that the data support the belief that, in the rut, certain open habitats are used. It is also interesting that bunchberry (Cornus canadensis) appeared in an October rumen (sample 31-37) obtained from a female moose shot by a resident hunter. The occurrence of bunchberry in trace amounts not only suggests limited use of this species but also reflects wide ranging habits of the moose; the animal was harvested on a road near a mature pine - spruce community and where the slope was in excess of 25 degrees. The steep slope undoubtedly allowed the short-necked moose to easily crop the low-growing bunchberry, a view that has received support by observations presented elsewhere (5-7.3). LeResche and Davis (1973) reported spring use of bunchberry by moose in Alaska. Traces of lodgepole pine needles in several autumn rumens are consistent with the use of jackpine (Pinus banksiana) reported by Peek et al. (1976) for boreal forest habitats of Minnesota. Early winter analyses were composed mainly of willow; trace amount of cow parsnip and Jacob's ladder (Polemonium spp.) present in one sample indicate limited use of non-browse species. The small early winter sample size may not fairly indicate the heavy use of aspen and other tree species. Aspen dominated samples collected in late winter (54 percent) but willow accounted for 43 percent of the volume. Traces of raspberry identified were consistent with trailing observations (5-7.2).

5-7.2 Trailing Studies

A total of 5,342 instances of moose foraging were documented for the 1973-1974 winter period. These data represent but a fraction of the desirable sampling intensity. Poor winter access, other research demands on time and lack of field assistance influenced the sampling. Tables 16 and 17 summarize the composition and foraging height of preferred winter forage sources as determined during trailing. Summaries of these observations indicate that 53.3 percent of the total winter diet was willow while aspen and bog birch contributed 15.4 and 14.2 percent of the total diet respectively (Figure 9).

Foraging activity was concentrated between 0.6 and 1.8 meters above snow level with 64 percent of the observed use (bites) occurring in this height range. Browsing in excess of 2.4 m was rare (1 percent). During the early winter period, 37 percent of the observed forage selected was willow and low growing plants such as alder and high bush cranberry received moderate use. Late winter data indicate that preference by moose for willow increased to 57 percent; snow depths to 84 cm covered the short plant species. Consequently, foraging was concentrated between 0.6 and 1.2 m. However, cratering activities and utilization of plants in qamaniqs accounted for 7.2 percent of the late winter diet. Debarking of aspen was observed in the late winter - early spring transition, suggesting that bark provides some attraction during the period of sap mobilization (Figures 10 and 11). Symington (1960) and des Meules (1968) concluded that debarking of trees during winter indicated a browse shortage and critical snow conditions but that spring debarking suggested a marked preference for highly palatable bark and cambium. Des Meules (1968) also noted that not all moose obtain spring forage by debarking. The low percentage of alder and birch in the overall diet may be the result of a repelling chemical; Ahlen (1968) suggested

TABLE 16
WINTER FORAGE PREFERRED BY MOOSE AS
DETERMINED BY TRAILING ANALYSIS

	Forage Source		Percentage Composition of Total Plants Browsed (n = 5,342)
WOODY SPECIES	Willow	(*Salix spp*)	53.3
	Aspen	(*Populus tremuloides*)	15.4
	Birch	(*Betula glandulosa*)[1]	14.2
	Alder	(*Alnus crispa*)	7.0
	High Bush Cranberry	(*Viburnum edule*)	4.2
	Raspberry	(*Rubus idaeus var strigosus*)	2.4
	Rose	(*Rosa acicularis*)	0.4
	Labrador Tea	(*Ledum groenlandicum*)	0.4
HERBS	Fireweed, Cow Parsnip and other herbs	(*Epilobium angustifolium*, *Heracleum lanatum*, etc.)	2.7

[1]Paper birch (*Betula papyrifera*) was used on one occasion; it is not common in the area and tends to occur in isolated groves. It is, however, common in other parts of northern British Columbia.

TABLE 17
BROWSING HEIGHT DURING THE WINTER PERIOD
AS DETERMINED BY TRAILING ANALYSIS

Height of Browsing Point Above Snow Level	Percentage of Total Browsing Points (n = 4,489)
Snow - .6 m	12.3
.6 - 1.2 m	36.8
1.2 - 1.8 m	27.4
1.8 - 2.4 m	7.5
2.4 - 3.0 m	0.6
3.0 m	0.7
Not recorded	14.7

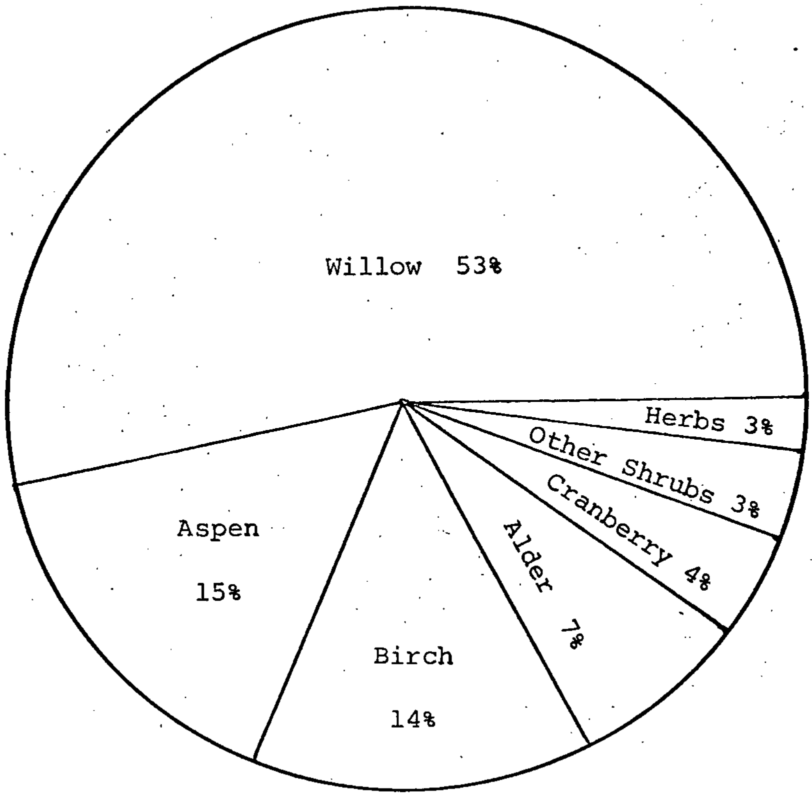


Figure 9. Winter Forage Sources of Moose as Determined by Trailing Analysis

Figure 10. Extensive areas of debarking of decadent willow and aspen was observed in the spring of 1974.

Figure 11. Marks left by frontal teeth indicate method of bark removal.

that these high protein forages contain chemical repellents especially as young plants.

Comparison of rumen analysis and trailing technique data reveal minor differences in ranking of important winter forage sources (Table 18). Willow plants constituted the most important forage source throughout the winter period. Hybridization of willow plants and identification of species during the dormant period influenced accurate documentation of willow species use. Salix bebbiana var. bebbiana of lowland shrub areas received little use, especially when large shrubs of the preferred Salix scouleriana existed. Aspen and bog birch were of secondary importance. Data presented must be regarded with some caution because of the small sample size.

The relative importance of forage sources during the winter period for various locations in North America is comparatively examined in Table 19. Data collected resembles the Alaskan data of LeResche et al. (1973) and Spencer and Chatelain (1953 in Peek, 1974). LeResche et al. (1973) concluded that paper birch, willow and alder comprised the bulk of winter forage secured from the tall shrubs of the Kenai peninsula of Alaska. Spencer and Chatelain (1953 in Peek, 1974) reported major use of quaking aspen in south central Alaska. Peek (1974) provided a detailed analysis of food habits of North American moose and suggested food habit studies in successional sequence would be valuable. Variations in methods, sampling, and biological factors, make comparisons difficult. The data presented for northeastern British Columbia, preliminary as it may be, is a basis for a future detailed browse production (as a function of successional patterns) and utilization study.

Table 18

Important Winter Forage Sources For Moose In Northeastern British Columbia

Plant Species		Method of Analysis Rumen	Trailing
		(order of preference)	
Willow	*Salix spp*	1	1
Aspen	*Populus tremuloides*	2	2
Bog Birch	*Betula glandulosa*	3	3
Alder	*Alnus crispa*	5	4
High Bush Cranberry	*Viburnum edule*	4	5

TABLE 19
KNOWN IMPORTANT FORAGE
SOURCES FOR MOOSE IN
NORTH AMERICA (Ranked)

	WINTER FORAGE SOURCE		REFERENCE					
			SILVER NE B.C. 1976	EASTMAN N B.C. unpub.	RITCEY S B.C. 1965	LERESCHE *et al* Alaska 1973	PEEK *et al* Minn. 1976	SMITH Montana 1958
DECIDUOUS	Willow	*Salix spp*	1	1	1	3	1	1
	Aspen	*Populus tremuloides*	2					
	Birch	*Betula glandulosa*	3				2	
	Paper Birch	*Betula papyrifera*		2	3	1		
	Red Osier Dogwood	*Cornus stolonifera*		4	5			2
	Alder	*Alnus crispa*	4			4		
	Beaked Hazel	*Corylus cornuta*					3	

TABLE 19 - Continued
KNOWN IMPORTANT FORAGE
SOURCES FOR MOOSE IN
NORTH AMERICA (Ranked)

	WINTER FORAGE SOURCE		REFERENCE					
			SILVER NE B.C. 1976	EASTMAN N B.C. unpub.	RITCEY S B.C. 1965	LERESCHE *et al* Alaska 1973	PEEK *et al* Minn. 1976	SMITH Montana 1958
DECIDUOUS	Low Bush Cranberry	*Vaccinium vitis-idaea*				2		
DECIDUOUS	False Box	*Pachystima myrsinites*			2			
DECIDUOUS	High Bush Cranberry	*Viburum edule*	5					
DECIDUOUS	Hazel	*Corylus Californica*			4			
CONIFEROUS	Subalpine Fir	*Abies lasiocarpa*		3				

5-7.3 General Observations of Moose Food Habits

The study provided a variety of qualitative observations to be made on forage use by moose. A terrain that offered few vantage points for observations prevented the use of such methods as animal minute quantification of moose foraging. However, occasional direct observations of moose foraging and observations of moose browsing activity were used to establish forage preferences.

Spring

Observations of willow and alder debarking were recorded and complement the previous documentation of aspen debarking. Later in the spring, the use of coltsfoot (*Petasites frigidus*) stems and flowers indicates a turn to lush, new growth as winter faded. Two separate observations substantiate this conclusion. A cow and unclassified yearling moose were observed foraging on a disturbed mound of earth bordering the Alaska Highway. Examination revealed extensive use of new coltsfoot and fireweed shoots. Observations along the Westcoast Transmission line during the spring suggested that heat generated from the underground gas stimulated rapid spring green-up of vegetation on the mound of earth immediately above the pipeline well before natural green-up of surrounding vegetation occurred. Use of new grass and coltsfoot shoots by moose were noted on this mound. In both cases, the opportunity for the short-necked moose to use the low-growing herbs was aided by the elevation of the disturbed soil (Figures 12 and 13). Charman (personal communication) also reported early use of the same pipeline right-of-way by deer in southern British Columbia.

Figure 12. Warmth generated by the underground transportation of natural gas stimulates early spring growth of herbs and grass.

Figure 13. Coltsfoot plants produce shoots very early in the spring over natural gas lines. It provides important early spring forage for moose.

Summer

Limited summer observations of moose foraging indicate extensive use of fireweed; observations also made by LeResche and Davis (1973) in Alaska. An instance of the use of rock harlequin (Corydalis sempervirens) was noted. This plant is uncommon in the study area. Cultivated oat crops (Avena sativa) were also used.

Autumn

Hunter pressure and rut activities made moose difficult to observe and few opportunities were provided to observe moose food habits. Little (personal communication) reported the use of clover (Trifolium - probably pratense) and Breitkreutz (personal communication) documented instances of debarking of aspen blowdowns in October.

Winter

LeResche and Davis (1973) documented the importance of non-browse foods to wintering moose in Alaska. Pawing or cratering exposed low-growing plants in a crater of snow. No written record of cratering by moose in British Columbia exists. Several outdoorsmen have observed cratering activities by moose in northern B.C. During the course of this research, many craters were seen, examined, and the forage taken from them identified. The first instance of cratering, observed in January 1973, consisted of a trampled area of approximately 46.5 m^2. Extensive use of bulrush (Scirpus microcarpus), which in summer grow in several feet of water, was evident. A mesic, west-facing slope, dominated by aspen, bordered the marsh. Disturbed roadside and seismic line sites provide an excellent environment for fireweed growth and cratering was common in such areas. An abandoned sand pit near the height of land between Blair and Townsend Creeks was extensively and frequently cratered through the 1973-1974 winter period. A fireweed sample, secured in March for crude protein analysis purposes, yielded an extremely low crude protein value of 1.84 percent. Cratering to obtain vigorous raspberry (*Rubus idaeus* var. *strigosus*) plants commonly occurring on disturbed roadside sites was also noted (Figure 14). Cratering for cow parsnip (*Heracleum lanatum*), illustrated in Figures 15 and 16, rounds out the evidently considerable list of species sought for by cratering. Recent land clearing for agricultural purposes, allowed establishment of healthy cow parsnip plants which, in turn, attracted wintering moose. Cow parsnip in craters was commonly observed along vehicular travel routes (disturbed soils). Portions of the plants remaining in the crater were sampled in March 1974. A very low level of 1.3 percent crude protein indicates the plant is a very poor source of fixed nitrogen but may serve other dietary needs. Observations presented in Appendix 17 show that cratering for grasses (mainly *Bromus* spp.) occurs. Stooks of oats in the Halfway River valley attracted twenty-two moose to a field during February and March 1974. Aided to some extent by pawing of several horses, the moose obtained oat plants by cratering and frequently kneeling to obtain the forage in a manner similar to that seen in Alaska by LeResche and Davis (1973) (see also Figures 17 and 18). Browse species, bog birch for example, covered by snow, were also exposed by cratering and eaten. Eastman

Figure 14. Cratering for raspberry was common at this disturbed site throughout the winter of 1973-1974.

Figure 15. Cratering for Cow Parsnip in the Halfway River valley on a recently cleared field.

Figure 16. Cow Parsnip was taken both above and below the snow line at various locations in the study area.

Figure 17. Stooks of oat sheaves provided an artificial forage source for 22 moose during the winter of 1973-1974. Four horses shared this resource.

Figure 18. Cratering for oats often resulted in moose having to kneel to secure forage.

(personal communication) reported extensive cratering by moose for unknown species in the Spatsizi Plateau region of northern British Columbia.

5-8 The Dispersion of Moose in the Habitats of the Study Area

Moose in the Cameron River Reserve are widely dispersed in spring, summer and autumn. With the effects of climate minimal and preferred forage abundant, behaviour is a major dispersion factor during the post-winter period. Dispersion data for spring are scanty and it is almost as though the large valleys, the center of winter activity, are vacant during this period. The majority of the large wintering concentration in the Halfway River valley in 1973-1974 moved rapidly to the ridges to the west and east as rising temperatures decreased the snow pack. The warmth generated from the sun shining on the thick, black winter coat, the glare from melting snow (Gosling, personal communication), and the effect of spring heat on tick infestations may be important factors in the induction of movements to coniferous cover. Harper (personal communication) also noted the importance of the coniferous stands of the islands of the Peace River for calving. Beattie (personal communication) reported the use of conifer stands near water courses for calving in foothill areas. The shift in May to secluded cover by cow moose is probable but was not personally observed in this area. Markgren (1969) documented the need for secluded calving locations by moose in Sweden.

Observations of moose in summer were restricted by thick foliage. A short, summer helicopter search failed to locate any moose within the study area. Though some swampy habitats exist, large bodies of water, providing refuge from black flies, are lacking and the few summer observations suggest that moose seek windy ridgetops with deciduous tree cover. Movements from ridge to ridge were common as shown by tracks on wet soil following summer rain.

During autumn, the dispersion of moose was influenced by behavioural activities associated with the rut and by the presence of hunters. Habitat selection was extremely variable though ridges having diverse coniferous-deciduous habitats, a mosaic of vegetation types and ecotones, were preferred. Appendix 18 diagrams the autumn distribution of harvested moose.

Winter is the period of greatest stress for the populations of ungulates in North America (Pruitt, 1960). Year to year variation in the winter climate is considered the primary cause of natural mortality with shelter, predation and disease as related factors. Observations of moose in the Cameron River Reserve suggest that the dispersion of moose is largely influenced by the snow depth in neighbouring foothill regions and by the abundance and availability of preferred forage. Accumulations of snow in the foothills force moose to the river valleys incised in the Alberta Plateau, viz. the valley of the Halfway River and its tributaries. Ease in obtaining forage is important in providing the energy necessary for moose to exist in the stressful period of winter. The composition of the plant cover, age and sere are important determinants of forage abundance and availability. Data collection for the two winters of the study was influenced by winter severity and budgetary restrictions. The 1972-1973 winter period was characterized by mild winter conditions and moose were widely dispersed. A heavier than usual snowfall in the foothills in 1973-1974 forced a large number of moose to winter in the adjacent river valleys of the Alberta plateau and moose were commonly observed in large concentrations.

Winter dispersion maps (Appendix 18), developed solely from aerial reconnaissance data, document the dispersion of moose in the study area. Clumping was prominent in the Halfway River valley, upper Cameron River headwaters area, and in small old burn habitats. Deep snow in the study area during the 1973-1974 winter period reflects similar conditions in the neighbouring foothills region, although measurements were not possible there. Conversations with trappers verified that the 1973-1974 snowfall in the foothills was exceptionally heavy, restricting travel by snowmobile. Moose sightings in this region were rare. It should be noted, however, that British Columbia Snow Survey do not record a major difference between the years in snow readings taken at selected Rocky Mountain stations. Interestingly, readings for the Pink Mountain station, on the periphery of the Alberta Plateau, support snow stake data presented in 5-5.2. Thus, British Columbia Snow Survey data for the two winters of study, document important yearly differences in snow depths for a station situated near the Alberta Plateau but do not describe any similar trends for mountain stations. Possible explanations of this phenomenon include:

1. British Columbia Snow Survey data represent localized areas of terrain important only for hydrological predictions. Meteorological stations in the northern Rockies are lacking.
2. Localized deep snow cover conditions were characteristic in

only the foothills area adjacent to the study area.

3. Moose were forced from the foothills area by another factor or combination of factors (viz. predators, snow crusting, wind, storms, or lack of preferred forage).

Future studies should attempt to quantify moose dispersion as related to climatological variables comparing foothill and plateau habitats. The observations from the study area show that moose must move to the valley bottoms and low elevation burns.

LeResche (1974) recognized three types of moose migrations:

Type A: Those migrations involving short distances between two seasonal ranges with little difference in elevation.

Type B: Those migrations involving medium to long distances between two seasonal ranges with significant differences between range elevations.

Type C: Those migrations involving medium to long distances between three distinct seasonal ranges with significant differences in range elevations.

Edwards and Ritcey (1956) defined both Type A and Type B moose migrations in central British Columbia. Though quantification of migratory movements by either marking or radio-tracking was not attempted in this study, observations suggest that at least Type A and Type B migrations involve the winter habitats of the study area.

The wintering population of moose in the study was estimated using aerial census data corrected for estimated visibility biases. To document moose dispersion patterns in the habitats, the same data were used <u>without</u> the correction factors. Aerial census data were challenged by observations of moose while on the ground, the trailing of moose in habitats, and the completion of road transects. In all instances, habitat type was defined by a simple expression of dominant forest canopy. Three categories ratings - "coniferous", "deciduous" and "no canopy" were used. The "deciduous" habitat type included communities dominated by aspen, balsam poplar and/or paper birch. The "coniferous" habitat type included canopies dominated by white spruce, lodgepole pine and/or black spruce. The "no canopy" habitat category included shrub communities of willow, bog birch and/or alder and areas dominated by grasses, herbaceous material resulting from recent disturbance (ecotones) and agricultural crops. A continuous tree canopy did not exist though patchy tree areas were common but not continuous enough to be mapped at the forest canopy type level.

The frequency distribution of moose observations in the three habitat type categories are in Table 20. Little differences in early and late winter habitat preferenda can be seen. "No canopy" and "deciduous" habitat account for 80 percent of the observed habitat types. Approximately 20 percent of the moose observed were found in "coniferous" canopies. The limitations of the aerial reconnaissance data have been previously discussed (5-2). Ground observation and road transect data separately support the total data base (Appendix 18) even though distinct biases also exist in these methods. Data from road transects were achieved while traversing established routes but these routes may not intercept all the available habitat types or intercept areas of preferred moose habitat (i.e. areas of highest use by wintering moose). However, the data suggest that moose in the

TABLE 20
EMPIRICAL RESULTS OF VARIABLES
DESCRIBING DISPERSION OF MOOSE IN
WINTER HABITATS

Variable	Observation Frequency (percent)		
	Early Winter (n=179)	Late Winter (n=563)	Change
A. TYPE (Dominant Forest Canopy)			
1. "Deciduous"	39.6	38.0	- 1.6
2. "Coniferous"	19.6	21.2	+ 1.6
3. "No Canopy"	40.8	40.9	+ 0.1
B. SLOPE			
1. 0-10 degrees (flat)	40.2	56.3	+16.1
2. 11-25 degrees (moderate)	53.6	32.5	-21.1
3. 26 plus degrees (steep)	6.1	11.2	+ 5.1
C. ASPECT (Direction of Exposure)			
1. North	2.2	3.9	+ 1.7
2. South	8.4	29.8	+21.4
3. West	50.3	43.3	- 7.0
4. East	38.5	22.9	-15.6
D. SNOW (Estimate of Snow Depth)			
1. 28-38 cm (11-15")	26.8		
2. 38-51 cm (16-20")	73.2		
3. 51-64 cm (21-25")		48.0	
4. 64-76 cm (26-30")		52.0	
E. RECENT LAND MODIFICATION (if any)			
0. Absent	42.5	36.8	- 5.7
1. Fire	39.7	30.4	- 9.3
2. Agriculture	1.1	8.5	+ 7.4
3. Forestry (Logging)	0	0	0
4. Seismic Line	16.2	21.1	+ 4.9
5. Flood Area	.6	3.2	+ 2.6

TABLE 20 (continued)
EMPIRICAL RESULTS OF VARIABLES
DESCRIBING DISPERSION OF MOOSE IN
WINTER HABITATS

Variable	Observation Frequency (percent)		
	Early Winter (n=179)	Late Winter (n=563)	Change
F. FOREST EDGE EFFECT			
0. Not recorded	19.0	5.5	-13.5
1. Edge present	29.1	37.1	+ 8.0
2. Edge absent	52.0	57.4	+ 5.4
G. HEIGHT (of Dominant Forest Canopy)			
0. No canopy	42.5	41.7	- 0.8
1. .3-10.7 m (1-35+')	33.5	33.7	+ 0.2
2. 10.8-19.8 m (36-65+')	17.3	13.5	- 3.8
3. 19.9-29.0 m (66-95+')	6.7	10.3	+ 3.6
4. 29.0-38.1 m (96-125+')	0	0.7	+ 0.7
H. FAGE (Age of Dominant Forest Canopy)			
0. No canopy (sapling)	35.2	38.4	+ 3.2
1. 10-30 years	31.3	27.5	- 3.8
2. 31-50 years	14.5	15.3	+ 0.8
3. 51-70 years	16.8	13.7	- 3.1
4. 71+ years (mature)	2.2	5.2	+ 3.0

Alberta Plateau area of the Boreal White and Black Spruce Biogeoclimatic Zone select habitats characterized by either no forest canopy or a deciduous canopy. Coniferous canopy dominated habitats receive minor use probably due to the suppressed shrub production charactertic of these habitats. All data support the hypothesis:

> Ho: During the winter period, moose in the Boreal White and Black Spruce Biogeoclimatic Zone are dispersed in preferred habitat types;

and further defines the preferred habitat types as a) "no canopy" shrub land, and b) "deciduous" canopies (old and recent burns).

Limited data collected during trailing analysis activities, designed to quantify forage preferences, support the habitat selection information. The majority of the bites recorded occurred in either "deciduous" or "no canopy" habitat types. The few instances of browsing in areas of coniferous habitat were restricted to ecotone areas such as seismic lines and road right-of-ways. Trailed moose tended to pass through conifers to the more abundant forage sources of ecotone and deciduous habitat areas.

Examination of 19 fresh beds indicated a similar preference for areas that were not coniferous. Beds were located an average of 8.8 m from the nearest tree with but a single occurrence of bedding in a conifer-created qamaniq was noted. The nearest tree to the beds averaged 11.4 cm in diameter at breast height, suggesting the tree provided very limited shelter. Previous data suggested coniferous stands nearing maturity provided the greatest degree of snowfall interception and protection from the winter environment. The limited number of moose beds examined along with observations and photographs resulting from aerial reconnaissance suggest a preference for open and deciduous habitats for bedding activities (Appendix 19). Variability of microtopography and the sheltering effect of diffuse deciduous species may provide protection from wind and storms. The radio-tagging of moose or definite searches for animals during storms are necessary to verify these preliminary observations. However, in some study area locations, coniferous cover was virtually non-existent and both aerial and ground observations support the thesis presented. Peek (1971) noted that moose beds in Minnesota were common in the densest coniferous cover during the winter period during all weather conditions. Sumanik (personal communication), working in northeastern B.C., noted a distinct general winter shift from open to conifer habitat influenced by wind during cold weather periods.

Though habitat type was considered the main variable in habitat description, other variables were quantified to provide further informstion on Alces winter habitat preferenda (Table 20). A summary of empirical results follows:

Slope: Moderately steep and flat areas were preferred slopes during the winter period. Steep slopes, although they occur infrequently in the study area, received little use. A definite increase in late winter period moose sightings in flat terrain correlated with an increased use of available habitats of U-shaped river valleys.

Aspect (direction of slope): Due to the north-south orientation of the terrain, east and west aspects predominate. In early winter, 89 percent of the observations occurred on east and west aspects. In the late winter period, however, a marked increase in observations occurred in habitats facing south and west. "Warm" exposures are consistent with moose utilization of river valley habitats during the critical stress period.

Estimated Snow Depth: The data achieved for this variable summarize snow depth estimates for each observation period (i.e. flight, transect) and are of little analytical value due to the range in the depth categories and frequency of observations.

Recent Land Modification: The recent land base modification variable was designed to describe areas altered by nature and man during the last 15 years. Observations of wintering moose in habitats influenced by fire and seismic exploration remained almost constant throughout the winter period while the use of habitats influenced by flooding and agricultural activities showed a marked increase during the late winter period: (viz. those habitats of valley bottoms).

Forest Edge: For the purpose of this analysis, forest edge was defined as a contrast between continuous forest cover types in the immediate observation area. In broad terms, deciduous-coniferous, coniferous-shrubland and deciduous-shrubland ecotones comprise the forest edge vegetation. Data were secured from both field observations and forest cover maps with questionable and missing observations included in the not recorded category. More than 50 percent of both early and late winter observations were characterized by a lack of a continuous forest edge. Typical observations supporting the data include sightings of wintering moose in large burn areas, on grassland slopes, and in fields cleared for marginal agriculture.

Height of Dominant Forest Canopy: The height variable documented tree canopy characteristics independent of canopy type. The data indicate over 70 percent of all moose observations were concentrated in the no canopy and very short canopy (.3-10.7 m) categories. No winter period difference was demonstrated.

Forest Age: Forest canopy age characteristics were secured from forest cover maps to check field assessments. The data document the fact that over 60 percent of all moose were observed in no canopy and limited canopy (10-30 years old) categories.

The Multiple Classification Analysis evaluated the proportion of the observed moose dispersion variance explained by the chosen predictor variables (R-squared). These experimental variables accounted for 43 percent ($R^2 = .43$) of early winter dispersion and 24 percent ($R^2 = .24$) of late winter patterns. These data document the proportion of observed MOOSE DISPERSION variability explained by the analytical model. A stepwise MCA regression procedure was employed to discard predictor variables that contributed little to the overall explanation. Eta-squared and Beta-squared values ranked the importance of the predictor variables (Table 21). Predictor variables EDGE (forest edge, $B^2 = .401$) explained the largest proportion of moose dispersion variability during the early winter period. Variables MODI (recent land modification, $B^2 = .092$) and EDGE (forest edge, $B^2 = .082$) were the most important late winter variables. MCA coefficients of the most significant predictor variables examined positive and negative relationships between predictor variable categories and the dependent variable MOOSE DISPERSION.

Table 21

Relative Ability Of Predictor Variables To Explain Moose Dispersion Variability

Time Period					
Early Winter			Late Winter		
Predictor Variable	B^2	E^2	Predictor Variable	B^2	E^2
EDGE (forest edge)	.401	.440	MODI (recent land modification)	.092	.128
FAGE (forest age)	.015	.076	EDGE (forest edge)	.082	.139
MODI (recent land modification)	.012	.008	ASP (aspect)	.019	.019
ASP (aspect)	.010	.004	SNO (snow depth)	.017	.023
HT. (forest height)	.007	.011	FAGE (forest age)	.006	.023
	R^2 = .43			R^2 = .24	

6. DISCUSSION

6-1 The Dispersion of Moose in the Habitats of the Study Area

This study of moose habitat selection was designed to provide base line information about an important wildlife reserve in northeastern British Columbia. The winter period was chosen for the majority of the fieldwork since the adverse season is extremely important for animal survival, moose are more easily observed, and research funds were very limited. As a result, spring, summer and autumn dispersion patterns were not well documented and data represent very general trends. Ideally, year round habitat preferenda should be described utilizing radio telemetry to monitor movements and overcome the problems of moose observability and behaviour.

All empirical data for the winter period indicate a preference for open shrubland areas and deciduous forest types. Sole use of open areas and deciduous forest by moose in late winter is not common in the literature. Ritcey (1965) concluded snow depth and forage abundance determined winter habitat areas and Franzmann et al. (1974) indicated that wintering moose may have an affinity for birch regrowth areas (73-83%). Mature hardwood (14-17% and spruce regrowth areas (3-11%) received relatively less use. Trailing techniques and bed site analyses of this project support aerial reconnaissance, ground observation and road transect data. During the 1973-1974 winter period, characterized by exceptional snow depths, the data suggest moose failed to shift to the shelter of coniferous canopies and were commonly observed in open habitat types devoid of conifers. In many of the observations of moose in coniferous canopies, accounting for approximately 20 percent over the winter period, ecotone areas, created by seismic line and road construction influences, provided unusual forage sources that perhaps influenced the choice of that habitat (Figure 19). In the Alberta Plateau, snow depth does not seem to influence habitat selection though it is thought to influence Type B moose migrations from the neighbouring foothills area. Available forage sources and the protection from the environment offered by the U-shaped river valleys seem to be the most important determinants of moose dispersion in available winter habitat types (Figure 20).

Peek et al. (1976) documented a mid-winter shift to dense conifer stands by moose in Minnesota. Increasing snow depths and snow texture conditions were suggested as reasons for the shift to tall conifer stands. Thus, both deciduous and coniferous habitats alike received use during the winter period. Similarly, Eastman (1974) concluded that dense conifer canopies provided valuable late winter habitats for moose in the Sub-Boreal Spruce Zone near Prince George. Deep snow conditions necessitated use of coniferous canopies for shelter and some foraging activity. Telfer (1968) suggested deep snow conditions in New Brunswick restricted moose to shelter types and the edges immediately adjoining food-type stands. Smith (1962) concluded that Shiras moose in Montana preferred to feed in areas having sufficient coniferous cover nearby. However, extensive general use of coniferous habitats was not recorded during the 1972-1973 and 1973-1974 winter periods in northeastern British Columbia.

Figure 19. Miles of seismograph lines and pipelines provide edge, forage and travel corridors for moose. Note the use of the ecotone.

Figure 20. The U-shaped Halfway River valley provides a mosaic of habitat types for wintering moose. The foothills of the Rocky Mountains are in the distance (west).

Peek et al. (1974) suggested that large group sizes of moose, in habitats of Alaska, Minnesota and Montana characterized by open cover, may be partially explained by a psychological phenomenon wherein the larger group replaces the vegetative cover. It is difficult to prove such a theory in the study area as deeper foothill snows and the abundance and availability of valley bottom forage sources are also important factors in the dispersion of moose in winter habitats. Peek et al. (1974) concluded that forage abundance, snow conditions and topography played a major role in moose aggregation patterns in the mountainous areas. The location of the Halfway River valley near the foothills, the relatively light snowfall and valley soils rated as having a high capability for the production of forests and browse species alike, support the application of this thesis to at least the western portion of the study area. Though not quantified by this study, limited observations of moose during stormy periods indicate that valley topography provides important shelter and protection from prevailing winds and storms. Perhaps future studies may attempt wind and temperature measurements to establish air movement patterns (Peattie, 1936). Movement of moose from neighbouring ridges to valley bottom habitats during periods of storm or extreme cold is thought to partially be a response to available forage. Open shrublands (bog birch and willow) and riparian vegetation were usually characterized by dense plant populations as opposed to the scattered distribution of the preferred willow and aspen species of upland areas. Utilization of bog birch, not considered a preferred species, provides a large volume of forage within a small area and reduces the energy expenditures associated with searching for forage. Houston (1968) and Geist (1971) suggested that moose populations are widely dispersed in late winter cover having sparse forage sources. It is apparent, though, that dispersion and aggregation patterns developed from aerial reconnaissance are severely limited by methodology biases as previously discussed in 5-2 (Chamberlin, 1972). Table 22 documents the frequency of moose aggregations for the 1973-1974 winter period. The moose is considered to be the least gregarious member of the deer family (Peterson, 1955). Sixty-four percent of the moose observed were single individuals and the largest aggregation was 22 animals. The large aggregations occurred in open habitats consistent with the observations of Peek et al. (1974) (Figure 21).

While Shannon et al. (1975) explained approximately 65 percent of the variability of bighorn sheep spatial distribution ($R^2 = .65$), the low R-squared values reported in 5-8 were influenced by several important factors.

Animal Factors

Behavioural considerations such as rutting, calving, mother-young relationship and male social system had an unmeasured effect on moose observability. The responses of moose to the presence of a large hunter population are also unknown.

Artificial forage sources such as hay, oats and barley may have promoted unnatural dispersion biases. Farmers complained of moose trampling and eating tender oat shoots during summer and concentrations of moose near haystacks were not uncommon. Larson (personal communication) complained of 10 to 20 moose raiding haystacks located

TABLE 22

AGGREGATION SIZES OF MOOSE OBSERVED

Aggregation (number of moose) in observation	Number Of Observations In EARLY WINTER	Number Of Observations In LATE WINTER	Total Winter Observations (n=731)	Percentage (%)
1	141	330	471	64
2	31	115	146	20
3	7	47	54	7
4	2	16	18	3
5	2	10	12	2
6	1	5	6	.8
7		5	5	.7
8		5	5	.7
9		4	4	.5
10	1	1	2	.3
12	1	1	2	.3
13		2	2	.3
14		1	1	.1
15		1	1	.1
17		1	1	.1
22		1	1	.1

Figure 21. Large winter moose concentrations occurred in this sparsely vegetated flood plain area of the Halfway River.

Figure 22. Using traditional winter ranges, moose often become a nuisance by destroying hay stacks.

on the banks of the Halfway River during the 1973-1974 winter period (Figure 22). Cattle refused to eat trampled hay saturated with moose urine. Just south of the study area, Simpson (personal communication) claimed hay losses in excess of two thousand dollars as moose, concentrating in traditional Halfway River winter ranges, were attracted to haystacks in fields.

Possible differential habitat use behaviour by sexes and groups introduced further unmeasured variability. Peek et al. (1974), Peek et al. (1976), documented differential habitat use by moose sex groupings in several North American moose ranges. Evidence of lowland shrub habitat selection by post-rut male groups was noted here but radio-tracking is really required to substantiate these data.

Type A and Type B moose migrations were dispersed in a variety of habitats as a result of geography and topography. Inability to separately describe the habitat selection by these migratory populations may mask the relative importance of each datum.

The study area is characteristic of excellent moose winter range. Perhaps a comparison of several winter ranges having greater contrasts would provide a more complete data base for predictor variable comparisons.

Aerial reconnaissance data document time specific observations of moose in a) habitat without any measure of use of adjacent habitat types (i.e. spruce stringers in brulé areas, coniferous stands bordering riparian vegetation, aspen stands bordering agricultural fields). Daily movements for food and shelter, especially in patchy forest mosaics, were not documented.

The effects of predators on the numbers and dispersion patterns of the moose of the study area received cursory study. Only the very general dispersion patterns of wolves, considered to be the most important predator, are known. In October 1972, McCormick (personal communication) reported a pack of "20 or more wolves" attacked penned domestic calves on the upper Blair Creek drainage. The author observed wolf sign in the same general area but never to a degree indicative of such a large pack. A lone, large, black wolf with a light silver marking on one flank was observed on July 8, 1972 on a ridge to the east of Blair Creek. Wolf sign was plentiful and wolf howls were heard in the immediate area. A wolf of similar description was observed at mile 127.5 of the Alaska Highway but it could not be verified as the same individual even though the observations occurred in the same general area. Westergaard (personal communication) reported that several wolves had surrounded a lynx held by a leg-hold trap and the author observed tracks of a pack of 6 or 8 wolves travelling the mile 132 access road in the same area. A lick at mile 10 of this road received repeated scrutiny. These data suggest a small pack utilized the Townsend Creek, Blair Creek and upper Cameron River drainages. Several cattle were taken in November 1972 by wolves in this latter location. Tracks and scent spots of 4 or 6 animals were recorded here in October and December 1973 and one wolf was observed on a late winter flight. In the southeastern portion of the study area, wolf activity was reported by hunters in October 1972. Meat from several cooling carcasses was scavenged by an unknown number of wolves. Wolf numbers in the Halfway River valley to the west are unknown but complaints of livestock loss and harassment by these canids indicate their presence in the valley. Two moose carcasses, either killed or found by wolves, were observed during aerial surveys. In one instance, December 1973, a small moose carcass was observed in the same general brulé area as two wolves and a cow and juvenile moose. Another kill was observed nearer the Halfway River itself in a coniferous stand but no wolves were observed. Frozen watercourses are known to be used by wolves as travel routes during the winter period. Because of this fact, and considering the large concentrations of prey (moose and livestock) and the nearness of the uninhabited foothills area, the Halfway valley should provide a suitable environment for a number of wolves. However, exact numbers are unknown, as is the habitat selection response of moose to their presence. Beattie (personal communication) suggested conifer stands near watercourses of the foothills were important in early spring. Moose were observed to seek refuge in the icy water when the presence of a newborn calf or the occurrence of crusted snow made other escape from wolves impractical. The author observed moose utilizing a small watercourse as an escape route in an area of heavy snowfall near Revelstoke in southern British Columbia. A moose calf was observed in the cold waters of a beaver pond near mile 108 of the Alaska Highway in October 1973. The victim had been attacked by wolves and had taken to the water either to prevent further attacks or to soothe the wounds already inflicted. Harper (personal communication) suggested islands in the Peace River, dominated by canopies of spruce and balsam poplar, were utilized for calving because of the protection from predators after the river ice had gone. However, Peace River power projects have altered the temperature regimes of the water and it is not known to what extent these island habitats are now utilized. Cow moose must now swim to the islands as the river does not freeze over. A study of wolves and their effects on the wild ungulates of northern British Columbia is needed to provide answers to a number of important questions, the effect of predators on habitat selection being one of them.

Both black and grizzly bears range in the study area but their predation on moose is probably limited to new born calves (Wolfe, 1974). Black bears are common but only a few are harvested as an incidental species encountered during the moose hunt. The population of grizzly bears is very small. A large sow was shot on the ridge between the Halfway and Cameron Rivers in October 1973. In the southern portion of the study area, the same hunters that were harassed by wolves in 1972, lost several prime cuts of moose meat to at least one family group of grizzly bears. Grizzly tracks were also observed in the headwaters of the Cameron River Reserve during October 1973.

Reports of cougar sightings in the vicinity of the study area suggest that this predator may be present but in very small numbers. Rand (1944) reported cougar tracks had been seen in the Buckinghorse River area and two reports of cougar sightings were received during this study. Deer usually provide the bulk of the cougar's diet, however, moose are known to have been taken (Spalding and Lesowski, 1971; Wolfe, 1974).

The effects of other wild ungulates and domestic stock on moose dispersion in available habitats were not examined. A small population of deer share much of the Halfway River break habitats with moose. Wolfe (1974) concluded that deer and moose do not seriously compete with each other and are often oblivious to each others presence. Though caribou are infrequent visitors to the study area, little is known of moose - caribou coactions. Casual observations of caribou driven from the foothills by heavy snowfalls (i.e. to moose habitat), moose and caribou utilizing the same lick south of Pink Mountain and summer observations of moose in caribou habitats suggest a relationship similar to that with deer. Domestic livestock may compete for both herbaceous and browse food sources especially when the range is overstocked by livestock or in poor condition (Wolfe, 1974).

Two smaller animals, namely the beaver and snowshoe hare, may be important to moose. Beaver activities benefit moose by retarding forest succession and stimulating the growth of succulent browse shoots. The effects of snowshoe hare browsing on the flora and fauna of the area is not documented though some general discussions are available for North America (Wolfe, 1974). Definite hare - moose competition was noted for lowland shrub habitats of bog birch and willow. These habitats, located in the valley bottoms, are considered critical wintering areas for moose so that competition would be greatest during severe winters.

Moose are considered the least gregarious of the cervids as large aggregations are seldom seen (Peterson, 1955; Geist, 1963). Geist (1971) concluded that the majority of moose habitat was short-lived sub-climax plant communities. Since the development of the communities is characterized by rapid and erratic processes (viz. fire), a social moose would rapidly deplete productive habitats that are naturally becoming less productive as time passes. Habitat studies of moose must consider this characteristic as moose are much more difficult to observe than a social animal such as sheep. The very evolution of the animal places restrictions on the data base.

The presence and use of several known licks and their influence on habitat selection was not measured.

The effects of disease and parasites on moose productivity were not studied.

Technical Factors

Several variables were chosen in an attempt to explain winter moose dispersion patterns. Many other environmental variables remain unmeasured. These include the effects of artificial forage sources, the role of temperature and radiation, the response of moose to wind speed and direction, habitat use behaviour in storms and chinooks and the effect of ecotonal vegetation on habitat selection. Some of the variable categories were inadequate partly due to unfamiliarity with the analysis. These categories attempted to describe the variability of a predictor variable but there were no treatments per se. Ideally, an experimental design of habitat treatments for fire, agriculture, logging, etc., would provide a stronger analysis.

A number of measurement biases, including the difference in flushing effect of the aircraft, incorrect forest cover typing and canopy visibility differences, occurred.

Variations in procedures and human error were technical factors influenced by weather conditions, time of day, time of year, and monetary and time constraints.

Further analyses, recognizing other variables and using refined methods, are required to accurately define the factors affecting moose dispersion patterns in available winter habitats. This analysis has shown that not only is the choice of variable important, but also the categories of each variable must accurately describe the entire range of variability. Some of the difficulties in explaining variable category relationships are apparent in the data. Predictor variable EDGE, for example, was described by two categories; edge present and edge absent. But edge present described all ecotone areas without distinguishing the full range of edge conditions. Nevertheless, the frequency of moose observations where edge was not present combined with forest cover descriptions, supports the thesis that moose in northeastern British Columbia do not shift to maturing coniferous stands in late winter (Peek, 1962; Eastman, personal communication; Peek et al., 1976). A future examination of forest edge must differentiate between edge types and provide accurate distance measurements (Churchill, personal communication).

Figure 23 diagrams the MCA coefficients of the categories of predictor variable EDGE for the early winter period. A positive relationship to both the presence and absence of edge is shown. During the winter period, moose were dispersed in a wide variety of habitat types as a result of hunting pressure, differential behaviour and habitat selection by sexes (viz. late autumn use of open lowland shrub communities by male groups) and predator pressure. Forage was readily available as the small amounts of snow did not restrict

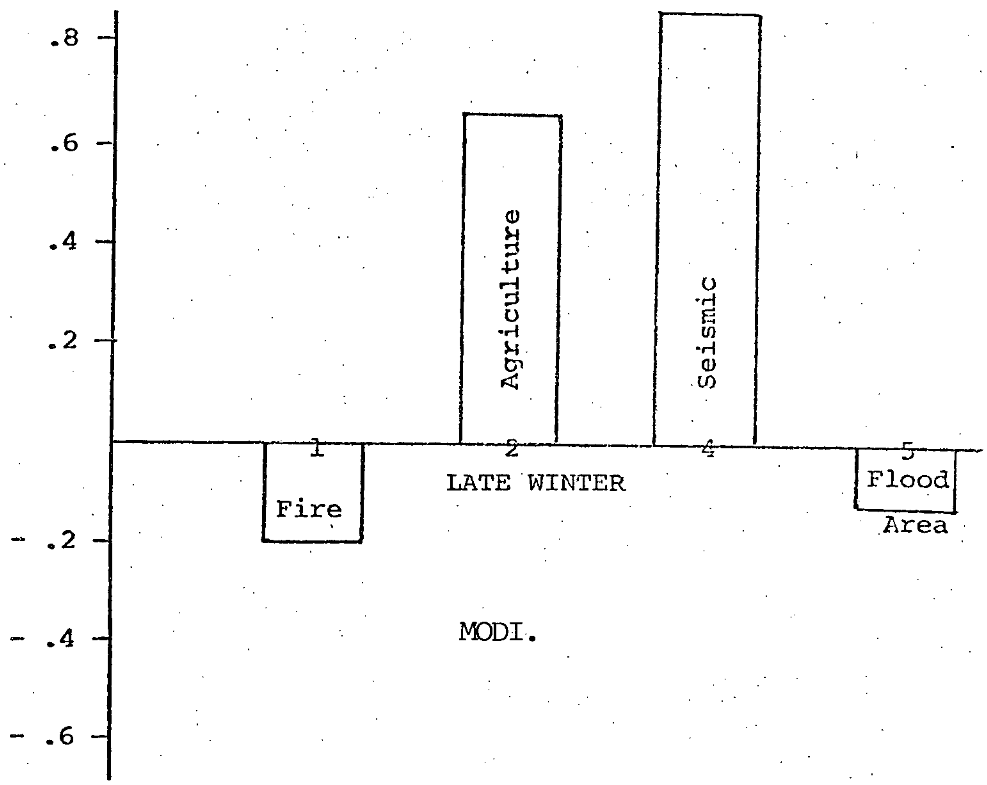


Figure 23. MCA coefficients of select predictor variable categories, early winter period.

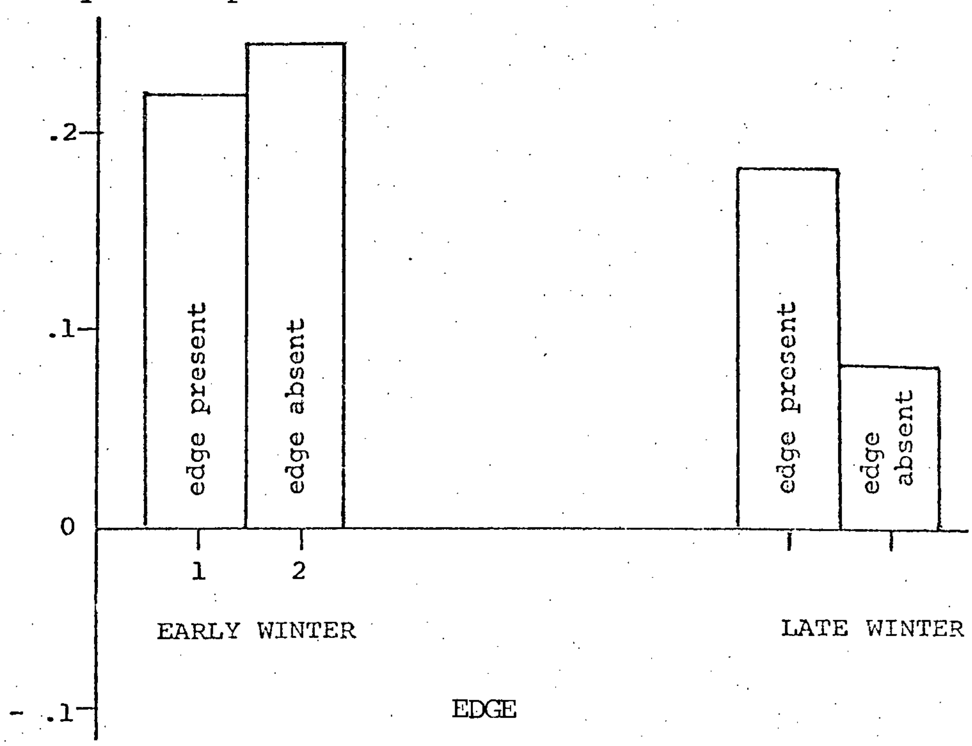


Figure 24. MCA coefficients of select predictor variable categories, late winter period.

movements and certain moose groups were observed in open shrubland habitats and large burns. Other groups required the forage and escape cover provided by edge. By late winter, changes in the values indicate a more positive relationship to the presence of edge. This increase may be the result of a) the need to utilize the ecotonal vegetation for food (viz. roadsides, seismic lines and agricultural borders), b) the shelter requirements for protection during the adverse period, and c) the concentration of moose in valley bottoms altered by a mosaic of clearing and agricultural activities creating many ecotone areas. Analyses indicated that predictor variable MODI (recent land modification) best explained late winter moose dispersion (Figure 24). All but one of the categories examined represented long-term alteration of natural vegetation; fire, however, was confined solely to the description of very recent burn areas viz. less than 15 years old. The negative relationship to recent fire may be a function of a limited acreage of recent burn habitats (viz. less than 20 percent) and concentrations of moose in the valley bottoms already altered through agricultural activities. The attraction to these areas is not to agriculture <u>per se</u> but rather a traditional response to the protective shelter and abundant forage resources of the U-shaped river valleys (Figure 25). Artificial forage sources such as oats and hay and ecotone and clearing regrowth areas may also attract moose. Seismograph lines show a positive relationship in describing moose dispersion in late winter as they not only provided edge for escape cover but also created favourable growing areas for deciduous browse and a corridor for travel. Flood areas, those climax riparian

Figure 25. The U-shaped nature of river valleys protects moose from winter storms. (Note lack of cover in foreground).

Figure 26. Riparian habitats common in the river valleys provide important winter browse.

habitats located below the average high water mark, showed a negative relationship to moose dispersion as these habitats were limited in area and are characterized by a poor shrub layer. Neighbouring developed riparian habitats, those not subject to flooding in an average year, were heavily utilized especially in the Halfway River valley (Figure 26).

6-2 The Effect of Human Activities on Moose Habitat

Analyses of terrestrial ecosystems provide essential data bases for the protection, management and enhancement of both habitat and animal components alike. Management decisions affecting the present and future consumptive and non-consumptive use of the resources is often based on limited biological information. The soils and vegetation of the Boreal White and Black Spruce Zone of northeastern British Columbia are influenced by more than the natural processes of erosion, fire, competition and succession. Too often, the sociological and political objectives of man represent a force equal to or greater than the natural ones, scarring natural ecosystems and molding future management options. An examination of historic land use practices provides direction for future land use decisions. To appreciate such a history, it must be stated that the still relatively small human population in northeastern British Columbia shows little concern for environmental issues. Wilderness resources seem unlimited. The problems of habitat and wildlife management of southern British Columbia viz. flooding of critical winter range, overgrazing by cattle, urban sprawl and recreational pressures, are unrecognized.

During the 1960's, agricultural development of both marginal and viable Peace River lands was encouraged by provincial and federal government agricultural agencies embracing a technology rather than developing a land ethic. There was an insatiable desire to promote agriculture throughout northern Canada (Harris et al., 1972). In British Columbia, the Lands Branch facilitated land disposition with little regard for agricultural capability or other inherent land values. As agricultural development inundated the wilderness, land use conflicts arose. Productive river valley bottoms, having high capabilities for the production of timber and wintering wildlife, were cleared and ploughed (Figure 27 and Appendix 20). At the same time, forest fire suppression techniques, developed for the more productive forests of the southern portion of the province, continued to harness one of the very natural processes responsible for the creation and maintenance of the boreal forest ecosystem. The forest industry grew. A policy of seeking short-term timber supplies rather than intensively managing lands having a high capability for the production of timber slowly evolved. As a result, all lands, regardless of forest capability, were protected from fire by the Forest Service under the auspices of Smokey Bear. Valuable moose habitats were destroyed and altered. The lush riparian habitats were replaced by crops of oats and barley and moose became nuisance animals on their own traditional winter ranges; the productive brulé areas of willow and aspen were allowed to regenerate to spruce (Figures 28, 29 and 30).

Figure 27. River-bottom lands have been altered to establish agriculture of a marginal nature.

Figure 28. Recent burn areas (brulé) are excellent habitats for moose. Note the presence of spruce stringers providing cover for escape and calving.

Figure 29. Forest fire suppression has allowed brulé areas to regenerate to spruce. The quality and quantity of forage for moose is reduced in these habitats. The decadent willow to the left is of little value to moose.

Figure 30. Recent burn areas, though restricted in size, provide valuable winter forage sources.

Management of both wildlife habitats and populations was very superficial and government personnel and monies were limited. Yet, the erosion of wildlife habitats was recognized and several important land reserves were established and publicized (Figures 31 and 32). Habitat manipulation projects were planned. However, the task of managing the wildlife resources of the Peace River area not only entailed reacting to the pressures of resource allocations, but also included a continuous commitment to educate people in this province as to the diversity and numbers of wildlife of the isolated but important region. This latter task was often difficult when the very agency responsible for the management of these resources was orientated towards the people - wildlife problems of southern British Columbia.

While agricultural activities and fire suppression destroyed and harnessed the land and natural processes necessary for the maintenance of quality moose habitat, a limited number of timber harvests and extensive oil and gas exploration activities have created small acreages of valued habitat. The clearing of miles of seismic lines and pipeline right-of-ways, though often destroying valuable habitat for furbearers and creating erosion problems affecting fishery values, allowed rapid regeneration of succulent moose forage species such as willow and alder. Edge and a travel corridor were also benefits from these lines (Figure 33). Small clearcuts and select logging projects have also increased shrub production and increased edge conditions. However, logging activities are closely related to economic conditions so that large tracts of preferred wood are sought rather than the

Figure 31. Establishment of the Cameron River Reserve prevented alienation of prime river-bottom habitats such as this (Cameron River).

Figure 32. Communicating with the public is important if wildlife habitat is to be maintained. This sign in the study area informed the public of the concern for the land base in the study area.

Figure 33. Construction of pipelines and seismograph lines has created many miles of valued moose habitat. However, the effect of removing fur habitat (and valuable timber) and the resulting erosion problems must be examined.

Figure 34. Proper logging prescriptions may enhance the habitats available for moose. However, the effects of recreational access must be considered in the logging plans.

patchy mosaic of timber common in areas such as the Cameron River Reserve (Figure 34).

Protection and maintenance of quality wildlife habitats and viable animal populations in northeastern British Columbia is a difficult challenge that must be met. As man's industrial activities thrive, the required management programs will necessitate a diligent educational program directed towards the public, politicians and bureaucrats alike. In the face of recent industrial plans (Government of British Columbia, 1975*), the program of protecting and maintaining the wildlife resources of northeastern British Columbia must be improved immediately.

6-3 A Strategy for the Protection and Enhancement of Moose Habitats

Several points, together formulating a rather general contingency plan, can be stated as a result of this study:

1. As proposed in a letter to the Lands Branch in March 1975, the boundaries of the Cameron River Reserve should be extended west to include the critical winter habitats of the neighbouring foothills area. Such an extension would discourage further alienation and reiterate the importance of the area for the migration and wintering of moose.

2. The Fish and Wildlife Branch should develop a detailed management plan for the reserve to confirm their active involvement in the protection, maintenance and enhancement of critical winter ranges.

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*Wildlife resources received token acknowledgement in this report and the guiding industry attracted similar cursory comments.

This plan should include such options as controlled burns of selected mature brulé types, winter logging in a variety of treatments, and wildlife management programs to provide new and unusual opportunities for both consumptive and non-consumptive users. Size of clearcut should be larger than those in the Prince George area but blocks and strips of cover must be incorporated into the design of these cutblocks. Other resources, resource users and government agencies should be considered in any plan. A coordinated land use plan may be best (Anderson and Scherzinger, 1975).

3. The Fish and Wildlife Branch, British Columbia Wildlife Federation and the Northern Guides Association should actively promote further moose research. Suggested topics include establishing migration routes, describing the importance of ecotones, documenting the role of fire in the boreal forest and perfecting aerial census techniques.

4. The Fish and Wildlife Branch should examine the possibility of purchasing or relocating ranching operations in the critical winter range of the Halfway River valley. Alienated land should be returned to the production of moose and trees (Harper, 1973). These critical areas should be considered for purchase and enhancement as mitigation for future Peace River power projects and coal mining developments in northeastern British Columbia.

7. SUMMARY

1. A broad, holistic approach was used to study the dispersion of moose in available winter habitats of a wildlife reserve in northeastern British Columbia.
2. Since 1968, estimated moose harvests in northern British Columbia have fluctuated between 3400 and 5700 animals. Changes in hunting seasons, access and autumn weather are the major factors that have influenced harvests.
3. Aerial reconnaissance in the study area indicated that the observed sex ratios and adult to juvenile ratios are similar to other locations in the Peace River area. Accurate population figures are complicated by seasonal migrations. A sample of aged moose provided an average age similar to published data from Alberta.
4. Eight vegetation plots, representing the major plant communities, were examined and described using the Wilderness Ecology methods. Shrubs were most abundant in the no canopy and deciduous canopy plots.
5. Moose seem well adapted to the cold air temperatures common during the winter period. The study area is characterized by temperature fluctuations as a result of chinooks (foehn winds).
6. The Cameron River Reserve is characterized by moderate winter snow depths. An index of snow depth as it affects moose (viz. greater than 76 cm) indicated that the 1973-1974 winter had the most severe snowfall of the decade. The effects of forest canopy on snow depth were examined. Deciduous canopies intercepted

little snowfall whereas maturing coniferous canopies greatly altered the depth of snow on the ground.

7. Very low crude protein values for eight selected forages probably indicated genuine low level of crude protein in the plants of the study area.
8. Winter food habits of moose were examined using both rumen and trailing analysis techniques. Willow, aspen and bog birch were the most important forage sources.
9. Open shrubland areas and deciduous forest types are the preferred winter habitats. No late winter shift to coniferous habitats was noted. Multiple Classification Analysis was employed to examine the interrelationships between several predictor variables and the dependent variable, MOOSE DISPERSION. The predictor variables explained 43 percent of early winter dispersion and 24 percent of late winter dispersion. Predictor variables EDGE (forest edge) and MODI (recent land modification) were the most important predictor variables. Models of this nature can be improved through accurate variable and variable category definition.
10. The protection and enhancement of critical winter range in the area should involve the extension of the existing range and the development of management plans. Alienated lands should be considered for purchase as compensation for hydro and coal developments in the region.

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APPENDIX 1

Report of the Lands Branch
Proposed Cameron River Reserve
1969

FORT ST. JOHN

LAND INSPECTION BRANCH

P R O P O S E D   R E S E R V E

C A M E R O N   R I V E R   A R E A

F E B R U A R Y   1 9 6 9

TABLE OF CONTENTS

CAMERON RIVER AREA
PROPOSED RESERVE PROJECT

AREA: The area of the proposed reserve covers 357 square miles.

LOCATION: It is located 75 miles North-West of Fort St. John reaching southwest from the Alaska Highway from Mile 124 to Mile 143 and extending to the East bank of the Halfway River covering the upper valley parts of Gundy, Townsend and Blair Creeks, the N. Cameron River valley and the North East portion of the Halfway River valley.

ACCESS: At Mile 109 an oil company road branches and provides access to Gundy, Townsend and Blair Creeks. These roads are not recognized by the Department of Highways but are used by the public for hunting and by settlers. The first three (3) miles are fair; the next fifteen (15) poor dirt road.

At Mile 132 on the Alaska Highway another oil company road provides access to the Cameron and Halfway River valleys. This road has been rebuilt by the Westcoast Transmission Co. to service a pumping station on their main gas pipeline from Fort Nelson and the company maintains the road as far as the Cameron River. Beyond this the settlers on the Halfway River keep the road usable. The first twelve (12) miles are good; then ten (10) miles are barely passable. There is a branch road to Blair Al Well and to six (6) undeveloped sections of land.

At Mile 143 on the Alaska Highway another oil company constructed road provides access to the Northern part of the area, for oil exploration West of the Halfway River. This is a public road and is graded occasionally by the Department of Highways. Each of these roads is known by the mile post on the Alaska Highway where they begin. This is the most used access and is a moderate all weather road. It would form the N. boundary of the reserve. Numerous abandoned oil roads, seismic and logging roads pass through the area but are not maintained and are only occasionally used by settlers, land seekers and hunters. Because of the North/South direction of the five (5) valleys the roads follow the topography - resulting in big road mileages between points. The distance from major agricultural services is in the region of 100 to 125 miles and few of the roads could be described as all weather. This long haul to markets is a major factor in costing operations in the area.

PRESENT PATTERN OF ALIENATION AND UTILIZATION

A distinct pattern of alienation can be observed on the large scale map (No. 2) attached to this report. Settlement has been dictated by the topography with the well-watered open river valley areas attracting the ranch type of farm operation. The area of present alienation is 12,689 acres of which 8,697 have been classed as arable.

This leaves a balance from the total 228,480 acres in the proposed reserve of 215,791 acres of Crown land (unalienated) of which only 6,873 acres can be fairly described as arable; (reasonably level, below 3000' and with sufficient depth of soil for cultivation). Unfortunately the remaining arable Crown land is widely scattered along the upper levels of the river valleys and cannot be consolidated under current methods of survey.

LOCATION OF CROWN LAND WITHIN THE PROPOSED RESERVE BELOW 3,000' A.S.L.

	TOTAL	ARABLE	NON-ARABLE
Halfway River Valley (E. Side of River in Reserve)	13,260	993	12,277
Cameron River Valley	38,045	3,455	34,590
Blair Creek Valley	16,219	1,248	14,971
Townsend Creek - 2 Valleys	10,407	1,177	9,230
Totals	77,931	6,873	71,068
Plus land above 3,000'	+137,860		
Total	215,791		

The 6,873 acres of arable Crown land remaining is only 3% of the total acreage within the proposed reserve of 3.2% of the remaining Crown land. The arable land of 993 acres in the Halfway Valley is in the pockets along the East of river and can only logically be added to existing holdings when required. In the Cameron Valley 3,455 acres have been classed as arable but they are again strung out along the valley. Only one sizeable block occurs at the lowest part of the valley.

On Blair Creek the pattern is the same with the arable land distributed in 50 - 100 acre parcels along the upper levels of the valley.

Townsend Creek. There are two forks to this creek and 1,177 acres of arable land have been identified. The same problem exists of surveying lots to 50% arability in order to make development economically feasible.

ECONOMICS OF THE PRESENT OPERATIONS IN THE AREA

The present low returns on most agricultural products against a background of rising costs stresses the need for efficient farm operations for profitable production. Even under good management on developed arable land and with costly inputs of fertilizer, quality seed and modern mechanized cultivations the best farmers in the Peace region are struggling to remain solvent. There are two alternative methods to beat this situation. One is the intensification of land use - higher production per acre; the other is the spreading of capital costs over more acres, accepting lower yields per acre but increasing total output without a corresponding increase in costs.

The present ranching operations in the area are marginally economic. Four operations grazed 267 head of stock on forest range at $1.00 per head for four (4) months in 1968. Assuming one (1) bull to forty (40) cows and a calving average of 85% these cows should produce 212 calves. If we allow 200 to be marketed as 1½ year old steers the current returns of $45.00 per head, net would mean $9,000.00 to four operations or $2,250.00 net to each outfit. This is the only cash return and must bear the whole cost of running expenses, management and return to capital invested - a low level of income. Without cheap grazing such operations cannot exist. A section of land of poor grazing (8 acres per animal unit per month) should support 16 animals in a year. The local estimate is ten (10).

The benefits of placing a Reserve over this area would be to ensure grazing to existing ranches especially in the area to the Southeast. This block of land has many surveyed lots vacant and contains more arable land (40%) and could support a large livestock population.

The protection of future forest resources and especially the preservation of <u>winter</u> moose range would guarantee public enjoyment of hunting and recreation.

In the past, ranching operations have tended to develop these willow flats first, because of light clearing and thus cause a conflict with the needs of wildlife.

Only one application for Crown land in the area is presently under consideraiton so the public demand is low.

Some improvement to existing forest range could be made if the demand arose. A grazing and wildlife reserve is considered to be the highest and best use, for this area at this time. It is felt that some speculation in land values has been behind previous alienations.

As these roads are not regularly plowed in the winter the increasing use of the snowmobile is making a useful contribution to the efficiency of farm operations in outlying areas.

SERVICES: At Mile 101 on the Alaska Highway there is a school and post office, service stations, store, cafes and a land clearing contractor. A service station and post office is also located at Mile 143 on the Alaska Highway. Major markets, services, hospital, etc., are located in Fort St. John 100 to 150 miles away.

FUTURE DEVELOPMENTS: There is a rumoured possibility that a gas plant may be set up to service the oil and gas wells in the Halfway and Cypress Creek region to the west of the Halfway River. The main gas pipeline from Fort Nelson passes through the area but is not tapped. Another possibility is the construction of a power line from Hudson Hope (Bennett Dam) to Fort Nelson but it would be uneconomical to tap this for power to the widely scattered ranches.

TOPOGRAPHY: The area is characterized by a series of valleys running North and South. The only areas suitable for development are in the lower parts of these valleys. 71% of the total area is above the 3000' A.S.L. mark and this combined with the narrow valleys greatly reduces the growing season. A profile of the area is enclosed which stresses this problem of the land aspect. The vertical scale (½"= 100') does exaggerate the situation but makes clear the differences between the different valleys and the general shortage of level arable land below 3000' A.S.L. This topography is the result of drainage erosion imposing a pattern on an area of Rocky Mountain foothill folds complicated by glacial action which cut the original N/South grooves in which the rivers now flow.

The area is rough, essentially non-arable except for those areas identified on the accompanying map which are below 3000' A.S.L. and level enough for cultivation.

Elevations range from 2500' to 3850' above sea level. 3000' A.S.L. is regarded as the upper limit for crop production and over this is considered too high in the narrow valleys with poor air - drainage.

<u>CLIMATE</u>: The climate approximates to that of the Fort St. John area, that is, of continental type with long cold winters, short mild summers. The frost-free period is 50 days but this is shortened in the high narrow valleys making grain production uneconomic. Precipitation averages 16" - 18" including snow, with growth commencing in <u>late</u> May to early June and ceasing with the frosts of late August to September.

<u>WATER</u>: Supplies of water in the area are adequate with the slower runoff into many rivers and streams caused by slow melting of snow and forest cover retaining moisture and preventing excess evaporation.

<u>SOIL</u>: The soils of the area are partly glacial in origin, of crushed sedimentary rocks with some mineralization. The valley soils are alluvial or belong to the Goose series of Orthic meadow silty clay loams and clays. These soils are poorly drained and occur in association with peat soils. The characteristic cover is groundbirch, with willow sedges and reeds. Cleared and drained they are capable of good forage production. They are not recommended for grain crops without expensive correction of acidity P.H. 5.6 - 7 and improved structure developed under grasses and legumes.

<u>BLUEBERRY SUSTAINED YIELD UNIT</u>

The proposed reserve lies within the Blueberry Sustained Yield Unit.

The forest cover of the area is resultant on major fires which spread over the area in the 1930's and 1940's. Most of the trees of merchantable species: Spruce and Pine, are therefore immature. There are some blocks of merchantable timber and information on volumes and productive potential could be supplied with more field work, but was not considered necessary at this stage. The area constitutes some <u>10%</u> of the total area of 2,456 square miles within the Blueberry S.Y.U. as shown on the included map (No. 3). It is expected that systematic harvesting of the forest and resources will be achieved under Forestry control as the timber matures. There are no current Timber Sales in the area, some old ones appear on our maps.

APPENDIX 2

The Climate of Northeastern British Columbia

KÖPPEN CLIMATE NOTATIONS
(from Wali and Krajina 1973)

D: humid and subhumid climates severe winters; coldest month below -3°C warmest month above 10°C

f: pronounced dry season lacking precipitation of driest month in summer more than 3 cm

c: summers cool and short; 1 to 3 months below 10°C

NORMAL CLIMATIC MEASUREMENTS
FORT ST. JOHN, B.C. 2275' ELEVATION
LATITUDE: 56° 14' LONGITUDE: 120° 44'
(Based on 1941 - 1970 records)

Month	Normal Temperature °C	Normal Bright Sunshine Hours	Normal Precipitation (cm)	Normal Snowfall (cm)
January	-17.0	73.4	.05	35.0
February	-11.9	106.3	.02	29.0
March	- 6.4	159.0	.07	28.2
April	2.4	217.6	.64	17.5
May	9.8	280.0	2.5	7.9
June	13.6	274.0	6.1	.5
July	15.8	300.0	6.3	0
August	14.6	270.0	5.2	1.5
September	9.9	174.0	2.9	3.3
October	4.1	137.0	1.2	18.0
November	- 6.4	81.0	.3	30.5
December	-13.2	61.4	.05	34.8

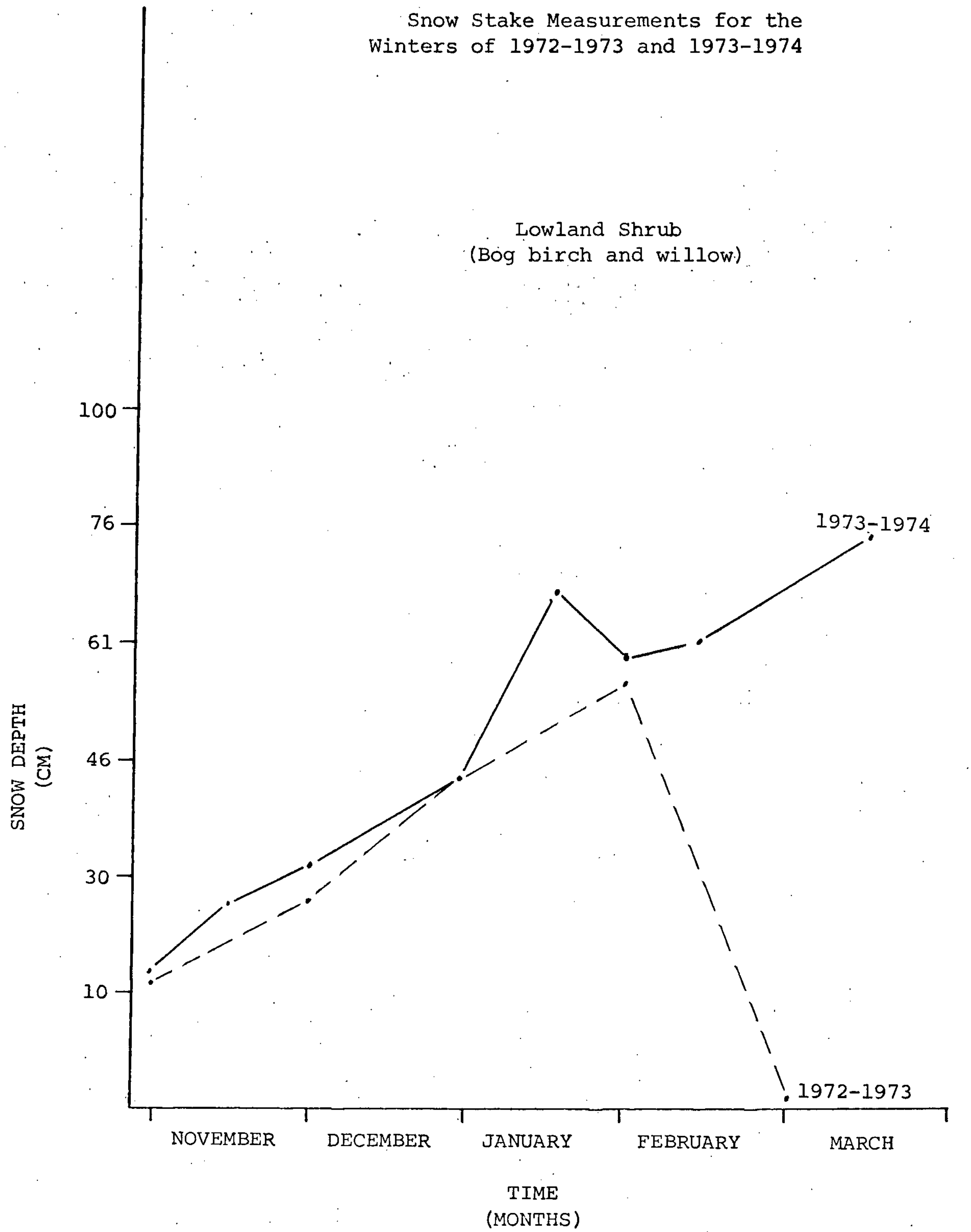
Source: Atmospheric Environment Service
Canada Department of the Environment
Meteorological Summary

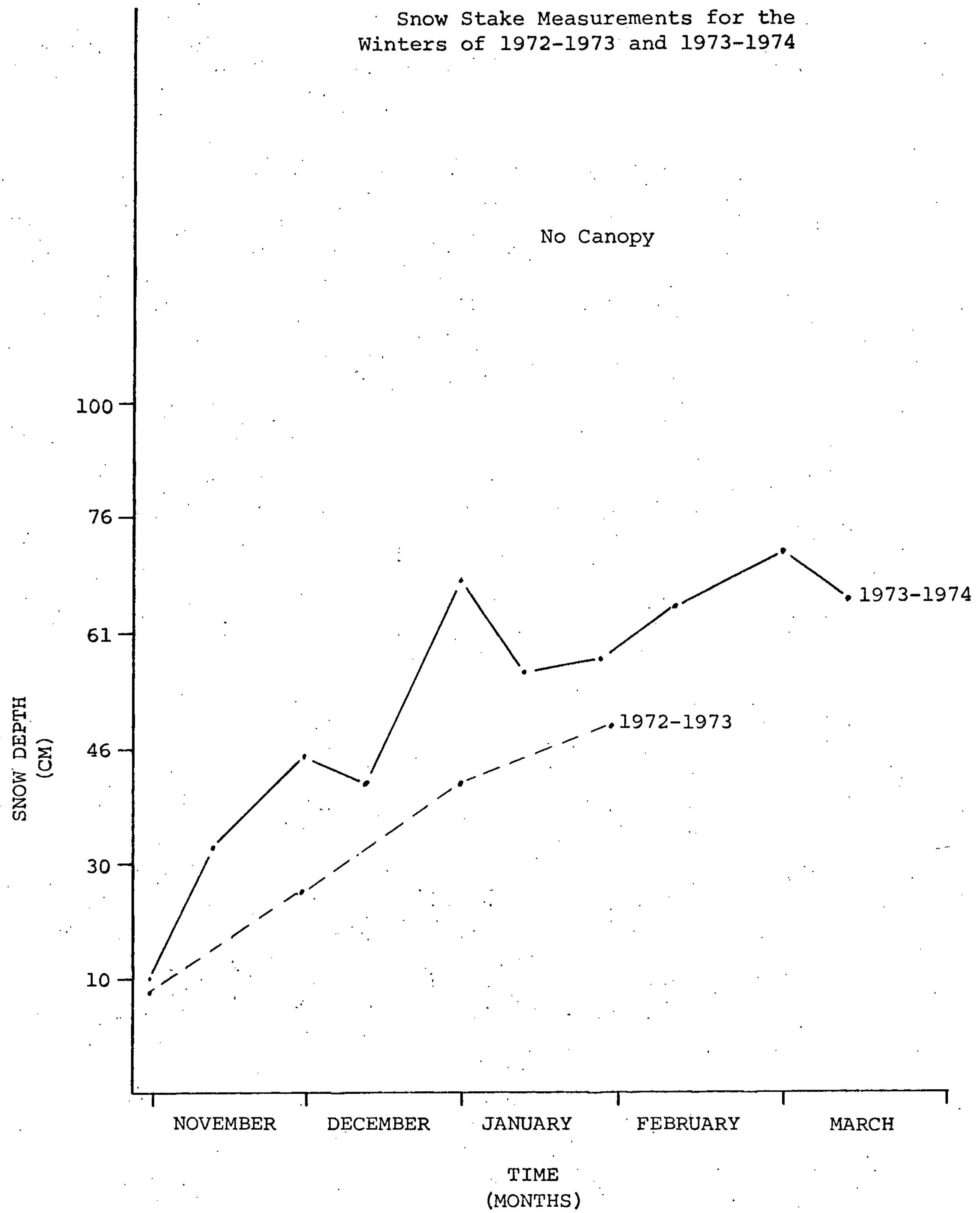
A SUMMARY OF SNOWFALL AT
FORT ST. JOHN DURING THE STUDY PERIOD
JUNE 1972 - MARCH 1974

Month	Total Snowfall (cm) By Year 1972	1973	1974	Normal Snowfall (cm) (1941-1970)
June	0	0		.5
July	0	0		0
August	0	20.8		1.5
September	31.0	0		3.3
October	23.4	23.9		18.0
November	49.5	36.3		30.5
December	49.3	26.2		34.8
January		48.3	77.7	35.1
February		62.9	18.0	29.0
March		8.9	76.2	28.2
April		11.4		17.5
May		0		7.9

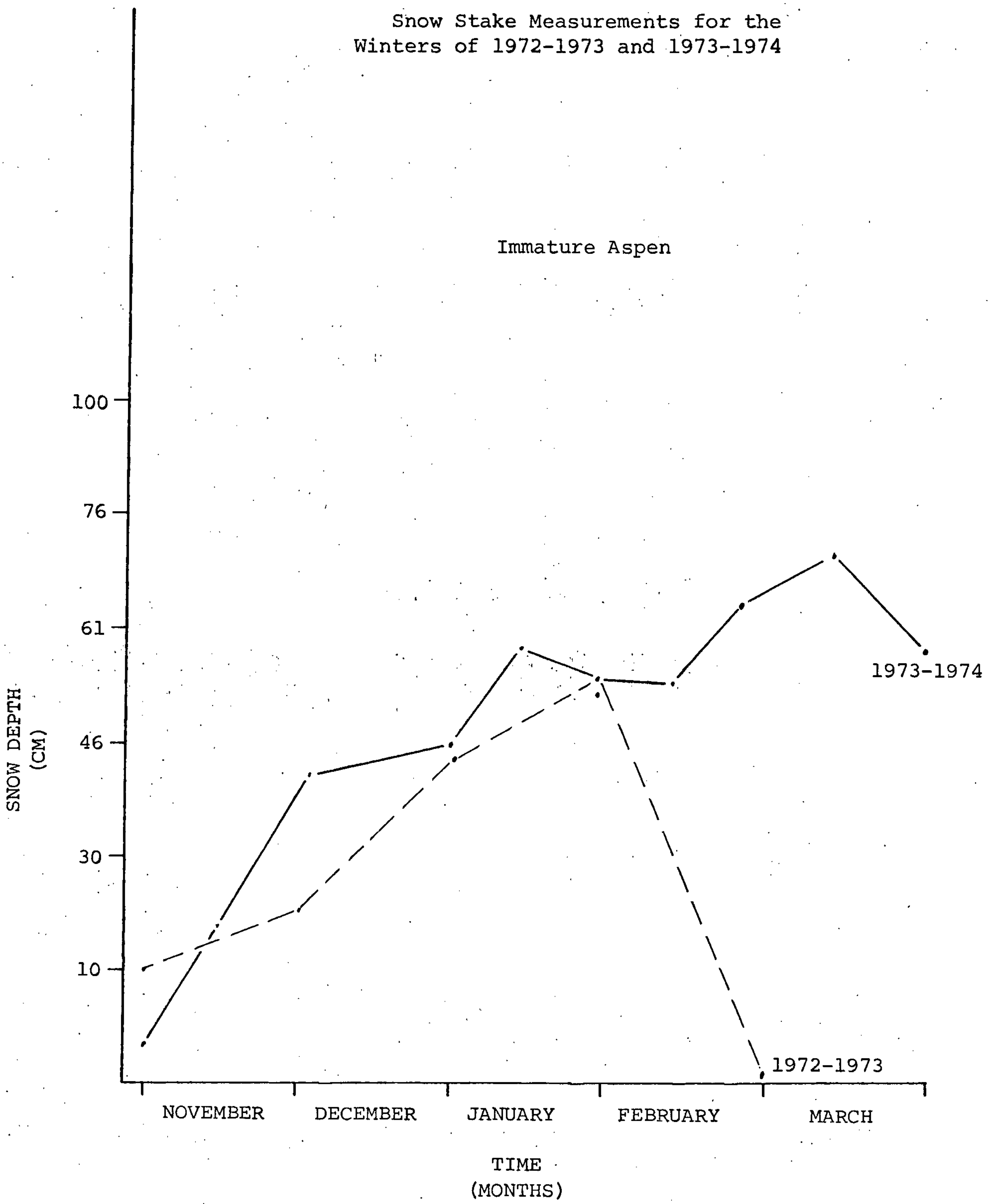
A TEN YEAR HISTORY OF A WINTER
SNOW DEPTH INDEX
FORT ST. JOHN, BRITISH COLUMBIA

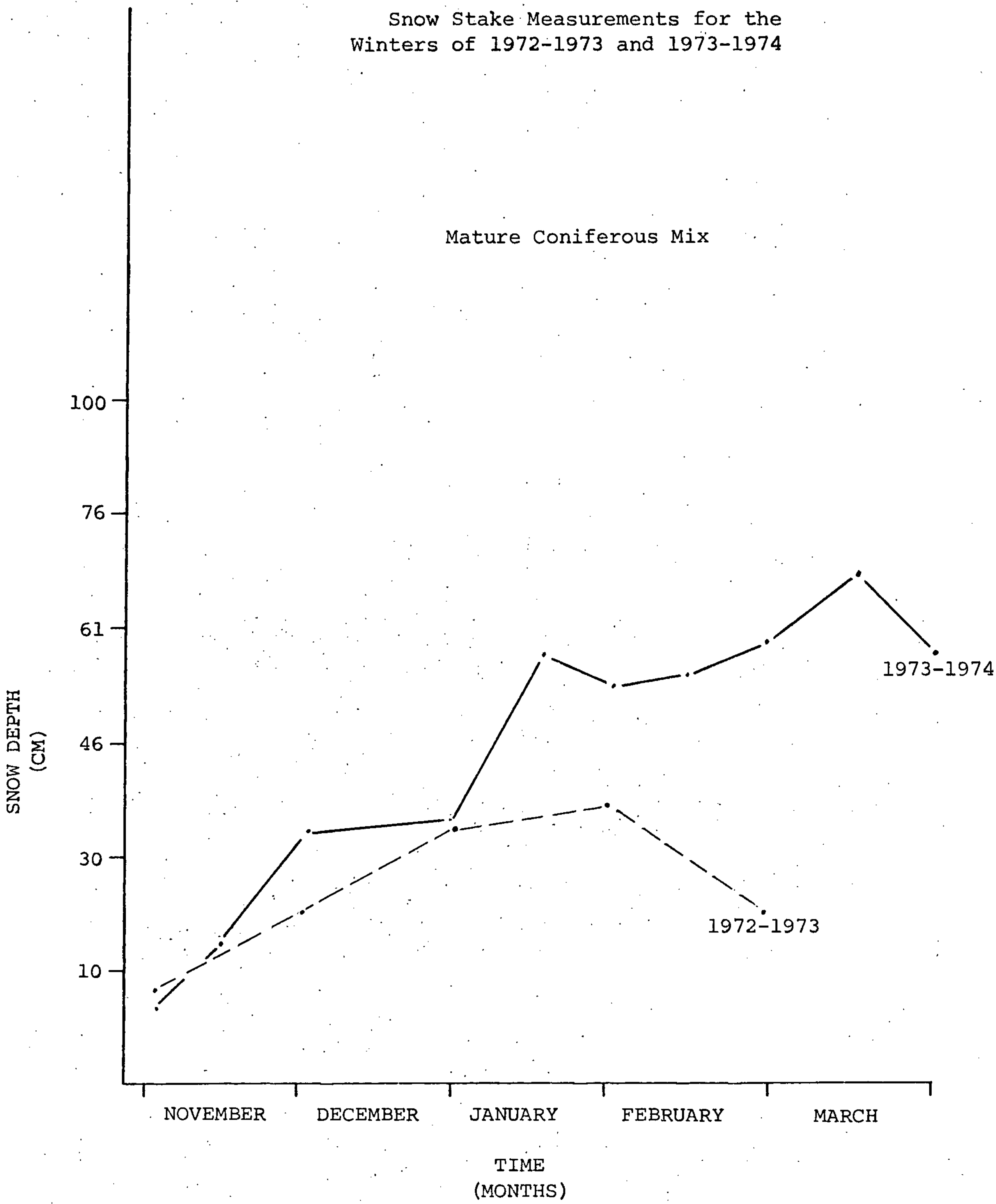
Winter Period	Number of Days of Snow Depth In Excess of 76 cm (30 inches)					Snow Depth Index For Winter Period
	NOV	DEC	JAN	FEB	MAR	
1963 - 1964	0	0	0	0	0	0
1964 - 1965	0	0	0	0	0	0
1965 - 1966	0	0	0	0	0	0
1966 - 1967	0	4	12	28	7	51
1967 - 1968	0	0	0	0	0	0
1968 - 1969	0	0	0	0	0	0
1969 - 1970	0	0	0	0	0	0
1970 - 1971	0	0	0	5	0	5
1971 - 1972	0	0	0	0	13	13
1972 - 1973	0	0	0	0	4	4
1973 - 1974	0	0	15	23	31	69

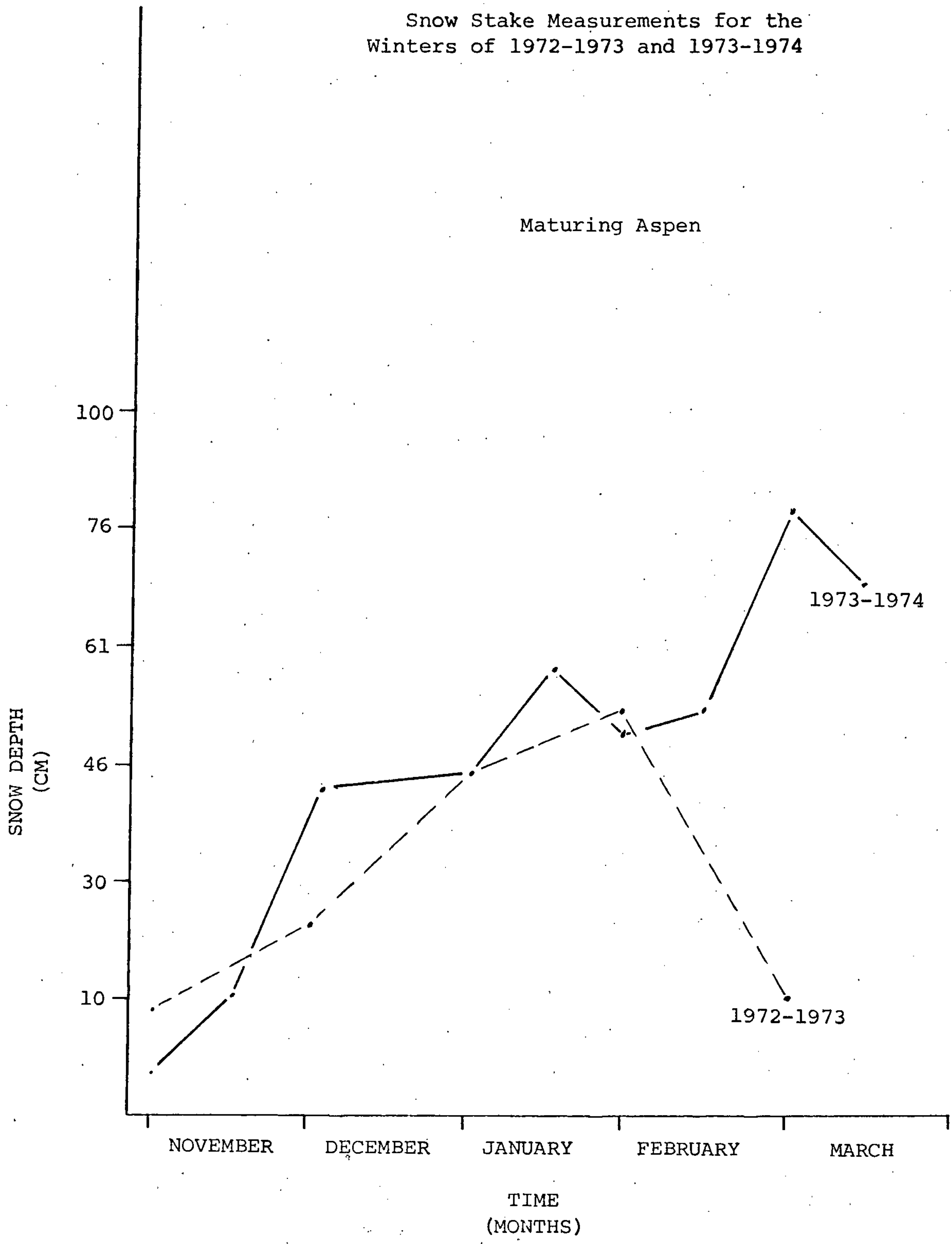

Snow Stake Measurements for the
Winters of 1972-1973 and 1973-1974
Lowland Shrub
(Bog birch and willow)
100
76
61
46
30
10
SNOW DEPTH
(CM)
1973-1974
1972-1973
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
TIME
(MONTHS)

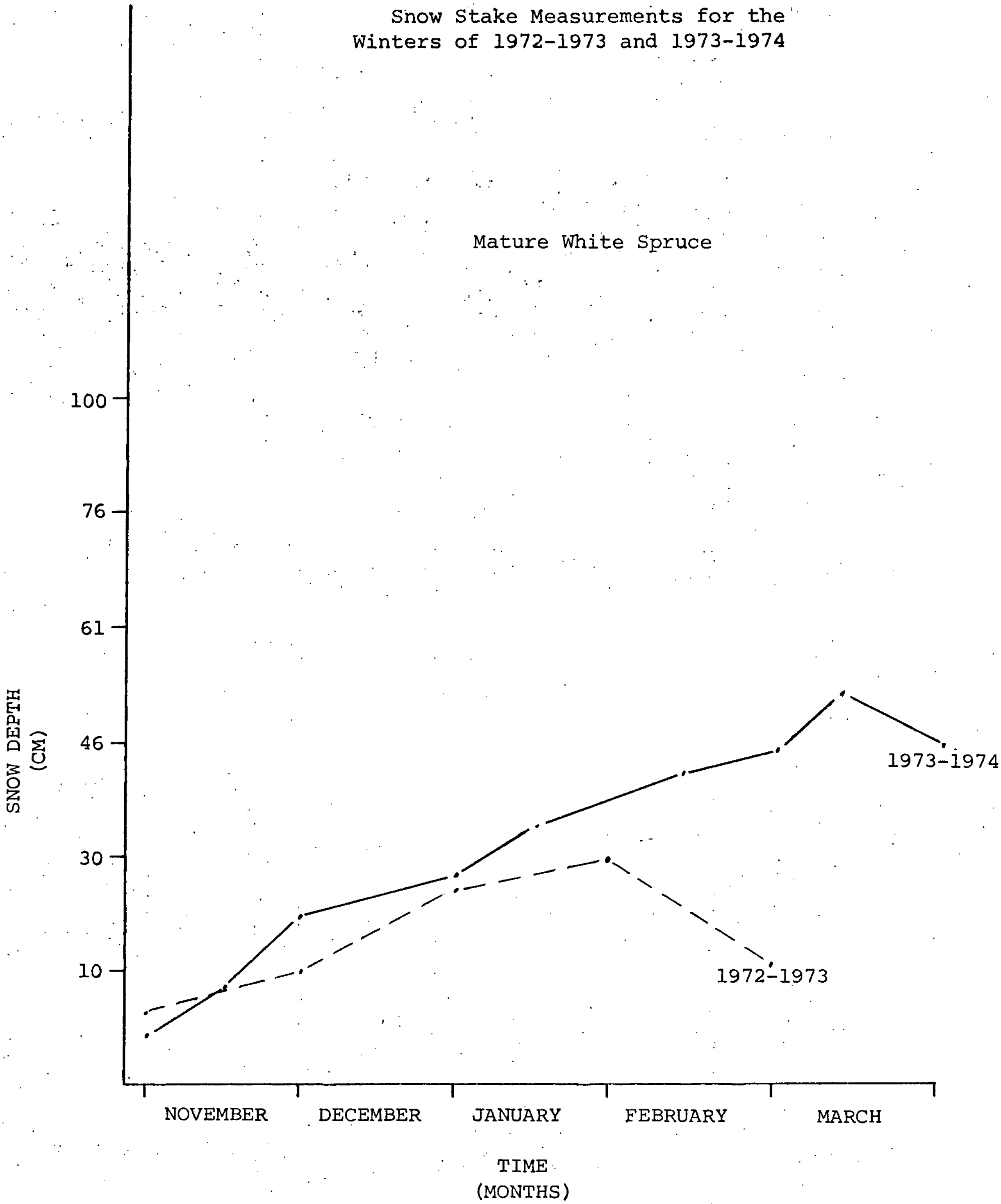


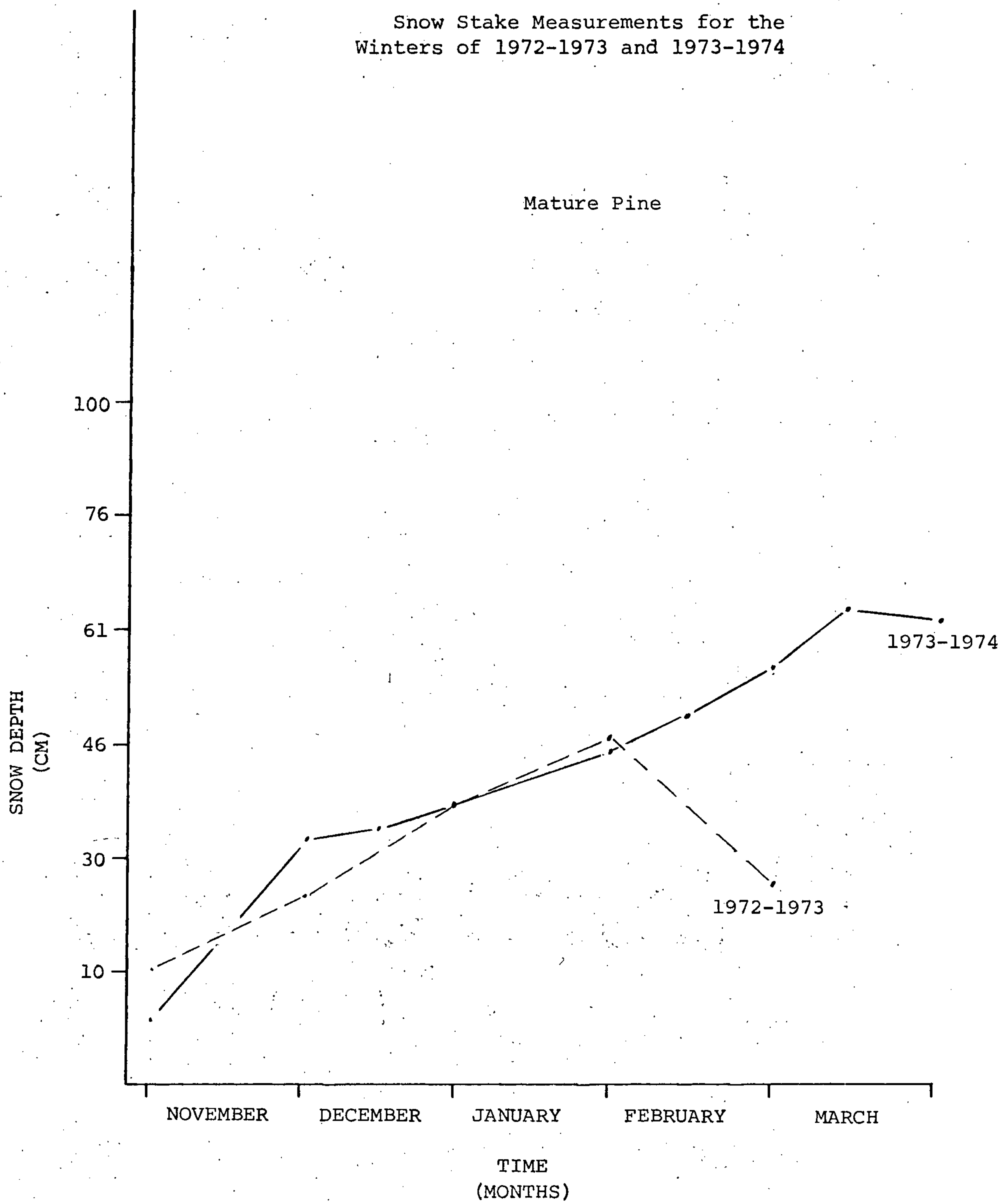
Snow Stake Measurements for the
Winters of 1972-1973 and 1973-1974
No Canopy
100
76
61
46
30
10
SNOW DEPTH
(CM)
1973-1974
1972-1973
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
TIME
(MONTHS)

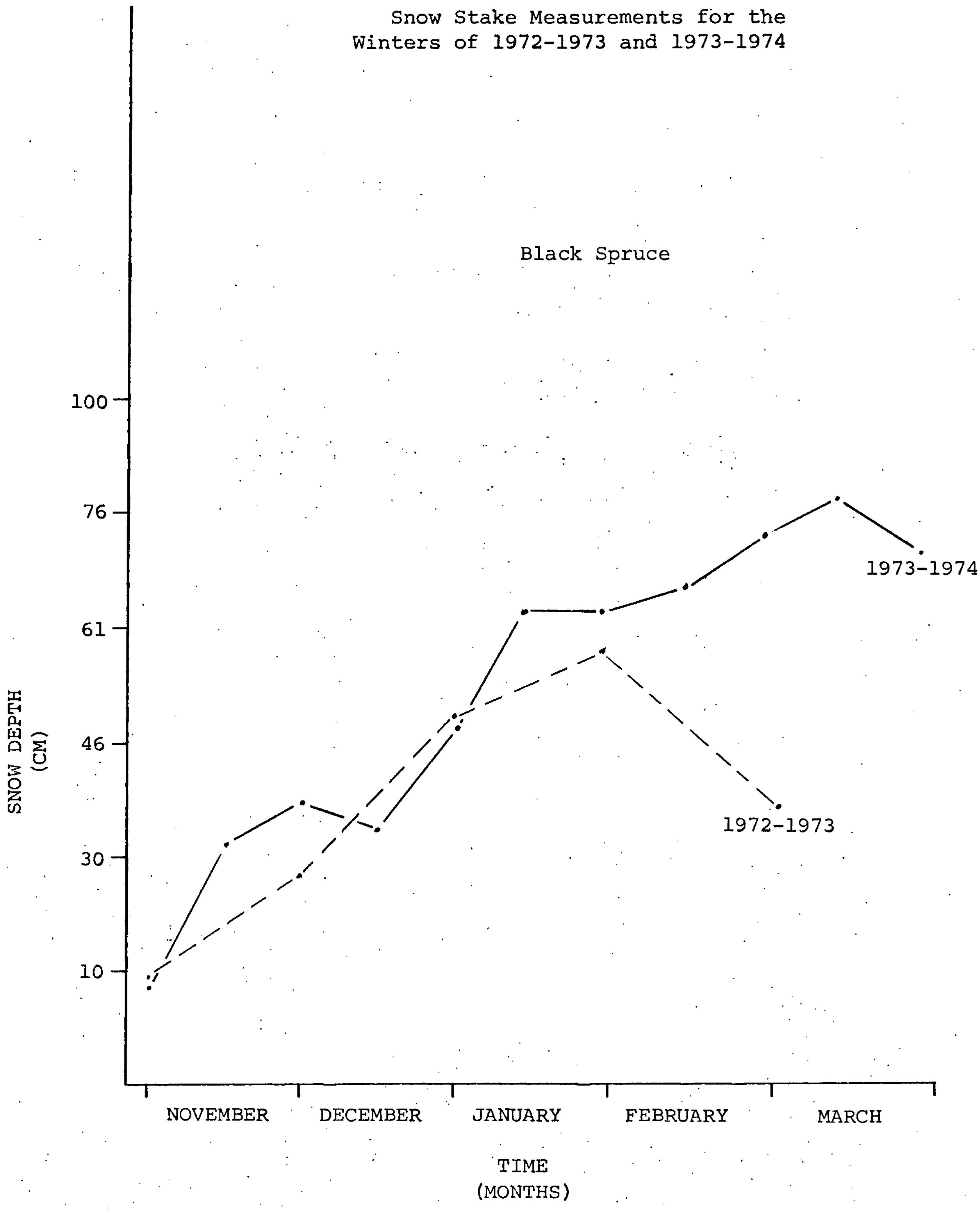

Snow Stake Measurements for the
Winters of 1972-1973 and 1973-1974
Immature Aspen
100
76
61
46
30
10
SNOW DEPTH
(CM)
1973-1974
1972-1973
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
TIME
(MONTHS)


Snow Stake Measurements for the
Winters of 1972-1973 and 1973-1974
Mature Coniferous Mix
100
76
61
46
30
10
SNOW DEPTH
(CM)
1973-1974
1972-1973
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
TIME
(MONTHS)


Snow Stake Measurements for the
Winters of 1972-1973 and 1973-1974
Maturing Aspen
SNOW DEPTH
(CM)
100
76
61
46
30
10
1973-1974
1972-1973
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
TIME
(MONTHS)


Snow Stake Measurements for the
Winters of 1972-1973 and 1973-1974
Mature White Spruce
100
76
61
46
30
10
SNOW DEPTH
(CM)
1973-1974
1972-1973
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
TIME
(MONTHS)


Snow Stake Measurements for the
Winters of 1972-1973 and 1973-1974
Mature Pine
100
76
61
46
30
10
SNOW DEPTH
(CM)
1973-1974
1972-1973
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
TIME
(MONTHS)


Snow Stake Measurements for the
Winters of 1972-1973 and 1973-1974
Black Spruce
100
76
61
46
30
10
SNOW DEPTH
(CM)
1973-1974
1972-1973
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
TIME
(MONTHS)

APPENDIX 53

Characteristics of Soil Associations
Cameron River Reserve

(Lord, 1972)

SOIL ASSOCIATION	LANDFORM AND GEOLOGIC MATERIALS	SOIL COMPONENTS Major	Minor	SIGNIFICANT CHARACTERISTICS OF THE SOILS
2e Fellers-Osborn	Deep, acid to neutral glacial till and lacustrine deposits overlying shale and sandstone on nearly level to moderately sloping, unpatterned uplands Elevation range: 840-1100 m (2750-3600 ft)	Fellers Brunicolic Gray Luvisol Osborn Gleyed Orthic Gray Luvisol	Gleysols	About 60% of the soils occupy shedding sites and are moderately deep, moderately well drained and slowly permeable; they have clay loam and clay horizons developed from till materials. About 40% of the soils occupy receiving sites and are moderately deep, imperfectly drained and slowly permeable; they have clay loam surface horizons overlying slightly calcareous clay subsoils developed from lacustrine deposits.
2f Fellers-Wonowon	Deep, acid to neutral glacial till overlying shale and sandstone on nearly level to moderately sloping unpatterned uplands Elevation range: 915-1220 m (3000-4000 ft)	Fellers Brunisolic Gray Luvisol Wonowon Gleyed Orthic Gray Luvisol	Gleysols	About 60% of the soils occupy shedding sites and are moderately deep, moderately well drained and slowly permeable; they have clay loam and clay horizons. About 40% of the soils occupy receiving sites and are moderately deep, imperfectly drained, and slowly permeable; the surface layers overlie clay loam and clay subsoils.
2g Jedney-Alcan-Rockland	Shallow to moderately deep, acid to neutral glacial till overlying sandstone and shale on moderately sloping to extremely steep uplands and escarpments Elevations less than 1220 m (4000 ft)	Jedney Lithic Orthic Gray Luvisol Alcan Orthic Gray Luvisol		About 40% of the soils are shallow, moderately well drained and slowly permeable; they have clay loam horizons overlying bedrock at 9-50 cm (4-20 in). About 30% of the soils are moderately deep, moderately well drained and slowly permeable; they have clay loam horizons over clay subsoils. About 30% of the mapping unit consists of Rock Outcrop. Most of the soils occur on shedding sites.
2h Jedney-Wonowon	Shallow to moderately deep, acid glacial till overlying sandstone and shale on nearly level to moderately sloping unpatterned uplands Elevation range: 970-1220 m (3200-4000 ft)	Jedney Lithic Orthic Gray Luvisol Wonowon Gleyed Orthic Gray Luvisol	Gleysols	About 60% of the soils occupy shedding sites and are shallow, moderately well drained and slowly permeable; they have clay loam horizons overlying bedrock at 9-50 cm (4-20 in). About 40% of the soils occupy receiving sites and are moderately deep, imperfectly drained and slowly permeable; the surface horizons overlie clay loam and clay subsoils.


2I
2J
3G
2F
2H
2E
4A
3F
3H
4E
3E
2I
3D
3A
2J
3G
3H
2E
2F
4A
3E

SOIL ASSOCIATION	LANDFORM AND GEOLOGIC MATERIALS	SOIL COMPONENTS Major	Minor	SIGNIFICANT CHARACTERISTICS OF THE SOILS
2i Wonowon-Jedney	Moderately deep to shallow acid to neutral glacial till overlying sandstone and shale on nearly level to moderately sloping, unpatterned uplands Elevation range: 760-1020 m (2500-3350 ft)	Wonowon Gleyed Orthic Gray Luvisol Jedney Lithic Orthic Gray Luvisol	Gleysols	About 80% of the soils occupy receiving sites and are moderately deep, imperfectly drained and slowly permeable; the surface horizons overlie clay loam and clay subsoils. About 20% of the soils occupy shedding sites and are shallow, moderately well drained and slowly permeable; they have clay loam horizons overlying bedrock at 9-50 cm (4-20 in).
2j Wonowon-Osborn-Jedney	Moderately deep to shallow acid to neutral glacial till overlying sandstone and shale on moderately to steeply sloping, unpatterned uplands Elevation range: 760-1220 m (2500-4000 ft)	Wonowon Gleyed Orthic Gray Luvisol Osborn Gleyed Orthic Gray Luvisol Jedney Lithic Orthic Gray Luvisol	Gleysols	About 50% of the soils are moderately deep, imperfectly drained, and slowly permeable; the surface horizons overlie clay loam and clay subsoils. About 30% of the soils have clay loam surface horizons overlying slightly calcareous lacustrine clay deposits. About 20% of the soils occupy shedding sites, are shallow, and have clay loam horizons overlying bedrock at 9-50 cm (4-20 in).

SOIL ASSOCIATION	LANDFORM AND GEOLOGIC MATERIALS	SOIL COMPONENTS Major	Minor	SIGNIFICANT CHARACTERISTICS OF THE SOILS
3a Donnelly-Snipe	Deep weakly calcareous mixed till and lacustrine deposits on nearly level to moderately sloping lower plateau areas Elevation range: 685-900 m (2250-2950 ft)	Donnelly Orthic Gray Luvisol Snipe Low Humic Eluviated Gleysol		About 70% of the soils occupy shedding sites and are deep, moderately well drained and slowly permeable; they have clay loam and loam surface horizons and compact clay subsoils. About 30% of the soils occupy ponded sites and are poorly drained, slowly permeable clays.
3e Nig-Kenzie-Osborn	Deep neutral to acid lacustrine deposits on level and depressional lower plateau areas Elevation Range: 840-990 m (2750-3250 ft)	Nig Rego Humic Gleysol Kenzie Terric Mesisol (Sphagnic) Osborn Gleyed Orthic Gray Luvisol	Eutric Brunisols	About 50% of the soils are deep, poorly drained and slowly permeable; they have dark coloured, silty clay loam surface horizons and massive compact clay subsoils. About 30% of the soils consist of very poorly drained organic materials, and about 20% are imperfectly drained clay loams. These soils occupy level and ponded sites. Well drained sandy soils occupy scattered hummocky shedding sites.
3f Osborn-Alcan	Deep weakly calcareous mixed till and lacustrine deposits on moderately sloping lower plateau areas Elevation range: 840-990 m (2750-3250 ft)	Osborn Gleyed Orthic Gray Luvisol Alcan Orthic Gray Luvisol	Gleysols	About 60% of the soils occupy receiving sites and are deep, imperfectly drained and slowly permeabl they have clay loam surface horizons over slightl calcareous lacustrine clay. About 30% of the soi occupy shedding sites and are moderately well dra ed clay loams developed from glacial till. Poorl drained slowly permeable clays occupy 10-20% of t mapping unit on ponded sites.
3g Osborn-Nig	Deep moderately calcareous lacustrine deposits on unpatterned nearly level slopes Elevation range: 760-990 m (2500-3250 ft)	Osborn Gleyed Orthic Gray Luvisol Nig Rego Humic Gleysol	Orthic Gray Luvisols	About 70% of the soils occupy receiving sites and are deep, imperfectly drained and slowly permeabl they have clay loam surface horizons over clay su soils. About 30% of the soils occupy ponded site are poorly drained slowly permeable clays.
3h Osborn (eroded phase)	Deep, weakly calcareous mixed till and lacustrine deposits of lower dissected plateau slopes Elevation range: 760-990 m (2500-3250 ft)	Osborn Gleyed Orthic Gray Luvisol	Regosols	Dominantly moderately well drained, slowly permea ble soils on shedding sites; they have clay loam surface horizons and compact clay subsoils. Variable amounts of eroded soils occur on irregular dissected topography along terrace edges

SOIL ASSOCIATION	LANDFORM AND GEOLOGIC MATERIALS	SOIL COMPONENTS Major	Minor	SIGNIFICANT CHARACTERISTICS OF THE SOILS
4a Bullmoose-Portage	Neutral to weakly calcareous, coarse textured alluvial and outwash materials overlying gravels on nearly level low terraces Elevation range: 730-1220 m (2400-4000 ft)	Bullmoose Cumulic Regosol Portage Degraded Eutric Brunisol	Orthic Regosols	About 80% of the soils are well drained and rapidly permeable; they have sandy loam surface horizons and gravelly subsoils. About 20% of the soils occur on gravelly river bars. Much of this mapping unit has a high seasonal water table and is subject to flooding. The soils occupy shedding sites.
4e Portage-Bullmoose	Neutral to weakly calcareous, coarse textured outwash and alluvial materials overlying gravels on undulating terraces Elevation range: 730-1100 m (2400-3600 ft)	Portage Degraded Eutric Brunisol	Orthic Regosols	Greater than 80% of the soils occupy shedding sites and are well drained and rapidly permeable; they have sandy loam surface horizons and gravelly subsoils. About 20% of the soils occupy receiving and ponded sites and are imperfectly and poorly drained. Parts of the mapping unit may be flooded in periods of high water.

APPENDIX 4

The Scientific Names of the Flora of the Cameron River Reserve

(from Hubbard 1955, Hultén 1968, Schofield 1969, Hale and Culberson 1970, and Hitchock and Cronquist 1973)

Scientific Name	Common Name
Alectoria sarmentosa (Ach.) Ach	
Cladonia gracilis (L.) Willd.	
Cladonia mitis (Sandst.) Hale & W. Culb.	
Dicranum fuscescens Turn.	
Dicranum scoparium Hedw.	
Hylocomium splendens (Hedw.) B.S.G.	
Nephroma arcticum	
Pleurozium schreberi (Brid.) Mitt.	
Polytrichum commune Hedw.	Hair Cap Moss
Ptilium crista-castrensis (Hedw.) De Not.	
Lycopodium annotinum L.	Stiff Club Moss
Equisetum hyemale L.	Horsetail
Equisetum sylraticum L.	Horsetail
Carex aquatilis	Sedge
Carex aurea	Sedge
Carex rostra	Beaked Sedge
Eriophorum brachyantherum Trautv. & Mey.	Cotton-grass
Eriophorum Scheuchzeri Hoppe.	Cotton-grass
Juncus arcticus	Rush
Juncus balticus Willd.	Rush
Juncus bufonius L.	Rush
Juncus castaneus Sm.	Rush
Luzula multiflora (Retz.) Lej.	Woodrush
Luzula parviflora (Ehrh.) Desv.	Woodrush

Scientific Name	Common Name
Scirpus microcarpus Presl.	Bulrush
Agropyron pauciflorum (Schwein.) Hitchc.	Wheatgrass
Agrostis scabra Willd.	Bentgrass
Alopecurus aequalis Sobol.	Short-awn Foxtail
Bechmannia syzigachne (Steud.) Fern.	Sloughgrass
Bromus pumpellianus Scribn.	Brome
Calamagrostis canadensis (Michx.) Beauv.	Bluejoint
Elymus innovatus Beal	Wild-rye
Hierochloe odorata (L.) Beauv.	Sweetgrass
Hordeum jubatum L.	Foxtail Barley
Poa compressa L.	Canada Bluegrass
Trisitum spicatum (L.) Richt.	Spike Trisetum
Achillea millefolium L.	Yarrow
Antennaria media	Pussytoe
Antennaria rosea Greene.	Rose Pussytoes
Arabis Drummondii Gray	Rock Cress
Arnica cordifolia Hook.	Arnica
Astragalus alpinus L.	Milk Vetch
Aster ciliolatus Lindl.	Aster
Aster conspicuous Lindl.	Aster
Brassica spp.	*Mustard*
Capsella bursa-pastoris (L.) Medic.	Shepherd's Purse
Chenopodium capitatum (L.) Aschers	Strawberry Blite
Cornus canadensis L.	Bunchberry
Corydalis aurea Willd.	Golden Corydalis

Scientific Name	Common Name
Corydalis sempervirens (L.) Pers.	Rock Harlequin
Delphinium glaucum S. Wats.	Larkspur
Empetrum nigrum L.	Crowberry
Epilobium adenocaulon Haussk.	*Willow-herb*
Epilobium angustifolium L.	Fireweed
Erigeron philadelphicus L.	Fleabane
Fragaria virginiana Duchesne.	Strawberry
Galeopsis tetrahit L.	Hemp Nettle
Galium boreale L.	Bedstraw
Geranium Bicknellii Britt.	Cranesbill
Geum macrophyllum Willd.	
Heracleum lanatum Michx.	Cow Parsnip
Hieracium gracile Hook.	Hawkweed
Hieracium scabriusculum Schwein.	Hawkweed
Hieracium umbellatum L.	Hawkweed
Lepidium densiflorum Schrad.	*Peppergrass*
Matricaria matricarioides (Less.) Porter.	Pineapple Weed
Melilotus officinalis (L.) Lam.	Sweet Clover
Mertensia paniculata (Ait.) G. Don.	Bluebell
Mitella nuda L.	Bishop's-Cap
Parnassia palustris L.	Bog Star
Pentstemon procerus Dougl.	Beardtongue
Petasites palmatus (Ait) Gray.	Coltsfoot
Phacelia franklinii (R.Br.) A. Gray.	*Phacelia*
Platanthera orbiculata (Pursh.) Lindl.	Bog Orchis
Platanthera unalaschcensis (Spreng.) Kurtz	Bog Orchis

Scientific Name	Common Name
Polemonium pulcherrimum Hook.	Jacob's Ladder
Polygonum viviparum L.	*Smartweed*
Pyrola asarifolia Michx.	Wintergreen
Pyrola secunda L.	Wintergreen
Ranunculus abortivus L.	Buttercup
Ranunculus cymbalaria Pursh.	Buttercup
Rhinanthus minor L.	Yellow Rattle
Senecio pariperculus Michx.	Ragwort
Sisyrinchium montanum (Greene.)	Blue-Eyed Grass
Solidago canadensis L.	Goldenrod
Thalictrum spp.	Meadow Rue
Trifolium hybridum L.	Alsike Clover
Valeriana dioica L.	Valerian
Veronica Wormskjoldii Roem. & Schult.	Speedwell
Vicia americana Muhl.	Vetch
Alnus crispa (Ait.) Pursh.	Alder
Arctostaphylos uva-ursi (L.) Speng.	Bearberry
Artemisia canadensis Michx.	Wormwood
Betula glandulosa	Bog Birch
Ledum groenlandicum Oeder.	Labrador Tea
Linnaea borealis L.	Twinflower
Potentilla fruiticosa L.	Shrubby Cinquefoil
Potentilla spp.	*cinquefoil*
Ribes oxyacanthoides L.	Currant
Rosa acicularis Lindl.	Rose
Rubus chamaemorus L.	Cloudberry

Scientific Name	Common Name
Rubus idaeus var strigosus (Michx.) Maxim.	Raspberry
* *Shepherdia canadensis* (L.) Nutt.	Soapberry
Vaccinium vitis-idaea L.	Lingonberry
Veratrum Eschscholtzii A. Gray	False Hellebore
Viburnum edule (Michx.) Raf.	High Bush Cranberry
Betula papyrifera Marsh.	Paper Birch
Picea glauca (Moench) Voss	White Spruce
Picea mariana (Mill.) Britt.	Black Spruce
Pinus contorta Dougl. ex Loud.	Lodgepole Pine
Populus balsamifera L.	Balsam Poplar
Populus tremuloides Michx.	Quaking Aspen

*Several willow species and/or hybrids occurred in the study area but only three were identified.

Salix bebbiana var bebbiana Sargent	Bebb's Willow
Salix glauca L.	
Salix scouleriana Baratt in Hooker	Scouler's Willow

APPENDIX 5

The Scientific Names of the Fauna of the Study Area

(Cowan and Guiget, 1965)

Scientific Name	Common Name
Alces alces andersoni	Moose
Canis latrans incolatus	Coyote
Canis lupus columbianus	Wolf
Castor canadensis canadensis	Beaver
Cervis canadensis nelsoni	Elk
Felis concolor missoulensis	Cougar
Gulo luscus luscus	Wolverine
Lepus americanus	Snowshoe Hare
Martes americana actuosa	Marten
Martes pennanti columbiana	Fisher
Mustela erminea richardsoni	Weasel
Odocoilus hemionus hemionus	Mule Deer
Rangifer tarandus osborni	Caribou
Ursus americanus cinnamomum	Black Bear
Ursus arctos horribilus	Grizzly Bear
Volpes fulva abietorum	Red Fox
Canachites canadensis	Spruce Grouse
Dendragapus obscurus	Blue Grouse
Bonasa umbellus	Ruffed Grouse
Bubo virginianus	Great-Horned Owl
Nyctea scandiaca	Snowy Owl

APPENDIX 6

Characteristics of Gas Wells

(Department of Mines and Petroleum
Resources Files and
Irish, 1970)

CHARACTERISTICS OF GAS WELLS IN THE CAMERON RIVER RESERVE

Well Name	Elevation (m)	Total Drill Depth (m)	Result	Strata Penetrated	
				Age	Depth Below Ground Level
Pacific Town (A-1)	970	2,259	Completed gas well from Mississippian strata	Mississippian	2,092
Phillips Petroleum Blair "A" No. 1	1,001	2,654	Abandoned, dry	Mississippian	2,324
Phillips Petroleum Town "A" No. 2	892	2,259	Abandoned, dry	Mississippian	2,085
French Petroleum Company - Richfield Daiber	1,077	1,651	Abandoned, dry	Triassic	1,581
French Petroleum Company - Richfield Daiber No. 1	882	1,739	Gas from Triassic	Triassic	1,292
French Petroleum Company - Richfield Daiber	974	1,494	Gas from Triassic	Triassic	1,432
Phillips Petroleum Daiber "A" 1	903	3,509	Abandoned, dry	Devonian	3,091
Texaco N.F.A. Cameron River (1)	891	1,563	Completed gas well from Triassic	Triassic	1,492
Texaco Texan Blair	1,053	2,159	Abandoned, dry		

....Continued

CHARACTERISTICS OF GAS WELLS IN THE CAMERON RIVER RESERVE

Well Name	Elevation (m)	Total Drill Depth (m)	Result	Strata Penetrated	
				Age	Depth Below Ground Level
Pacific *et al* Julienne	1,058	1,982	Abandoned	Triassic	1,965
Gigol BWG Blair	919	1,575	Abandoned	Triassic	1,554
Sinclair Julienne	1,130	4,189	Gas	Devonian	1,060
Arco Pacific Julienne	1,022	1,914	Gas	Triassic	1,899
Whitehal Cdn Sub Cameron	1,064	2,289	Dry, abandoned	Triassic	2,266

APPENDIX 7

History of Logging Activity

(Forest Service Files)

CAMERON RIVER RESERVE
LOGGING HISTORY

Timber Sale	Year	Total ha Logged	Type of Cut	Volume (CF)	Species Composition	Stand Age
X72275	1958	5.3	Selective	9,762	Spruce	
X72274	1960	1.8	78% Selective	1,111	Spruce, pine	
X81122	1960	25.3	Selective	101,345	Spruce	130
X98421	1970	32.3	Clear	301,909	Spruce, pine	140
X96414	1970	15.4	Clear	128,600	Spruce, pine	122
A02387	1970	4.0	Clear	20,798	Spruce	123
		84.0		596,525		

APPENDIX 8

A History of Trapline Catch, East Area of The Cameron River Reserve

(Fish and Wildlife Branch Files)

THE HISTORY OF TRAPPING CATCH, EAST AREA
OF CAMERON RIVER RESERVE, 1950 - 1974
(British Columbia Fish and Wildlife Branch Records)

Species	Beaver	Coyote	Fisher	Fox	Lynx	Martin	Mink	Muskrat	Squirrel	Weasel	Wolverine
Year											
73-74	–	3	5	–	12	1	–	–	1	2	1
72-73	–	11	8	–	29	1	2	–	4	8	1
71-72	3	–	3	–	45	2	2	–	8	4	–
70-71	–	–	2	–	18	–	–	–	–	–	1
69-70	–	–	–	–	–	–	–	–	–	–	–
68-69	–	–	–	–	–	–	–	–	–	–	–
67-68	41	–	–	–	–	–	–	–	–	–	–
66-67	–	–	–	–	–	–	–	–	–	–	–
65-66	36	–	1	–	3	2	–	–	–	–	–
64-65	23	1	–	–	14	–	–	–	300	4	–
63-64	64	3	5	–	23	4	1	–	170	15	2
62-63	14	–	–	–	–	–	–	–	–	–	–
61-62	–	–	–	–	–	–	–	–	–	–	–
60-61	38	2	2	–	4	3	6	2	183	17	–
59-60	–	–	–	–	–	–	–	–	–	–	–
58-59	25	–	1	2	3	8	1	–	230	16	–
57-58	41	–	–	–	–	6	–	8	265	15	–
56-57	7	–	1	2	3	2	1	–	107	9	–
55-56	60	1	1	1	2	7	–	4	319	12	–
54-55	50	–	–	1	1	9	–	–	130	18	–
53-54	54	2	1	7	5	6	2	5	182	22	–
52-53	52	–	1	7	25	7	9	–	287	26	–
51-52	50	–	2	5	11	18	1	5	240	8	–
50-51	50	–	–	–	–	–	–	16	6	2	–

APPENDIX 9

Some Characteristics And Methods of the Resident Moose Hunter In Northeastern British Columbia

(Full Report In Press)

MOOSE HUNTER CHARACTERISTICS
1972 and 1973

Category		1972	1973	Average
Number of moose hunters contacted		275	325	300
Number of hunters per motor vehicle		2.1	2.1	2.1
Time spent on hunting excursion (days)		8.9	10.8	9.9
Estimated average hunting mileage per day (miles)		61.8	49.5	55.7
Permanent residence of hunter:				
Vancouver Island		106	120	113
Lower Mainland		117	160	139
Interior		27	34	9.9
Peace River		25	11	6
History of hunting	New	77	116	97
	Returnees	144	183	164
Estimated maximum hunting distance from vehicle (miles):				
foot		1.50	1.80	1.65
auxiliary vehicle		7.40	5.20	6.30
Number of auxiliary vehicles utilized by hunter		28	46	37

APPENDIX 10

A Summary of Summer Traffic, Alaska Highway

(Canada Department of Public Works, 1971)

A Summary of Summer Traffic Mile 163, Alaska Highway

SOURCE: Canada Department of Public Works 1971
Alaska Highway Traffic Study, Summer 1971

TRAFFIC VOLUMES: (motor vehicles per hour)

Average hourly volume	69
Average daily volume	620

TOURIST COMPOSITION: (percentage)

American tourists	55
Canadian tourists	45

DESTINATION AND FREQUENCY OF TRIP: (percentage)

Northbound to Alaska	97.5
Yearly trip frequency	76.8

COMPOSITION OF VEHICLE TRAFFIC:

VEHICLE TYPE	NORTHBOUND %	SOUTHBOUND %
Car	37.3	37.7
Camper truck	22.2	19.9
Car with trailer	11.0	10.4
4-Wheel drive	14.3	16.4
5 Axle truck	7.0	7.8
Bus	2.8	2.5
2 Axle truck (6w)	1.4	1.6
3 Axle truck	1.4	2.1
4 Axle truck	.4	.3
Other	.3	.4
Not recorded	1.9	.8

APPENDIX 11

Canada Land Inventory
Categories (A.R.D.A.)

The Canada Land Inventory

Land Capability Classification for Wildlife

Land Classification for Ungulates

Capability Classes

Class 1 Lands having no significant limitations to the production of ungulates.

Class 1W Winter range.

Class 2 Lands having very slight limitations to the production of ungulates.

Class 2W Winter range.

Class 3 Lands having slight limitations to the production of ungulates.

Class 3W Winter range.

Capability Subclasses

Climate

Q - Snow Depth

The limitation is prolonged periods of snow conditions which reduce the mobility of ungulates and/or the availability of food plants. It is difficult to define the limitation or provide uniform standards for use across Canada because it may be due to one or more of the following factors: depth, texture, size of snow granules, compressibility, density and uniformity of the snow. Experience and knowledge of snow conditions on the winter ranges will assist the surveyor in arriving at a decision on whether or not snow is a limiting factor to the production or survival of ungulates.

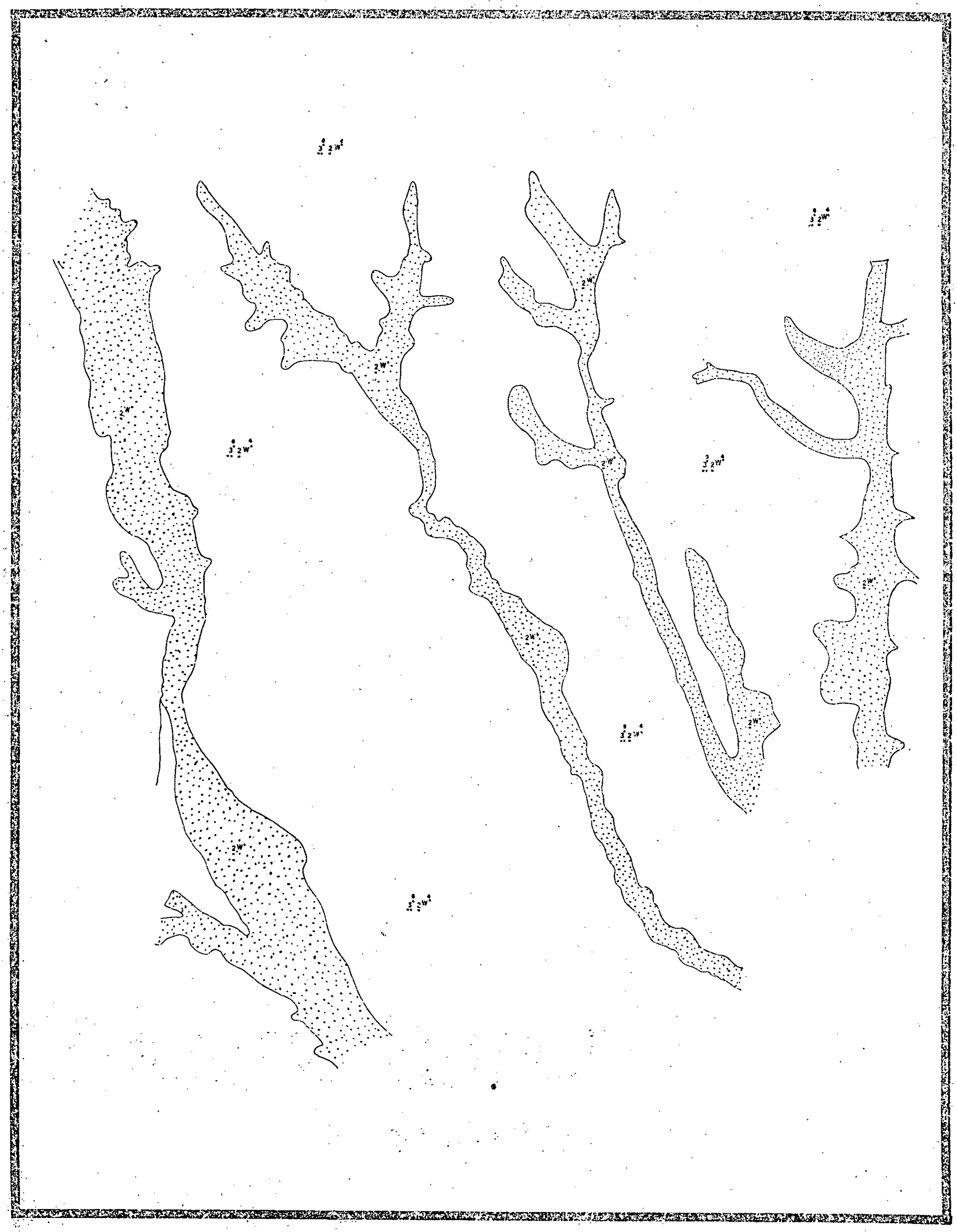
Ungulate Indicator Species

D Deer (white-tailed deer, Columbia black-tailed deer, mule deer)

M Moose

Reference

The Canada Land Inventory
Land Capability Classification for Wildlife
The Canada Land Inventory
Report No. 7
1970



The Canada Land Inventory

Land Capability Classification For Forestry

Capability Classes

Class 3 Lands having moderate limitations to the growth of commercial forests.

Class 4 Lands having moderately severe limitations to the growth of commercial forests.

Class 5 Lands having severe limitations to the growth of commercial forests.

Class 6 Lands having very severe limitations to the growth of commercial forests.

Class 7 Lands having severe limitations which preclude the growth of commercial forests.

Capability Subclasses

Climate

A - drought or aridity as a result of climate.
C - a combination of more than one climatic factor, or two or more features of climate that have significance.
H - low temperatures - that is, too cold.
U - exposure.

Soil Moisture

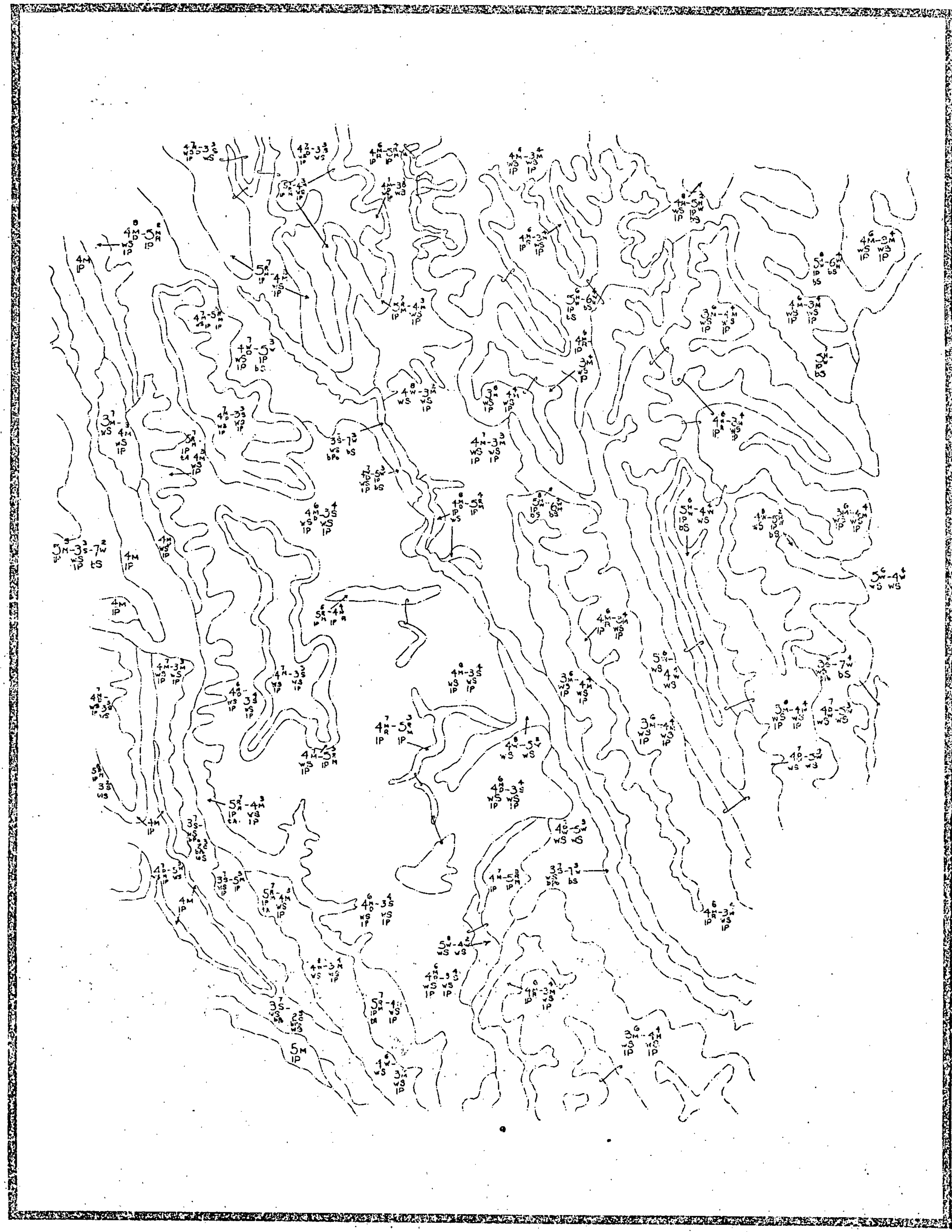
M - soil moisture deficiency.
W - excess soil moisture.
X - a pattern of "M" and "W" too intimately associated to map separately.
Z - a pattern of wet organic soils and bedrock too intimately associated to map separately.

Permeability and Depth of Rooting Zone

D - physical restriction to rooting caused by dense or consolidated layers, other than bedrock.
R - restriction of rooting zone by bedrock.
Y - intimate pattern of shallowness and compaction, or other restricting layers.

Other Soil Factors

E - actively eroding soils.
F - low fertility.
I - soils periodically inundated by streams or lakes.



L - excessive levels of calcium.
N - excessive levels of toxic elements, such as soluble salts.
P - stoniness which affects forest density or growth.
S - a combination of soil factors, none of which affect the class level by themselves, but which cumulatively lower the capability class.

Indicator Species

wS	White Spruce (*Picea glauca*)
lP	Lodgepole Pine (*Pinus contorta*)
bPo	Balsam Poplar (*Populus balsamifera*)
tA	Trembling Aspen (*Populus tremuloides*)
bS	Black Spruce (*Picea mariana*)

Reference

The Canada Land Inventory
Land Capability Classification for Forestry
The Canada Land Inventory
Report No. 4
1970

The Canada Land Inventory

Soil Capability Classification For Agriculture

Capability Classes

Class 1 Soils in this class have no significant limitations in use for crops.

Class 2 Soils in this class have moderate limitations that restrict the range of crops or require moderate conservation practices.

Class 3 Soils in this class have moderately severe limitations that restrict the range of crops or require special conservation practices.

Class 4 Soils in this class have severe limitations that restrict the range of crops or require special conservation practices, or both.

Class 5 Soils in this class have very severe limitations that restrict their capability to producing perennial forage crops, and improvement practices are feasible.

Class 6 Soils in this class are capable only of producing perennial forage crops, and improvement practices are not feasible.

Class 7 Soils in this class have no capability for arable culture or permanent pasture.

Capability Subclasses

Subclass C: adverse climate - The main limitation is low temperature or low or poor distribution of rainfall during the cropping season, or a combination of these.

Subclass I: inundation - Flooding by streams or lakes limits agricultural use of the land.

Subclass R: shallowness to solid bedrock - Solid bedrock is less than three feet from the surface.

Subclass T: adverse topography - Either steepness or the pattern of slopes limitssagricultural use.

Subclass W: excess water - Excess water other than from flooding limits use for agriculture. The excess water may be due to poor drainage, a high water table, seepage or runoff from surrounding areas.

<u>Reference</u>

The Canada Land Inventory
Soil Capability Classification for Agriculture
The Canada Land Inventory
Report No. 2
1969

The Canada Land Inventory

Land Capability Classification For Outdoor Recreation

Capability Classes

Class 1 Lands in this class have very high capability for outdoor recreation.

Class 2 Lands in this class have a high capability for outdoor recreation.

Class 3 Lands in this class have a moderately high capability for outdoor recreation.

Class 4 Lands in this class have moderate capability for outdoor recreation.

Class 5 Lands in this class have moderately low capability for outdoor recreation.

Class 6 Lands in this class have low capability for outdoor recreation.

Class 7 Lands in this class have very low capability for outdoor recreation.

U denotes "UPLAND" unit area

Capability Subclasses

Subclass A: Land providing access to water affording opportunity for angling or viewing of sport fish.

Subclass E: Land with vegetation possessing recreational value.

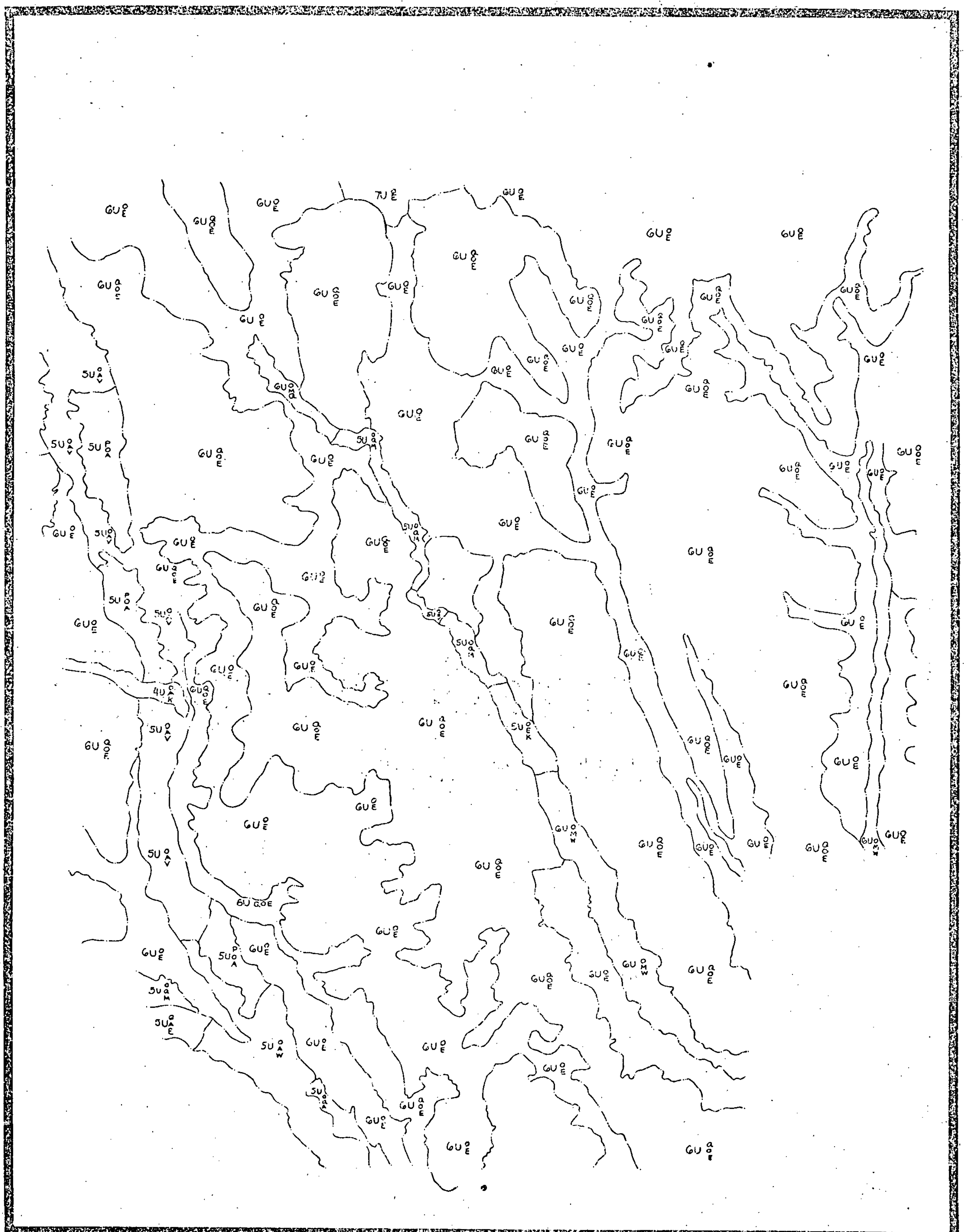
Subclass M: Frequent small water bodies or continuous streams occurring in upland areas.

Subclass O: Land affording opportunity for viewing of upland wildlife.

Subclass P: Areas exhibiting cultural landscape patterns of agricultural, industrial or social interest.

Subclass Q: Areas exhibiting variety, in topography or land and water relationships, which enhances opportunities for general outdoor recreation such as hiking and nature study or for aesthetic appreciation of the area.

Subclass V: A vantage point or area which offers a superior view relative to the class of the unit(s) which contain it, or a corridor or other area which provides frequent viewing opportunities.



Subclass W: Land affording opportunity for viewing of wetland wildlife.

Reference

The Canada Land Inventory
Land Capability Classification for Outdoor Recreation
The Canada Land Inventory
Report No. 6
1969

APPENDIX 12

Life Tables and Survivorship Curves Developed From Hunter Harvest Returns

NUMBERS OF HUNTERS AND MOOSE HARVESTED IN
GAME MANAGEMENT AREA 28 (M.U.'S 7-18-23, 31-36, 43-46) 1971-1974 (HUNTER SAMPLE)

Year	Estimated Number of Hunters	Estimated Number of Moose Harvested	Calculated Success	Estimated Percentage of Provincial Moose Harvest	Estimated Harvest Composition (per 100 cows)		
					Males	Females	Juveniles
1971	7,385	4,497	60	25	135	100	20
1972	6,647	2,578	38	22	144	100	15
1973	8,141	3,658	44	20	228	100	28
1974	6,263	2,488	39	21	217	100	27

NUMBERS OF HUNTERS AND MOOSE HARVESTED
IN THE CAMERON RIVER RESERVE, 1971-1973

Year	Estimated Numbers of Hunters[1] (actual numbers in brackets)	Estimated Numbers of Moose Harvested[1] (actual numbers in brackets)	Calculated Success	Estimated Harvest Composition (per 100 cows)		
				Males	Females	Juveniles
1971		100 - 120[2]				
1972	343 (275)	68 (55)	20	100	100	16
1973	404 (323)	141 (113)	35	224	100	14

[1]Calculated by assuming an 80 percent sample by field reconnaissance

[2]Harper (*per comm*)

RECENT MOOSE SEASONS
IN NORTHEASTERN BRITISH COLUMBIA
(Length of Season in Days in Parentheses)

Year	Male Season	Female Season	Bag Limit	Special Regulations
1966-67	August 13-December 11 (121)	October 8-December 11 (64)	1	
1967-68	August 1-December 10 (132)	October 7-December 10 (64)	1*	Except in M.A. 28 and that portion of M.A. 21 below the high water mark of the Peace River Dam - Bag limit 2.
1968-69	August 3-December 15 (134)	October 5-December 15 (71)	1*	Except in M.A. 28 and that portion of M.A. 21 below the high water mark of the Peace River Dam - Bag limit 2.
1969-70	August 16-December 14 (120)	October 4-December 14 (71)	1*	Except that portion of M.A. 21 and M.A. 28 below the high water mark of "Williston Lake", the open season on bull moose is August 16 to March 31 and on antlerless moose October 4 to March 31, 1970.
1970-71	August 15-December 13 (120)	October 3-December 13 (71)	1	
1971-72	August 14-December 12 (120)	October 2-December 12 (71)	1	

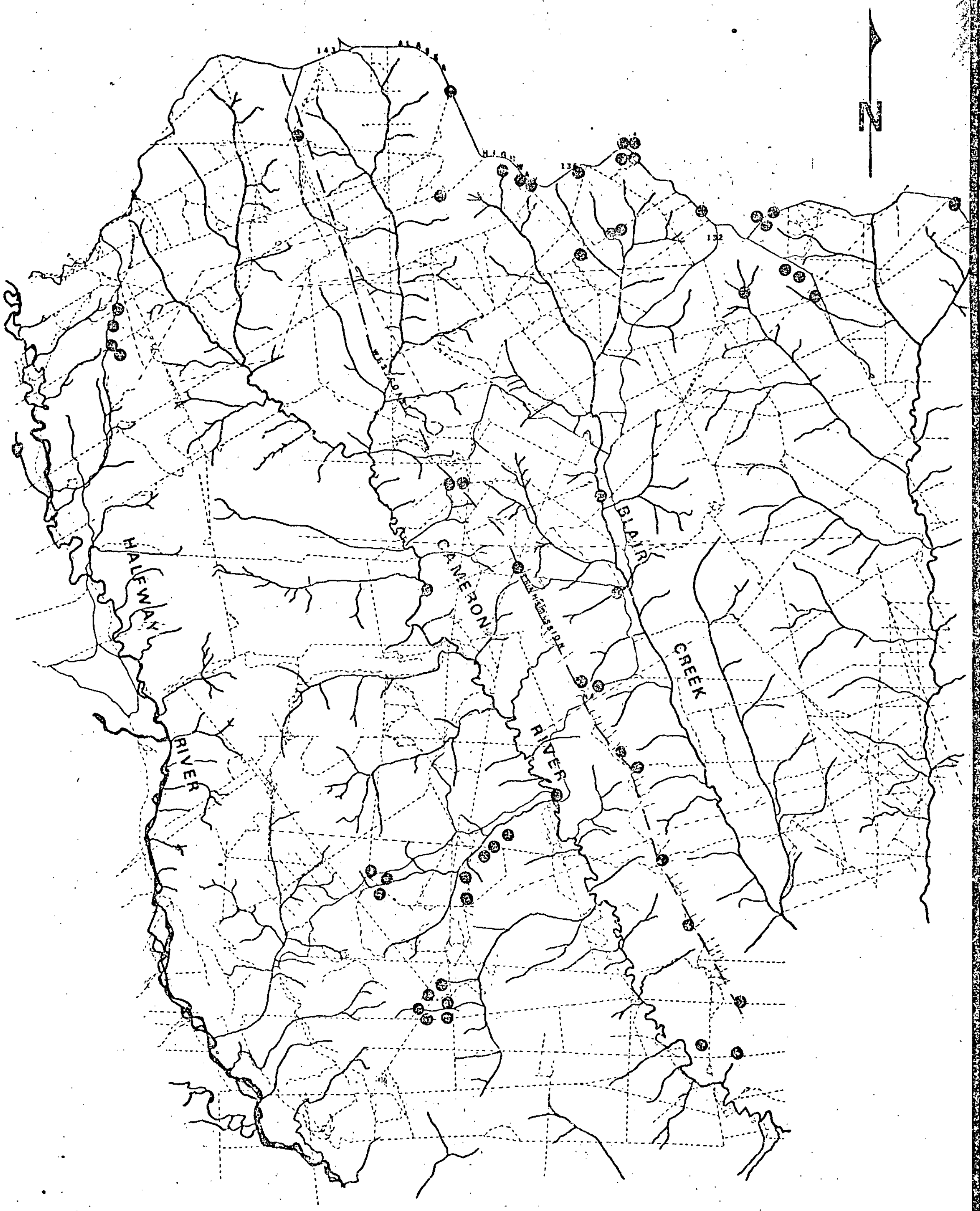
....Continued

RECENT MOOSE SEASON
IN NORTHEASTERN BRITISH COLUMBIA
(Length of Season in Days in Parentheses)

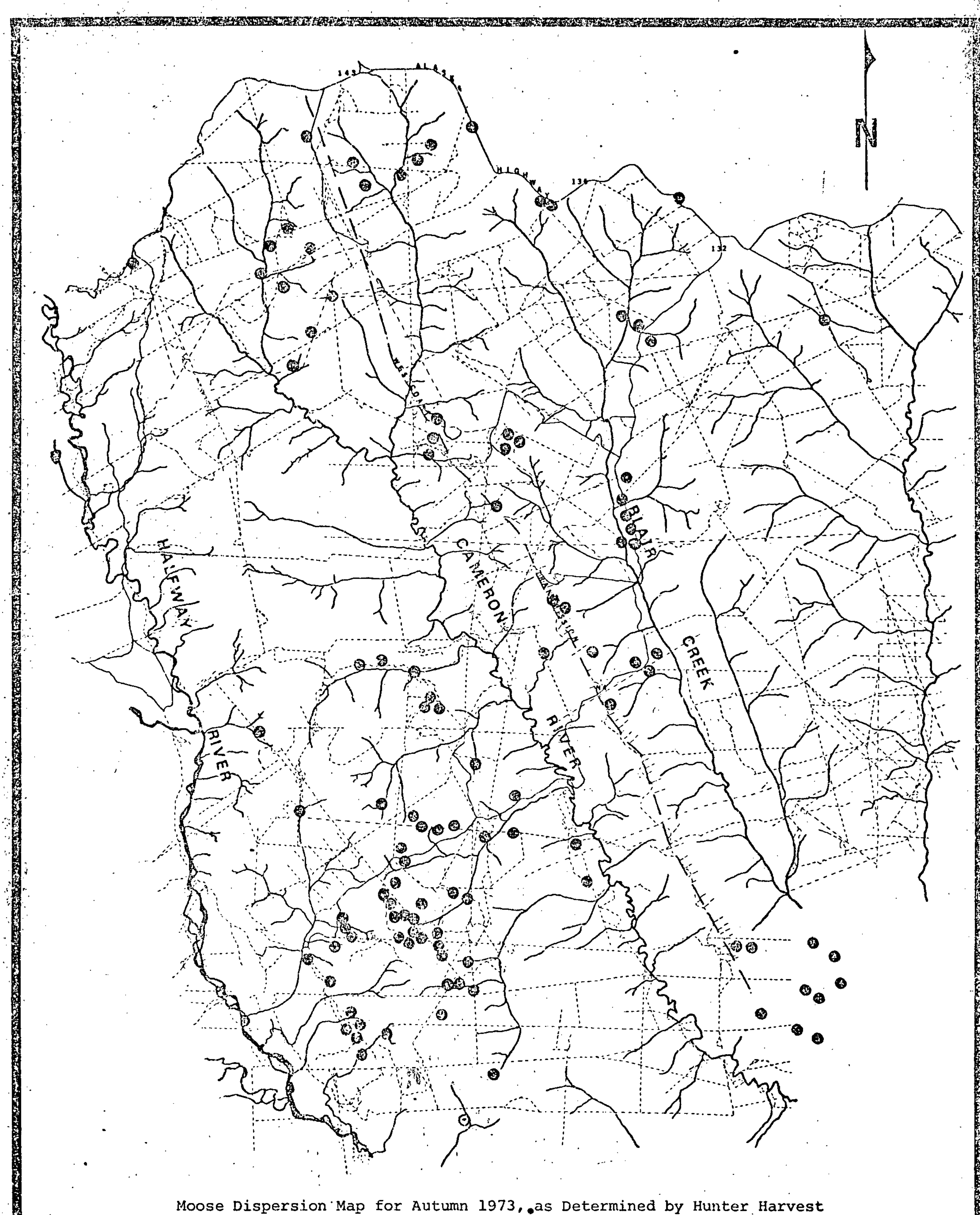
Year	Male Season	Female Season	Bag Limit	Special Regulations
1972-73	August 15-November 26 (103)	October 7-November 26 (50)	1	
1973-74	August 15-November 18 (95)	October 6-October 28 (22)	1	

Source: *B.C. Fish and Wildlife Hunting Regulations*

Courtesy: *G.D. Gosling, Senior Conservation Officer, Prince George*



Moose Dispersion Map for Autumn 1972, as Determined by Hunter Harvest



Moose Dispersion Map for Autumn 1973, as Determined by Hunter Harvest

LIFE TABLES DEVELOPED FOR
HUNTER HARVESTED MOOSE IN
NORTHERN BRITISH COLUMBIA

Age (Years)	Female Moose, Game Management Area 28 (M.U. 7-18-23, 7-31-36, 7-43-46)					
	1972			1973		
	lx	dx	qx	lx	dx	qx
1.5	1000	80	.08	1000	287	.29
2.5	920	145	.15	713	168	.23
3.5	785	209	.26	545	119	.21
4.5	576	129	.22	426	91	.21
5.5	447	97	.21	335	119	.35
6.5	350	97	.27	216	28	.12
7.5	253	16	.06	188	49	.26
8.5	237	16	.06	139	28	.20
9.5	221	32	.14	111	35	.31
10.5	189	32	.16	76	14	.18
11.5	124	65	.52	64	28	.43
12.5	108	16	.14	32	14	.43
13.5	92	16	.17	18	0	0

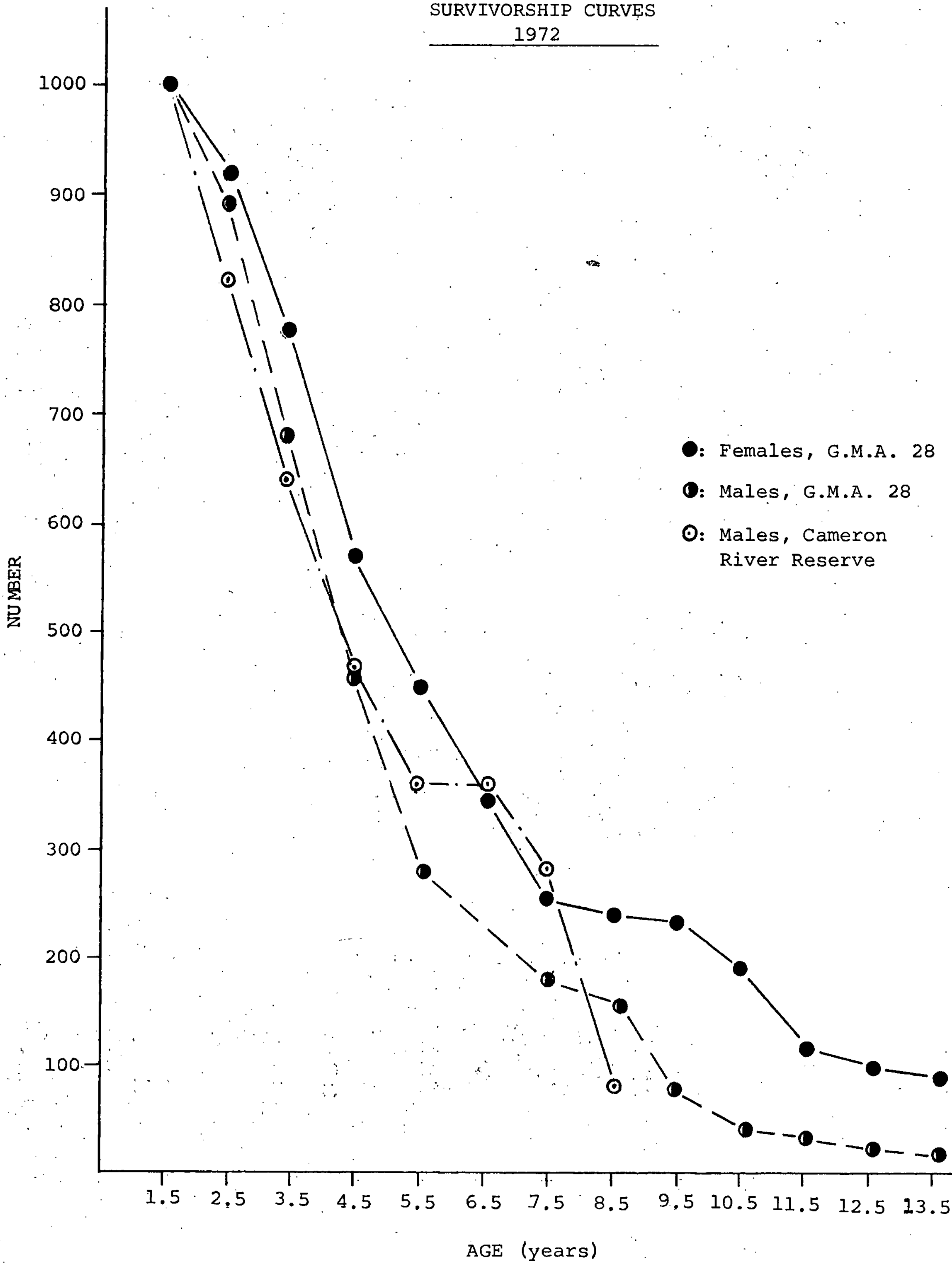
LIFE TABLES DEVELOPED FOR HUNTER HARVESTED MOOSE IN NORTHERN BRITISH COLUMBIA

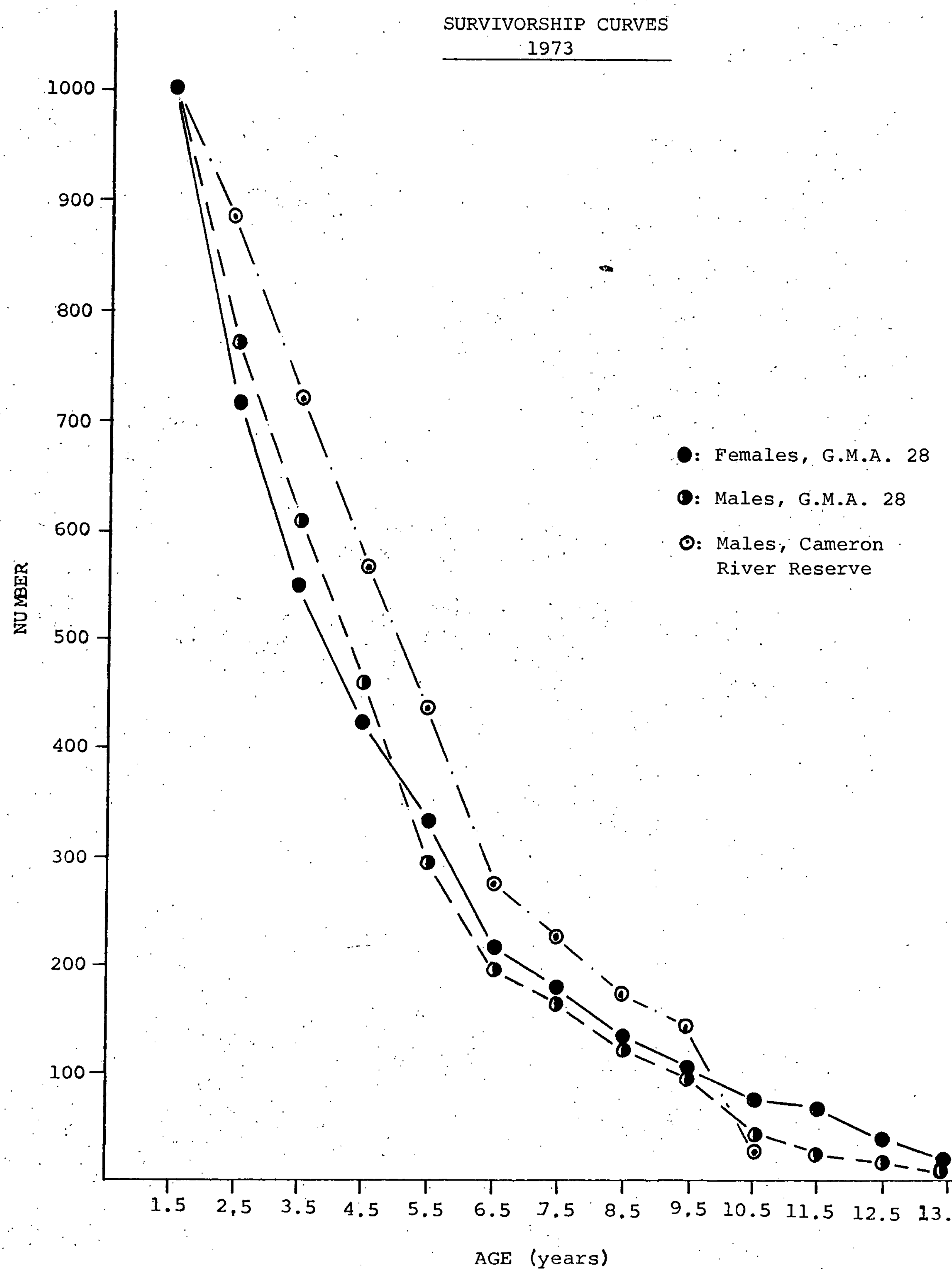
Age (Years)	Male Moose, Game Management Area 28 (M.U. 7-18-23, 7-31-36, 7-43-46)					
	1972			1973		
	lx	dx	qx	lx	dx	qx
1.5	1000	108	.11	1000	215	.22
2.5	892	206	.23	785	182	.23
3.5	686	235	.34	603	136	.22
4.5	451	167	.37	467	168	.35
5.5	284	108	.38	299	103	.34
6.5	176	39	.22	196	23	.11
7.5	137	49	.35	173	37	.21
8.5	88	39	.44	146	37	.25
9.5	49	10	.20	109	51	.46
10.5	39	20	.51	58	23	.39
11.5	19	10	.52	25	9	.36
12.5	9	10	1.0	14	5	.35
13.5	0	0	0	9	5	.56

LIFE TABLES DEVELOPED FOR
HUNTER HARVESTED MOOSE IN
NORTHERN BRITISH COLUMBIA

Age (Years)	Male Moose, Cameron River Reserve					
	1972			1973		
	lx	dx	qx	lx	dx	qx
1.5	1000	182	.18	1000	107	.11
2.5	818	182	.22	893	179	.20
3.5	636	182	.28	714	143	.20
4.5	454	182	.40	571	143	.25
5.5	363	0	0	428	143	.33
6.5	363	91	.25	285	71	.24
7.5	272	182	.66	214	36	.16
8.5	90	0	0	178	36	.20
9.5	0	0	0	142	107	.75
10.5	0	0	0	35	0	0

SURVIVORSHIP CURVES
1972





SURVIVORSHIP CURVES
1973
1000
900
800
700
600
500
400
300
200
100
NUMBER
●: Females, G.M.A. 28
◐: Males, G.M.A. 28
⊙: Males, Cameron River Reserve
1.5
2.5
3.5
4.5
5.5
6.5
7.5
8.5
9.5
10.5
11.5
12.5
13.
AGE (years)

Cameron River Reserve
Hunter Harvest 1972

Number	Sex	Date of Kill	Tooth Age if any
1	Male	September 10	6.5
2	Male	September 30	3.5
3	Male	October 1	1.5
4	Male	October 2	1.5
5	Male	October 1	2.5
6	Male	October 1 (Week)	4.5
7	Male	October 2	
8	Male	October 2	4.5
9	Male	October 3	2.5
10	Male	October 5	3.5
11	Unclassified	October (1st Week)	7.5
12	Female	October (1st Week)	1.5
13	Male	October 5	7.5
14	Male	October (1st Week)	
15	Female	October 7	
16	Male	October 7	
17	Male	October 5-7	
18	Female	October 5-10	
19	Male	October 5-10	
20	Male	October 5-10	
21	Female	October 5-10	
22	Male	October 5-10	

Number	Sex	Date of Kill	Tooth Age if any
23	Female	October 5-10	
24	Female	October 5-10	
25	Male	October 6	
26	Female	October 10	6.5
27	Calf	October 10	.5
28	Male	October 10	
29	Female	October 11	3.5
30	Female	October 11	
31	Male	October 9	
32	Male	October 13	
33	Male	October 12-14	
34	Female	October 12-14	
35	Female	October 12-14	
36	Male	October 12-14	
37	Female	October 12-14	
38	Calf	October 12-14	.5
39	Female	October 12-14	3.5
40	Female	October 12-14	
41	Female	October 12-14	
42	Male	November 8-13	
43	Female	November 8-13	
44	Female	November 8-13	
45	Female	November 8-13	
46	Female	November 8-13	
47	Female	November 9-12	

Number	Sex	Date of Kill	Tooth Age if any
48	Female	November (2nd Week)	
49	Calf	November (2nd Week)	.5
50	Female (dry)	November 10	
51	Female	November (2nd Week)	
52	Male	November (2nd Week)	
53	Female	November 13	6.5
54	Calf	November 13	.5
55	Female	November 14	4.5

Cameron River Reserve
Hunter Harvest 1973

Number	Sex	Date of Kill	Estimated Age	Tooth Age if any
1	Male	August 17	2.5	2.5
2	Male	August 20	1.5	
3	Male	August 17		
4	Male	September 1	3.5-4.5	
5	Male	September 23	2.5	
6	Female (illegal)	September 18		
7	Male	September 24	1.5	
8	Male	September 24		
9	Male	September 24	2.5	
10	Male	September 24	1.5	
11	Male	September 25	1.5-2.5	2.5
12	Male	September 26	2.5	
13	Male	September 26	2.5	
14	Male	September 26	3.5	
15	Male	September 27	3.5	3.5
16	Male	September 29	3.5	
17	Male	September 22		9.5
18	Male	September 27	3.5	
19	Male	September 30	3.5	2.5
20	Male	October 1	1.5	1.5
21	Male	October 4		3.5

Number	Sex	Date of Kill	Estimated Age	Tooth Age if any
22	Male	October 1	3.5-4.5	4.5
23	Male	October 6	2.5	
24	Male	October 6	2.5	
25	Male	October 6		9.5
26	Female	October 6	(Young)	
27	Calf	October 6	.5	
28	Female	October 6		2.5
29	Female	October 6		
30	Male	October 6	2.5	5.5
31	Male	October 6	2.5	
32	Female	October 6		
33	Male	October 7		5.5
34	Male	October 7		5.5
35	Male	October 7	(Mature)	4.5
36	Male	October 7	(Mature, 50")	
37	Female	October 7		
38	Female	October 7		
39	Male	October 7		
40	Male	October 7		3.5
41	Male	October 7	(Young)	
42	Male	October 7		8.5
43	unclassified	October 6		
44	Female	October 8		
45	Male	October 8		1.5
46	Male	October 8	3.5	2.5

Number	Sex	Date of Kill	Estimated Age	Tooth Age if any
47	Male	October 8		
48	Female	October 8		
49	Male	October 8	3.5	
50	Male	October 8	3.5	
51	Male	October 8	(Mature)	
52	Female	October 8		
53	Female	October 8		
54	Male	October 9		
55	Male	October 9	3.5	
56	Male	October 6	(Mature, 43")	7.5
57	Male	October 9	(Mature, 58")	9.5
58	Male	October 9		
59	Female	October 10		3.5
60	Calf	October 10	.5	.5
61	Female	October 10		
62	Female	October 10	3.5	
63	Female	October 10		
64	Male	October 10		
65	Male	October 10	(Mature)	5.5
66	Male	October 10	(Mature)	
67	Male	October 10	(Young)	
68	Male	October 10	(Mature)	
69	Male	October 10		
70	Female	October 10		
71	Male	October 11		12.5

Number	Sex	Date of Kill	Estimated Age	Tooth Age if any
72	Female	October 11		
73	Male	October 11		
74	Male	October 8		2.5
75	Female	October 11		8.5
76	Male	October 12	(Mature, 46")	
77	Male	October 12	2.5	
78	Female	October 12		
79	Female	October 13		12.5
80	Calf (Male)	October 14	.5	.5
81	Female (dry)	October 14		
82	Male	October 14		6.5
83	Male	October 8	(Mature)	6.5
84	Female (dry)	October 9		2.5
85	Male	October 10	(Mature)	5.5
86	Female (dry)	October 9		
87	Female	October 15		1.5
88	Calf	October 15	.5	.5
89	Male	October 16		
90	Female	October 16		
91	Female	October 16		
92	Male	October 17		
93	Female	October 17		
94	Female	October 17		
95	Male	October 16	(Young)	

Number	Sex	Date of Kill	Estimated Age	Tooth Age if any
96	Male	October 17		
97	Male	October 17	3.5	
98	Female	October 18		
99	Female	October 19		1.5
100	Female	October 20		
101	Female	October 22		1.5
102	Male	October 23	3.5	3.5
103	Calf	November 2	.5	
104	Male	November 18	2.5	
105	Male	November 8	(Mature, 45")	
106	Male	November 10	3.5-4.5	
107	Male	November 10	1.5	
108	Male	November 11	(Mature, 41")	4.5
109	Male	November 11	(Mature, 43")	4.5
110	Male	November 12	(Mature, 45")	
111	Male	November 12	(Young)	
112	Male	November 25	1.5-2.5	1.5
113	Male	October 7	3.5-4.5	

APPENDIX 13

Summary Printouts of Computer Analyses, Vegetation Plots

The following is an example of the computer printouts summarizing analysis of herbaceous and shrub components of selected vegetation types. All printouts are deposited with the original copy of the thesis at the University of British Columbia Library.

B ANALYSIS FOR PLOT NUMBER 1

BROWSE INDEX	FREQ. OF OCC	NO. OF SHRUBS	BASAL AREA	DENS/ ACRE	B.A./ ACRE	SPECIES	REL. FREQ.	REL. DENS.	REL. DOM.	IMPORT VALUE
1.0	6.	819	438.	1392300.	2.77	WILLOW	5.6	21.1	0.1	8.9
0.0	0.	0	0.	0.	0.0	ASPEN	0.0	0.0	0.0	0.0
0.0	0.	0	0.	0.	0.0	ALDER	0.0	0.0	0.0	0.0
1.0	100.	3065	459424.	613000.	24725.91	BIRCH	94.4	78.9	99.9	91.1
0.0	0.	0	0.	0.	0.0	SHEPERDI	0.0	0.0	0.0	0.0
0.0	0.	0	0.	0.	0.0	SPRUCE	0.0	0.0	0.0	0.0
0.0	0.	0	0.	0.	0.0	CRANBERR	0.0	0.0	0.0	0.0
0.0	0.	0	0.	0.	0.0	ROSE	0.0	0.0	0.0	0.0
0.0	0.	0	0.	0.	0.0	LEDUM	0.0	0.0	0.0	0.0
0.0	0.	0	0.	0.	0.0	ALDER	0.0	0.0	0.0	0.0
0.0	0.	0	0.	0.	0.0	CINQUEFO	0.0	0.0	0.0	0.0
0.1	106.	3884	459862.	2005300.	24728.68	TOTAL	100.0	100.0	100.0	100.0
	0.	0		0.		PELLETS				

LOWLAND SHRUB COMMUNITY
SHRUB ANALYSIS

CANOPY COVER AND FREQUENCY

NO	SPECIES NAME	% CANOPY COVER-MEAN	FREQUENCY PRESENCE	PERCENT OCCURRENCE	DOMINANCE PER ACRE	DOMINANCE PER HECTARE	RELATIVE DOMINANCE	RELATIVE FREQUENCY	IMPORTANCE VALUE
SITE 1									
1	ACHMIL	0.25	1	10.00	5439.32	13440.86	0.18	1.41	0.79
2	ADXMOS	0.50	2	20.00	10878.64	26881.71	0.35	2.82	1.59
3	ALNUSP	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
4	ARNCSP	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
5	ARNISP	1.00	4	40.00	21757.29	53763.43	0.71	5.63	3.17
6	BETUSP	50.25	10	100.00	1093303.00	2701611.00	35.64	14.08	24.86
7	CLAGRA	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
8	CLAMIT	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
9	CORCAN	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
10	CYPERA	4.00	6	60.00	87029.13	215053.69	2.84	8.45	5.64
11	DELGLA	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
12	DICESP	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
13	EMPNIG	0.25	1	10.00	5439.32	13440.86	0.18	1.41	0.79
14	EPIANG	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
15	ERGESP	0.25	1	10.00	5439.32	13440.86	0.18	1.41	0.79
16	EQUARV	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
17	FRAGSP	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
18	GALTRF	0.50	2	20.00	10878.64	26881.71	0.35	2.82	1.59
19	GRAMIN	6.75	7	70.00	146861.63	362903.13	4.79	9.86	7.32
20	GROUND	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
21	HIEGLA	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
22	HYLSPL	31.50	7	70.00	685354.63	1693548.00	22.34	9.86	16.10
23	JUNCAC	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
24	LATHSP	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
25	LEANED	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
26	LEDGRO	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
27	LEVNED	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
28	LINBOR	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
29	LYCANN	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
30	NEPARC	1.75	2	20.00	38075.25	94086.00	1.24	2.82	2.03
31	PEDLAP	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
32	PETASP	4.00	2	20.00	87029.13	215053.69	2.84	2.82	2.83
33	PICESP	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
34	PLESCH	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
35	POLYSP	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
36	POTFRT	0.50	2	20.00	10878.64	26881.71	0.35	2.82	1.59
37	PYROSP	0.25	1	10.00	5439.32	13440.86	0.18	1.41	0.79
38	ROSASP	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
39	RUBARC	0.50	2	20.00	10878.64	26881.71	0.35	2.82	1.59
40	SALXSP	9.00	7	70.00	195815.56	483870.81	6.38	9.86	8.12
41	SHPCAN	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
42	VACCSP	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
43	VACVIT	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
44	VIBEDL	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
45	VICISP	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
46	WOOLEV	20.25	9	90.00	440585.13	1088709.00	14.36	12.68	13.52
47	ARCTUV	9.50	5	50.00	206694.25	510752.69	6.74	7.04	6.89
48	EQUISP	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
49	PICISP	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
50	POPTRE	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
51	ASTCON	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
52	RUBUSP	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0

LOWLAND SHRUB COMMUNITY
HERBACEOUS PLANT ANALYSIS

APPENDIX 14

Blooming and Fruiting Times of Some Conspicuous Roadside Flora

Blooming and Fruiting Times of Some Conspicuous Roadside Flora, Cameron River Reserve

Date / Species		May June July August Sept.
Salix spp	Willow	******------------
Populus tremuloides	Aspen	****------------
Alnus spp	Alder	****------------
Taraxacum spp	Dandelion	------------------------------ ************************************----------
Mertensia paniculata	Bluebell	*****************----------
Eriophorum spp	Cotton grass	***********----------------
Fragaria spp	Stawberry	***********----------------
Cyperaceae spp	Sedges	***********----------------
Cornus canadensis	Bunchberry	*************----------
Ledum groenlandicum	Labrador tea	*************----------
Pyrola spp	Wintergreen	**************---------
Rosa spp	Rose	************-------------
Corydalis sempervirens	Rock Harlequin	********************---------
Galium trifidum	Bedstraw	***************------------
Achillea millefolium	Yarrow	************************-------
Epilobium angustifolium	Fireweed	************************-------
Gramineae spp	Grasses	*****************----------------
Viburnum edule	High Bush Cranberry	**************----------
Rubus spp	Cloudberry	***************---------

*** Blooming Period

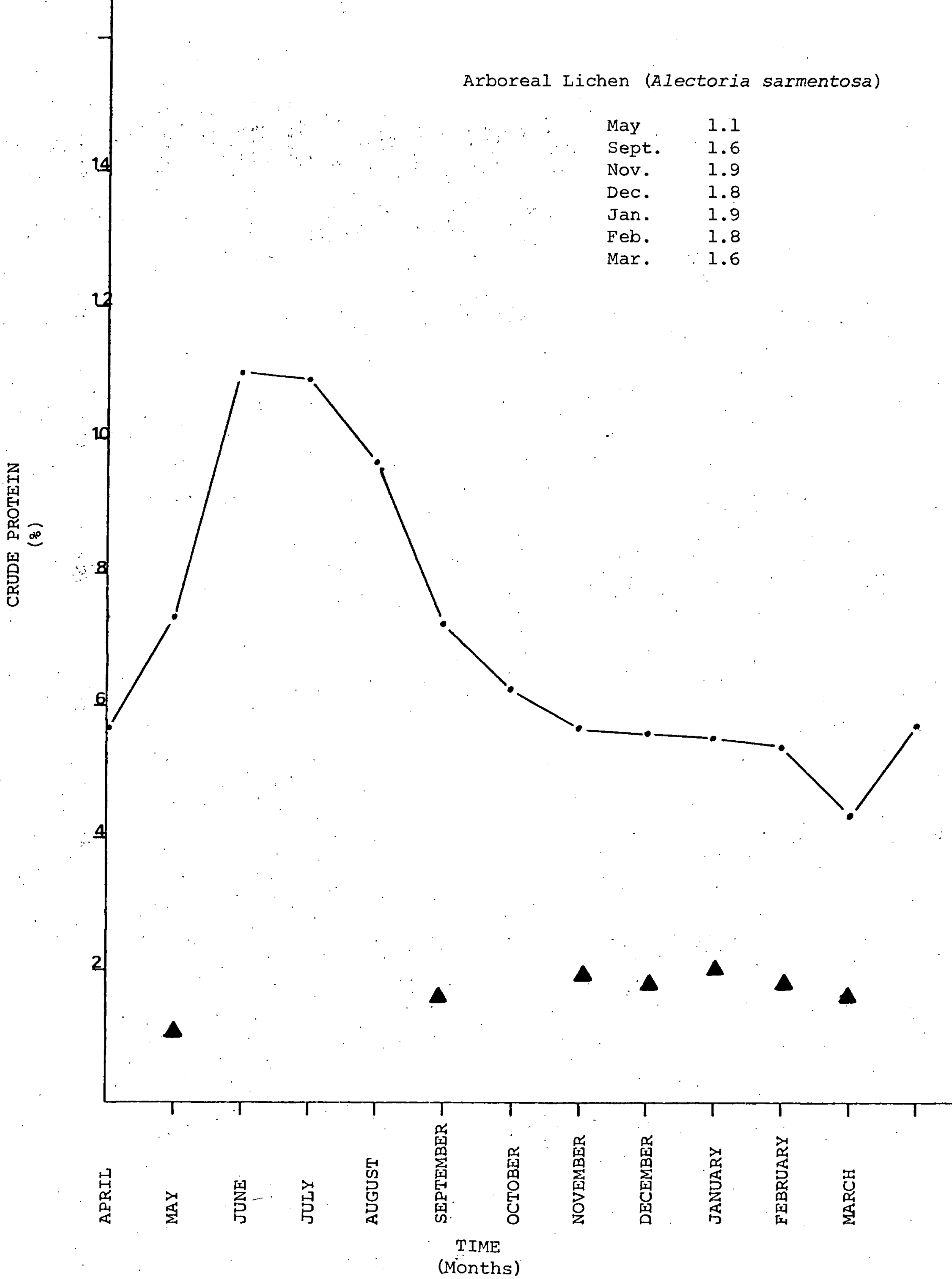
--- Fruiting Period

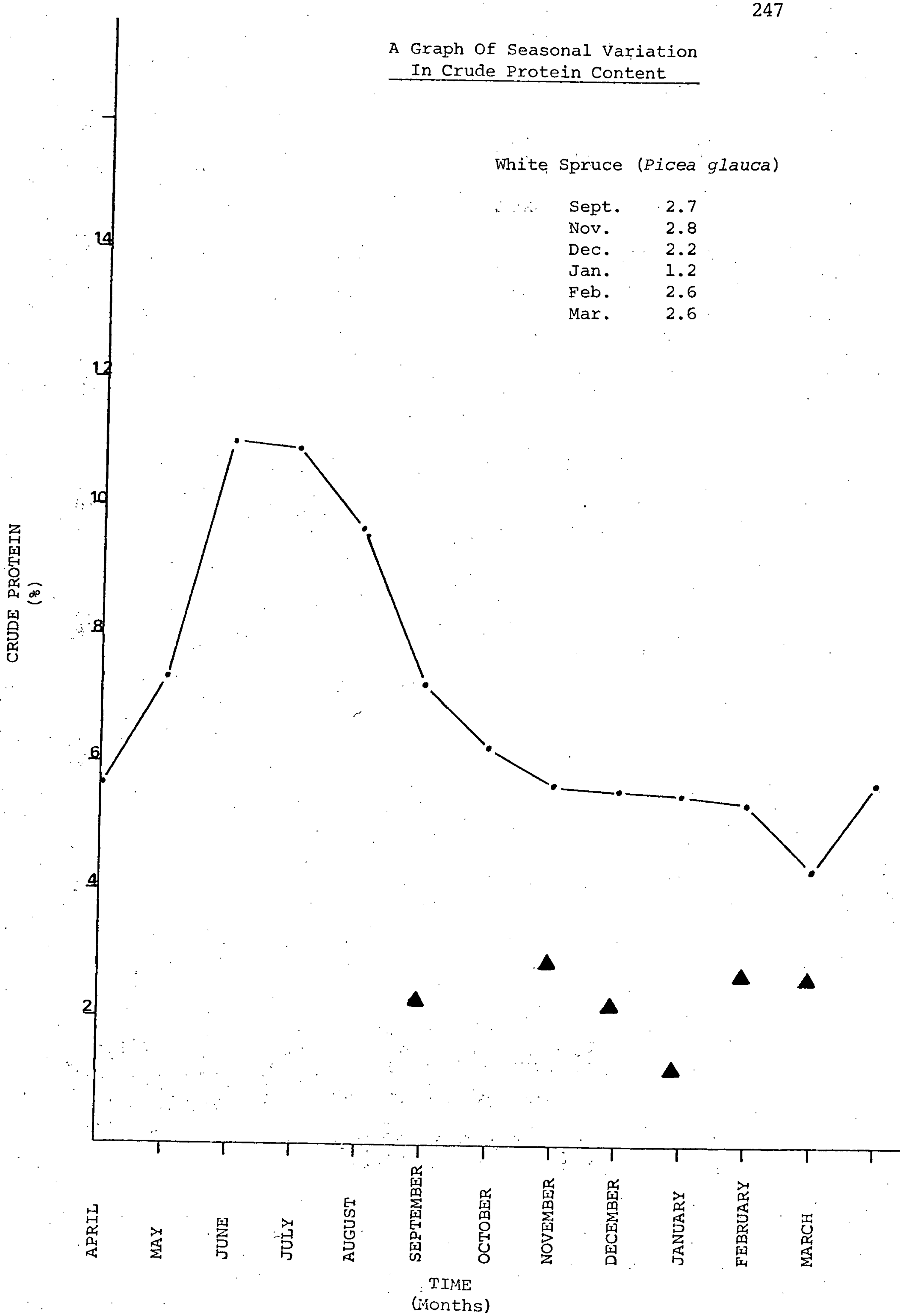
APPENDIX 15

The Crude Protein Content of
Eight Forages Compared To
the Values Obtained For Willow
by Eastman (unpublished)

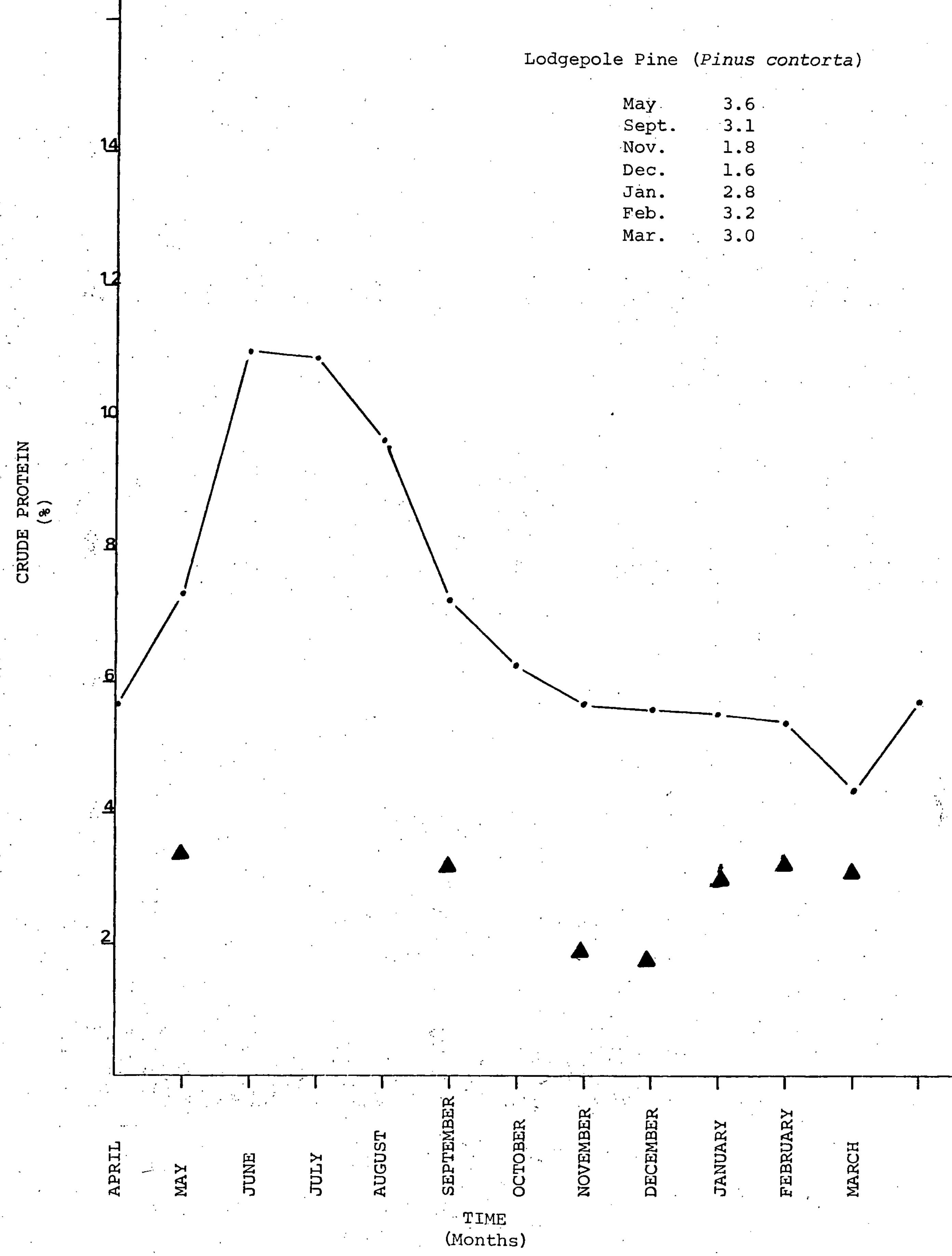
(The solid line represents a
wandering three point average
of Eastman's data)

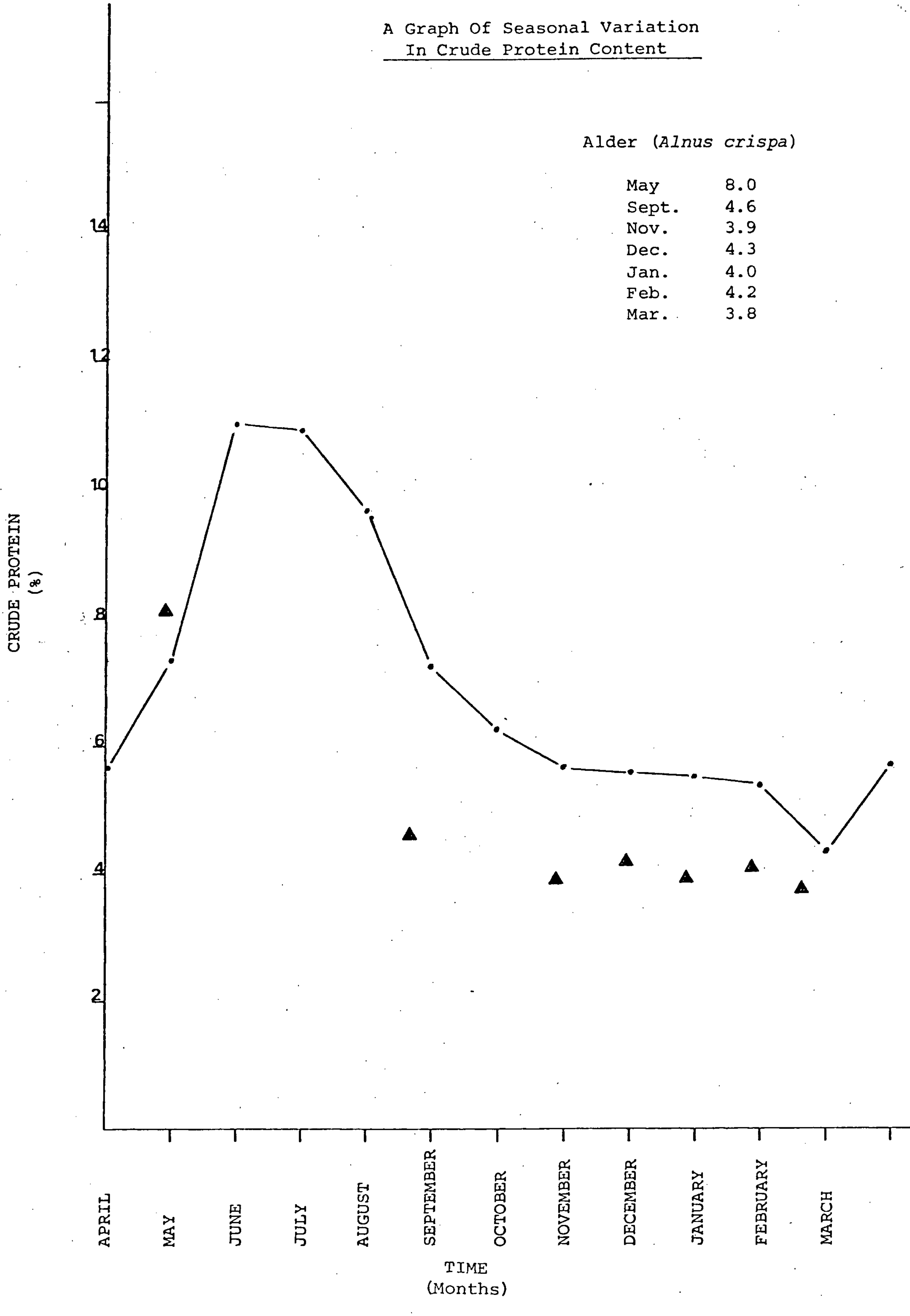
A Graph Of Seasonal Variation
In Crude Protein Content



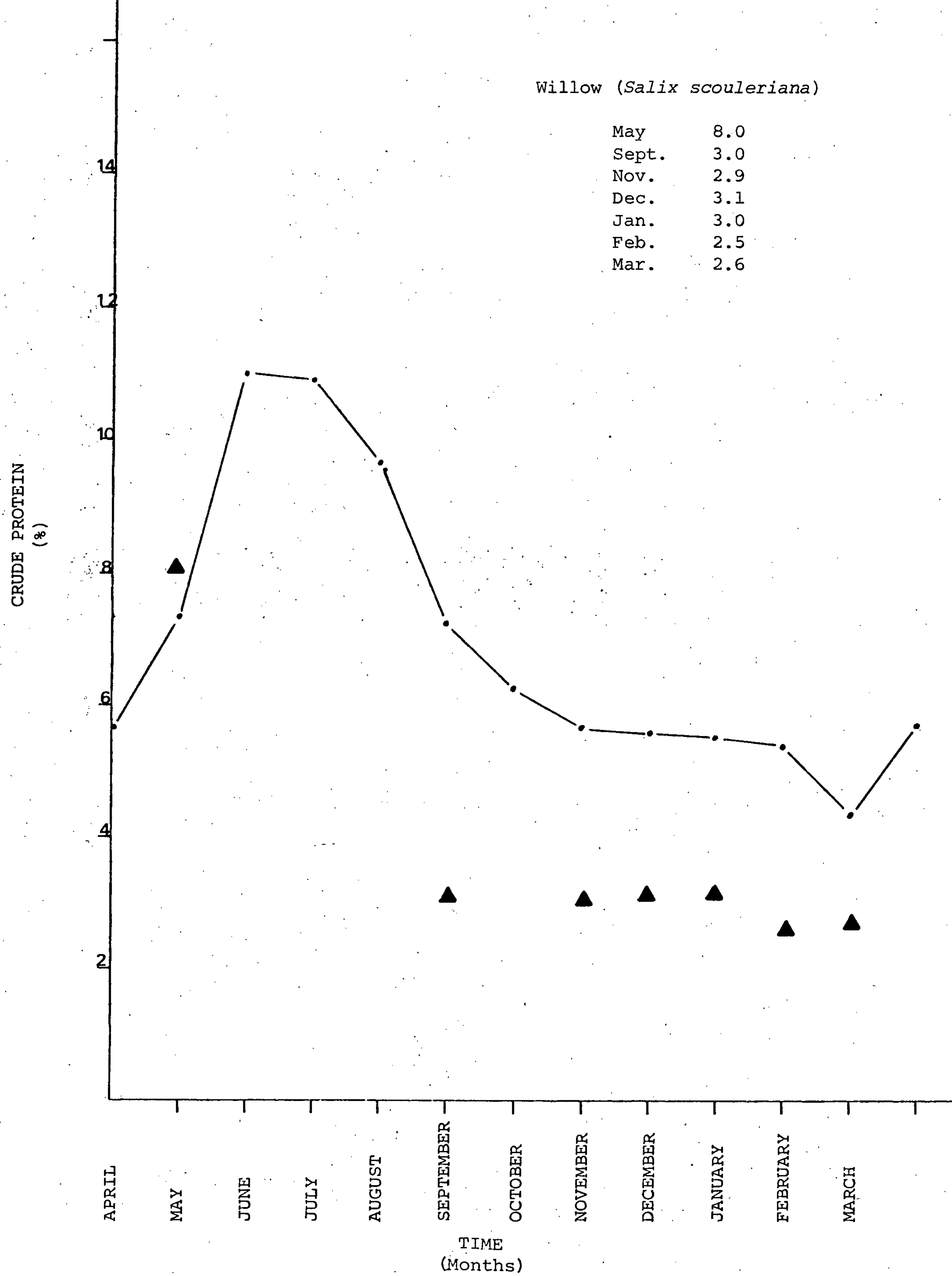

A Graph Of Seasonal Variation
In Crude Protein Content
White Spruce (*Picea glauca*)
Sept. 2.7
Nov. 2.8
Dec. 2.2
Jan. 1.2
Feb. 2.6
Mar. 2.6
CRUDE PROTEIN
(%)
14
12
10
8
6
4
2
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
TIME
(Months)

A Graph Of Seasonal Variation
In Crude Protein Content

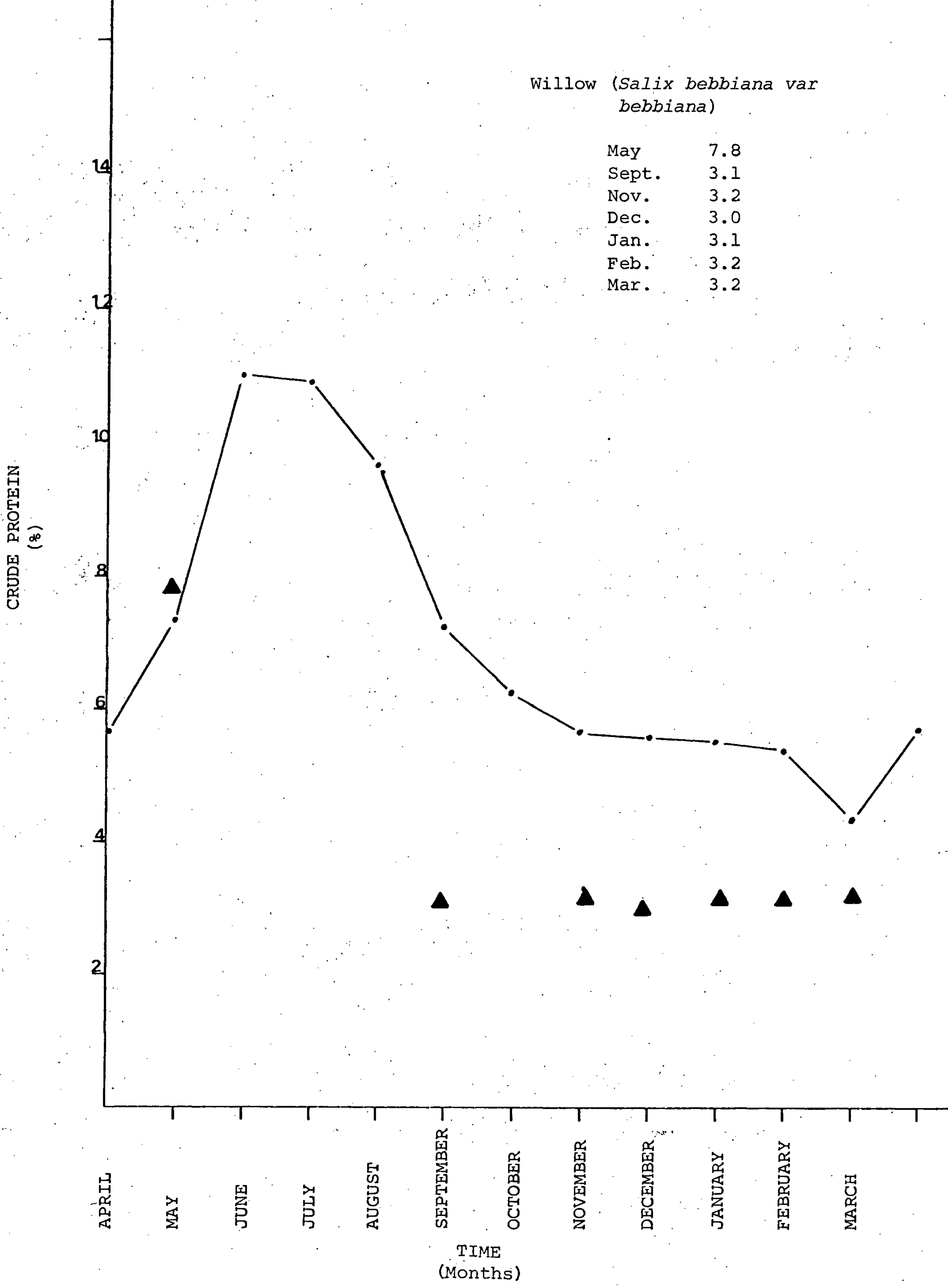


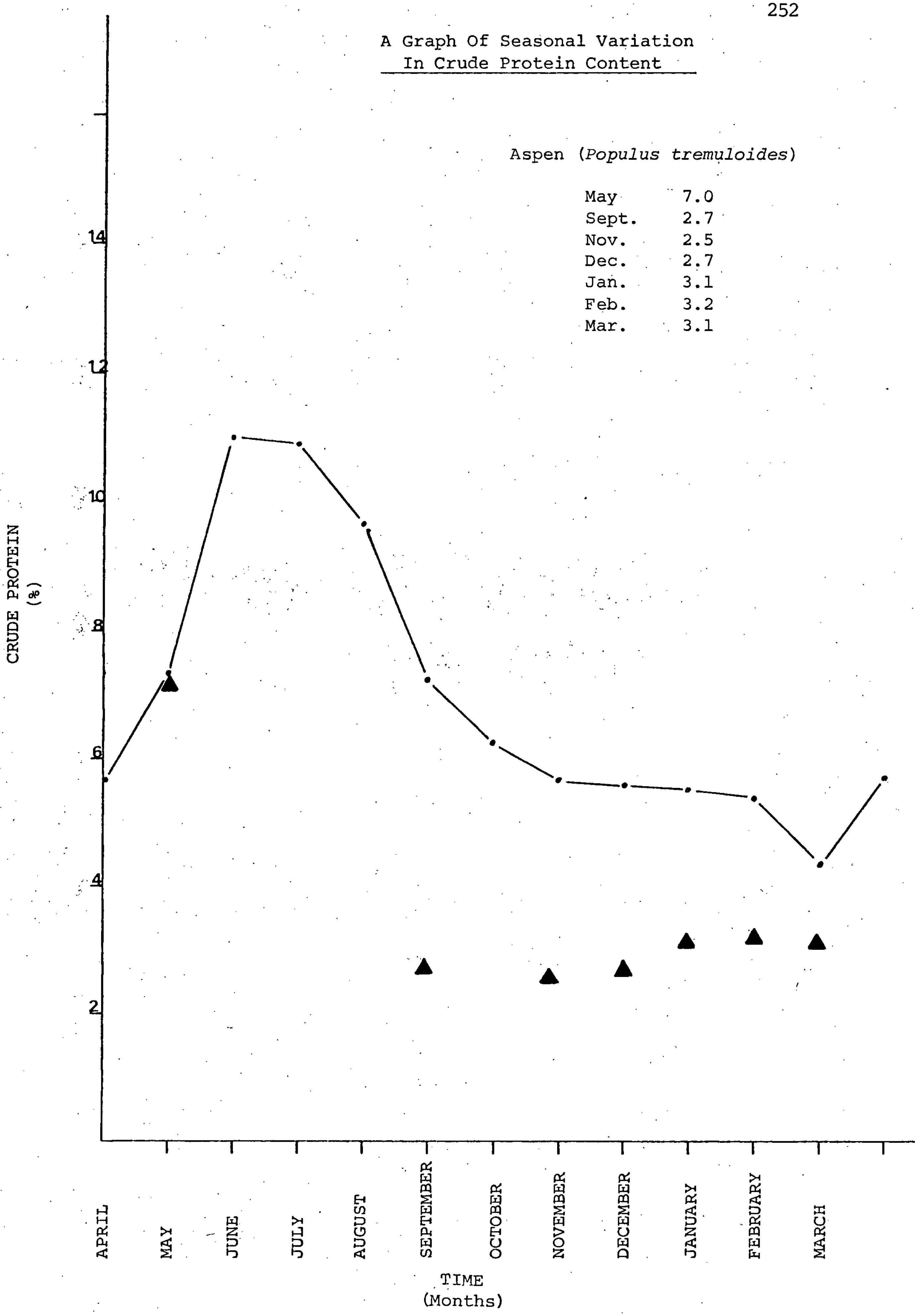

A Graph Of Seasonal Variation In Crude Protein Content
Alder (Alnus crispa)
May 8.0
Sept. 4.6
Nov. 3.9
Dec. 4.3
Jan. 4.0
Feb. 4.2
Mar. 3.8
CRUDE PROTEIN (%)
14
12
10
8
6
4
2
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
TIME (Months)

A Graph Of Seasonal Variation In Crude Protein Content

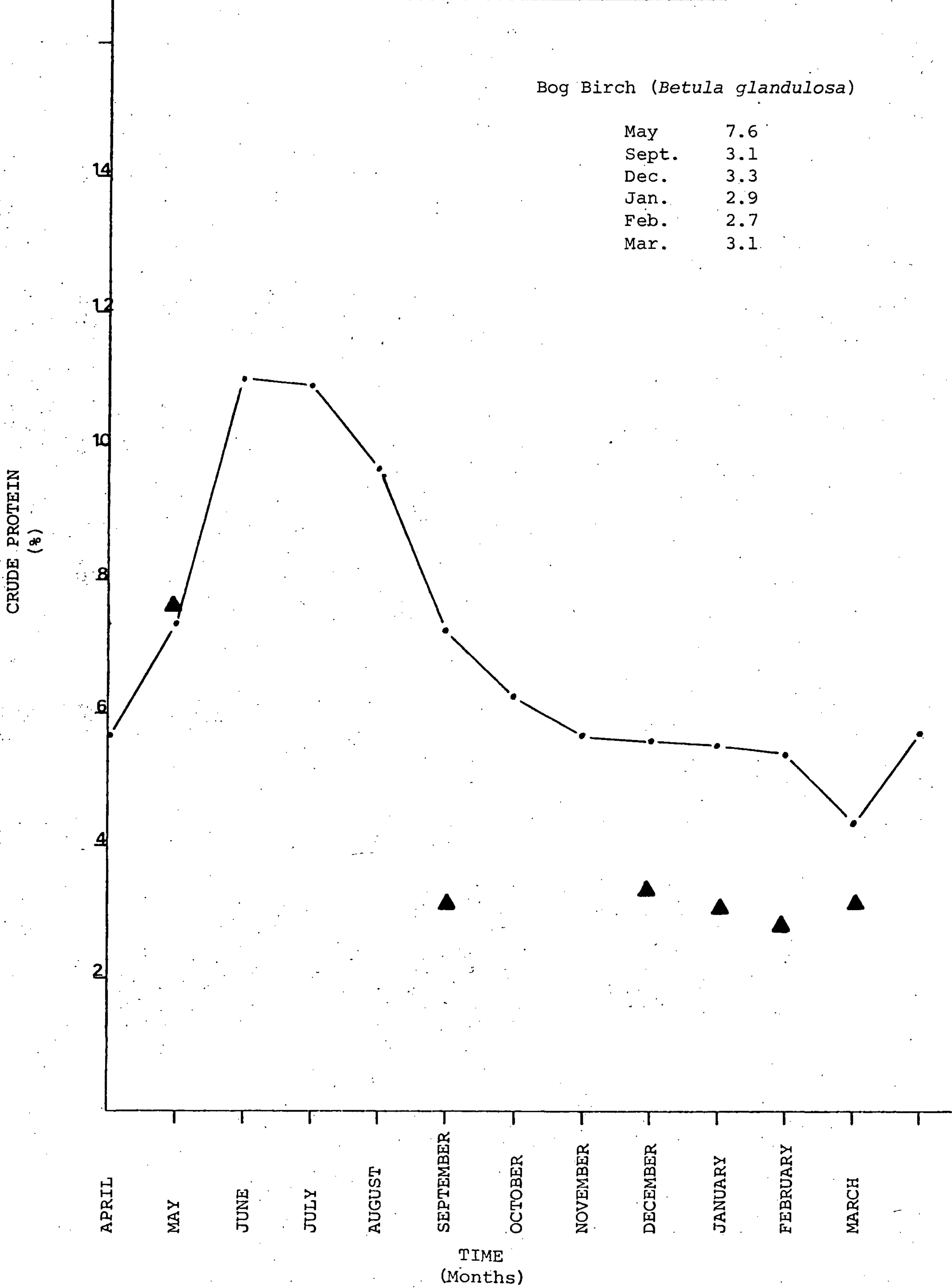


A Graph Of Seasonal Variation In Crude Protein Content




A Graph Of Seasonal Variation
In Crude Protein Content
Aspen (*Populus tremuloides*)
May 7.0
Sept. 2.7
Nov. 2.5
Dec. 2.7
Jan. 3.1
Feb. 3.2
Mar. 3.1
CRUDE PROTEIN
(%)
14
12
10
8
6
4
2
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
TIME
(Months)

A Graph Of Seasonal Variation In Crude Protein Content



APPENDIX 16

A Summary of Rumen Analyses

SUMMARY OF MOOSE RUMENS, ANALYSIS, CAMERON RIVER RESERVE

Rumen Identification	Approximate Date	Sex of Animal	Collection area Habitat Type (canopy-browse)	Estimated Relative Importance of Major Plant Species Found In Rumen (percent by volume)					Estimated Relative Importance of Minor Plant Species Found In Rumens
				Willow	Aspen	Alder	Birch	High Bush Cranberry	
August									
A-73	August 18	M	burn (aspen,-willow)	85	15	Tr.			
B-73	August 20	M	mature spruce-road ecotone	75	25				wintergreen leaves (Tr.)
September									
109 Rd.	September 26	U/C calf	burn (aspen,-willow)	70	25				raspberry (Tr.), pine (Tr.) monocot leaf (Tr.)
J-73	September 26	M	mature spruce	Tr.	Tr.				monocot leaf (probably sedge) (100) (rutpit?)
October									
7-72	October 2	M	mature spruce-pine-aspen mix	5	95				
6-72	October 3	M	pine-aspen mix, road ecotone	5	95			Tr.	monocot leaf (Tr.)
5-73	October 7	M	willow bottom-beds	55	30	15			raspberry
6-73	October 7	M	willow shrub type	75	Tr.	Tr.		10	cow parsnip (10), aster (Tr.)

SUMMARY OF MOOSE RUMENS, ANALYSIS, CAMERON RIVER RESERVE

Rumen Identi- fica- tion	Approx- imate Date	Sex of Animal	Collection area Habitat Type (canopy- browse)	Estimated Relative Importance of Major Plant Species Found In Rumen (percent by volume) Willow	Aspen	Alder	Birch	High Bush Cranberry	Estimated Relative Importance of Minor Plant Species Found In Rumens
October-Continued									
7-73	October 7	F	burn,-willow	60	18		5	18	monocot leaf (Tr.) unidentified her- baceous leaf (Tr.)
9-73	October 7	M	burn,-willow	70	25			Tr.	raspberry, unidentified wood (Tr.)
10-72	October 7	M	mature aspen	20	80				bunchberry (Tr.) monocot leaf (Tr.) (leaf and fruit)
L-73	October 9	F	immature spruce	Tr.	Tr.				monocot leaf (probably sedge) (80) unidentified (20)
16-73	October 9	M	mature aspen	40	60				fine grass (Tr.)
23-73	October 10	F	burn (aspen,- willow	85	10	Tr.		Tr.	monocot leaf (Tr.)
27-73	October 11	M	burn,-willow	55	5	40		Tr.	unidentified herbaceous (Tr.)
31-73	October 11	F	mature spruce -pine mix	5	95		Tr.		bunchberry (Tr.), pine (Tr.) monocot leaf (Tr.)
39-73	October 11	F	burn (aspen,- willow)	95	5	Tr.			herbaceous unidentified (Tr.)
55-73	October 17	F	willow bottom lands	90	10			Tr.	raspberry

SUMMARY OF MOOSE RUMENS, ANALYSIS, CAMERON RIVER RESERVE

Rumen Identi-fica-tion	Approx-imate Date	Sex of Animal	Collection area Habitat Type (canopy-browse)	Estimated Relative Importance of Major Plant Species Found In Rumen (percent by volume) Willow	Aspen	Alder	Birch	High Bush Cranberry	Estimated Relative Importance of Minor Plant Species Found In Rumens
56-73	October 17	M	mature aspen	50	30	15		Tr.	cow parsnip (5), monocot leaf (Tr.)
November Male	November 12	M	burn (aspen,-willow)	90	10	Tr.			
Late Winter Sample	January	F	spruce,-willow	90	Tr.				cow parsnip stem (5), larkspur (5)
Cow	February	F	aspen,-agri-culture	70	25			5	monocot leaf (Tr.) raspberry (Tr.)
Calf	February	F	aspen,-agri-culture	65	35				unidentified herbaceous (Tr.)
Wolf kill	February	F	black spruce, -willow	20	80	Tr.	Tr.		
Rd. kill	March	U/C	mature spruce-aspen mix	15	80		5		

APPENDIX 17

Observations of Moose
Cratering for Herbaceous Forages

OBSERVATIONS OF PAWING BY MOOSE (*Alces alces americana*) IN NORTHEASTERN BRITISH COLUMBIA

January 22, 1974
Mile 147, A.H. Beatton River
Temperature -5 -10° F
overcast, snow flurries
NcBr + old agriculture
rare mature Spruce 520 - 620
slope (0 - 10°)
Aspect East

Young Male plus unclassified adult
(M) (u/c) 2½ years est.

Occurrence	Front Leg	Times Pawed	Comments
u/c on knees eating			
u/c stood up			
paw	left	10	
eat			
paw	left	10	
eat	(beneath mature Spruce)		
paw	left	7	(on front knees)
eat			
paw	right	4	
paw	right	2	
eat			
paw	left	5	
eat			
paw	left	2	still beneath spruce tree
eat			
paw	left	4	
eat			
look			
eat			
paw	left	3	
paw	left	4	
eat			

....Continued

OBSERVATIONS OF PAWING BY MOOSE
(*Alces alces americana*) IN
NORTHEASTERN BRITISH COLUMBIA

Occurrence	Front Leg	Times Pawed	Comments
paw	left	5	
look			
paw	left	4	
eat			
paw	left	5	
eat			
paw	right	3	
eat			
paw	left	4	
	(30 sec)		
paw	left	5	
paw	left	6	
eat	(65 sec)		
paw	left	6	
eat	(20 sec)		
paw	left	5	
eat	(95 sec)		
paw	right	4	
eat	(80 sec)		
paw	right	4	
eat	(95 sec)		
paw	left	7	
eat	(20 sec)		
look	(30 sec)		
eat	(55 sec)		
look	(20 sec)		
eat shrubs	(55 sec)		
walk			
bed			

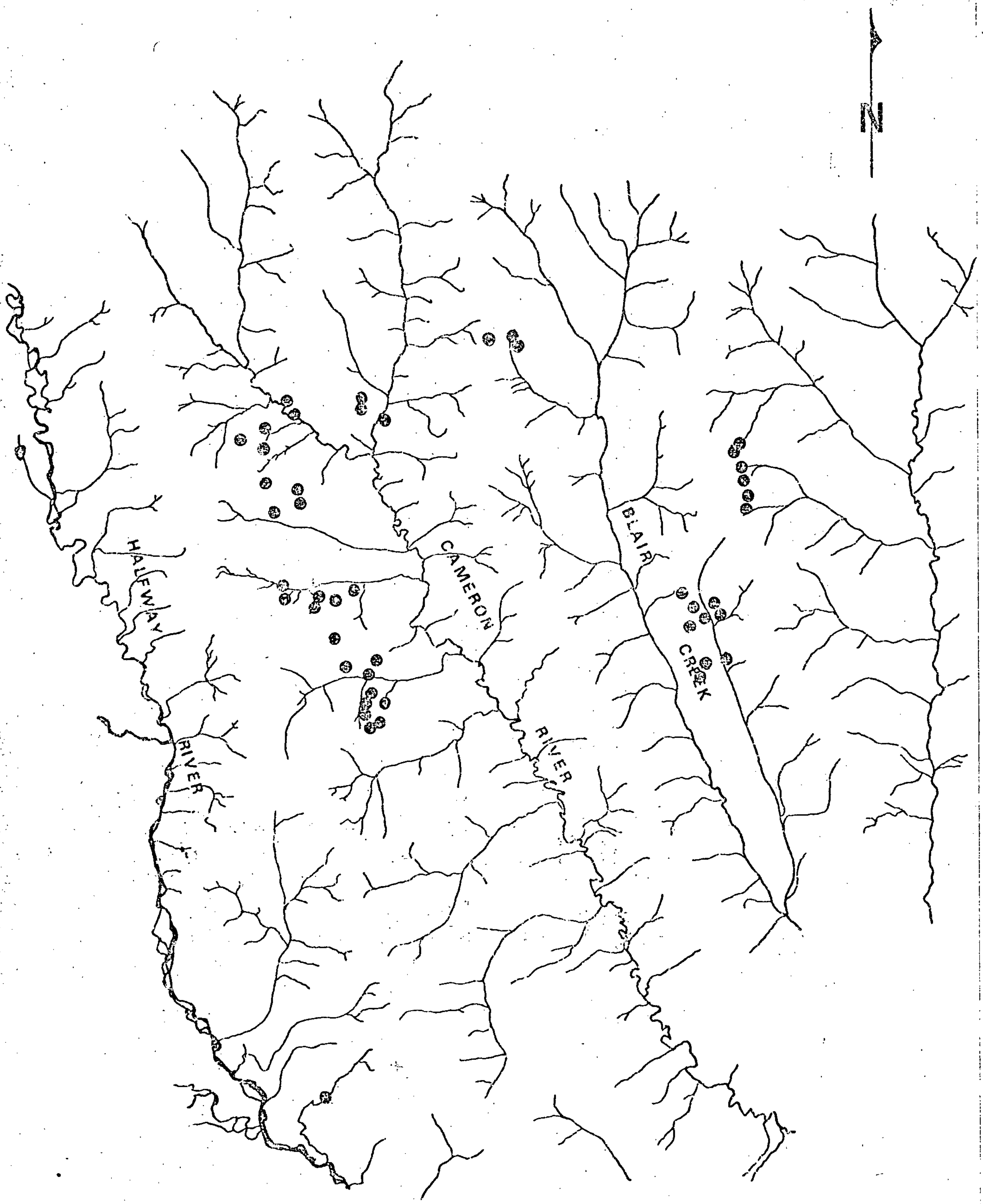
....Continued

OBSERVATIONS OF PAWING BY MOOSE
(*Alces alces americana*) IN
NORTHEASTERN BRITISH COLUMBIA

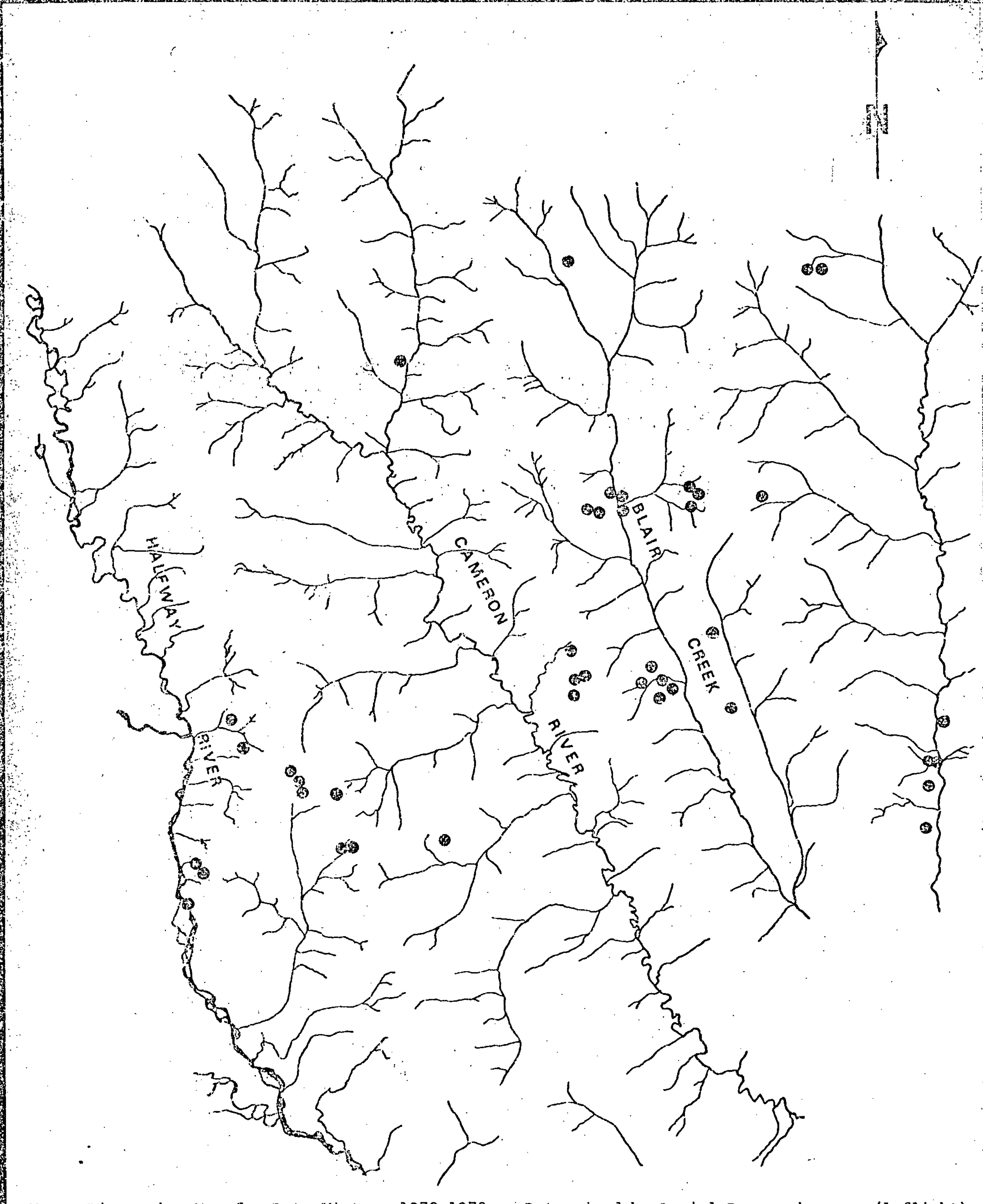
Occurrence	Front Leg	Times Pawed	Comments
Male:			
first observed pushing snow with nose			
paw	left	3	
eat			
paw	right	2	
4 steps			
eat			
4 steps			
eat	shrub use near banks of Beatton River		
5 steps			
eat			
3 steps			
eat			
bed			

APPENDIX 18

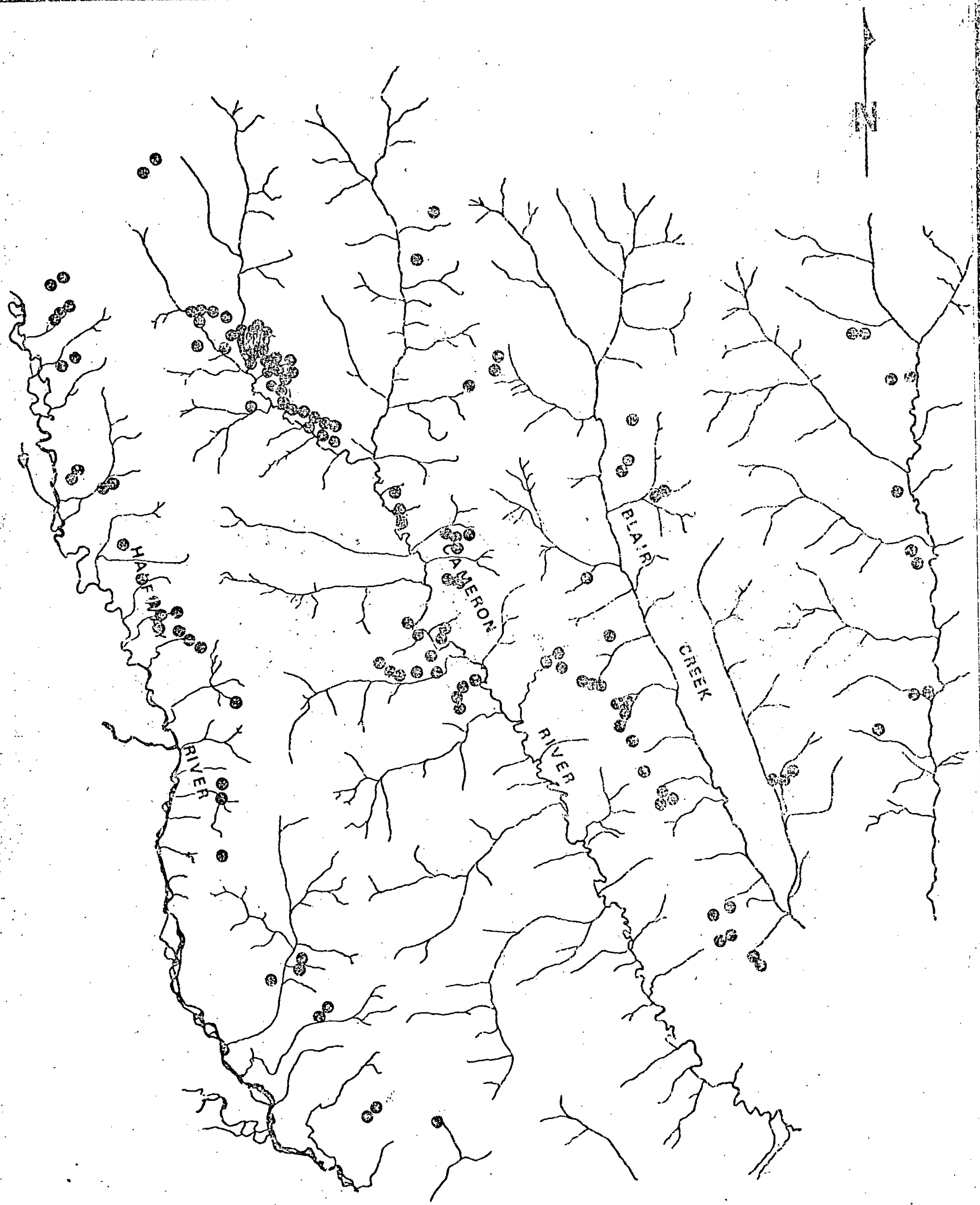
Dispersion Maps
(developed from aerial census)



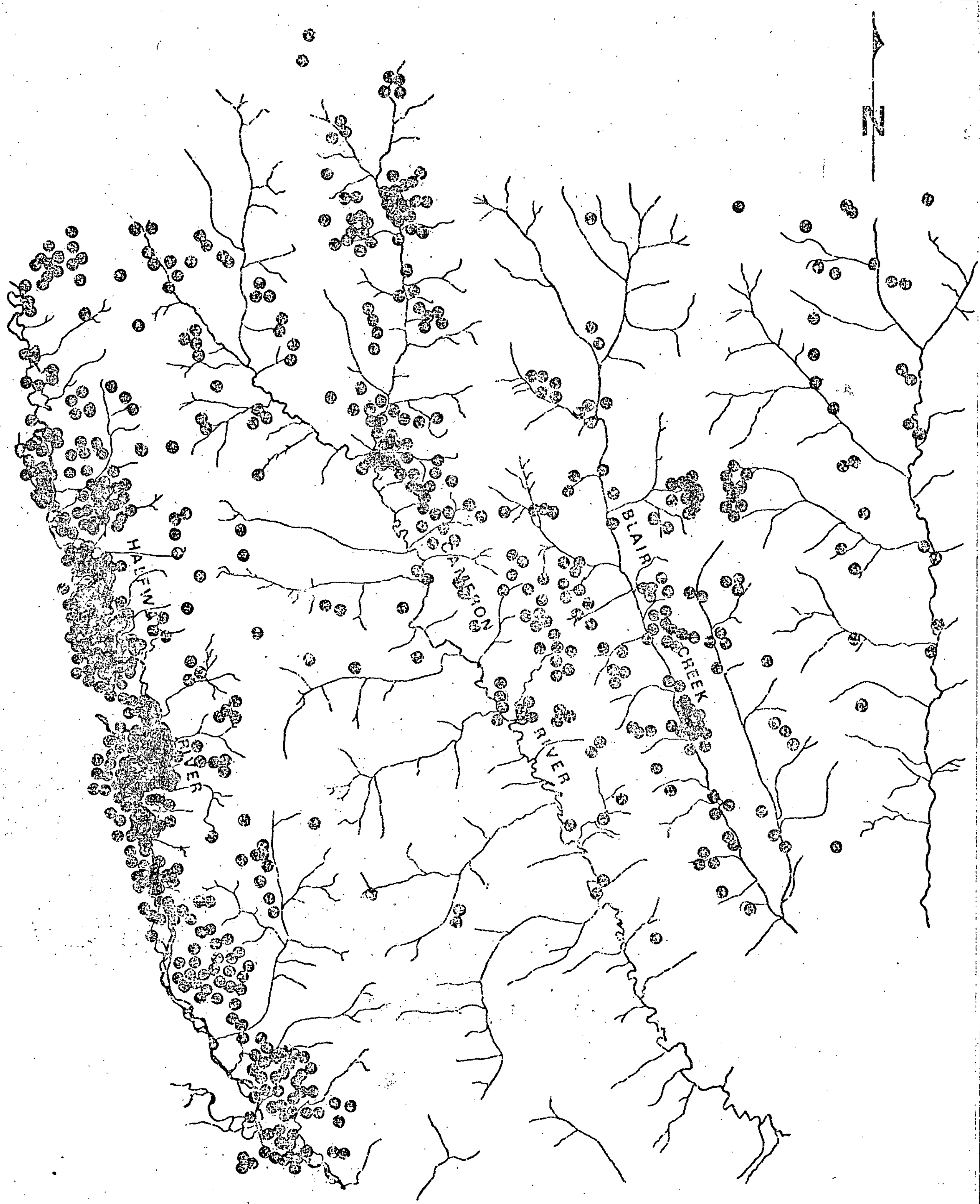
Moose Dispersion Map for Early Winter, 1972-1973 as Determined by Aerial Reconnaissance (1 flight)



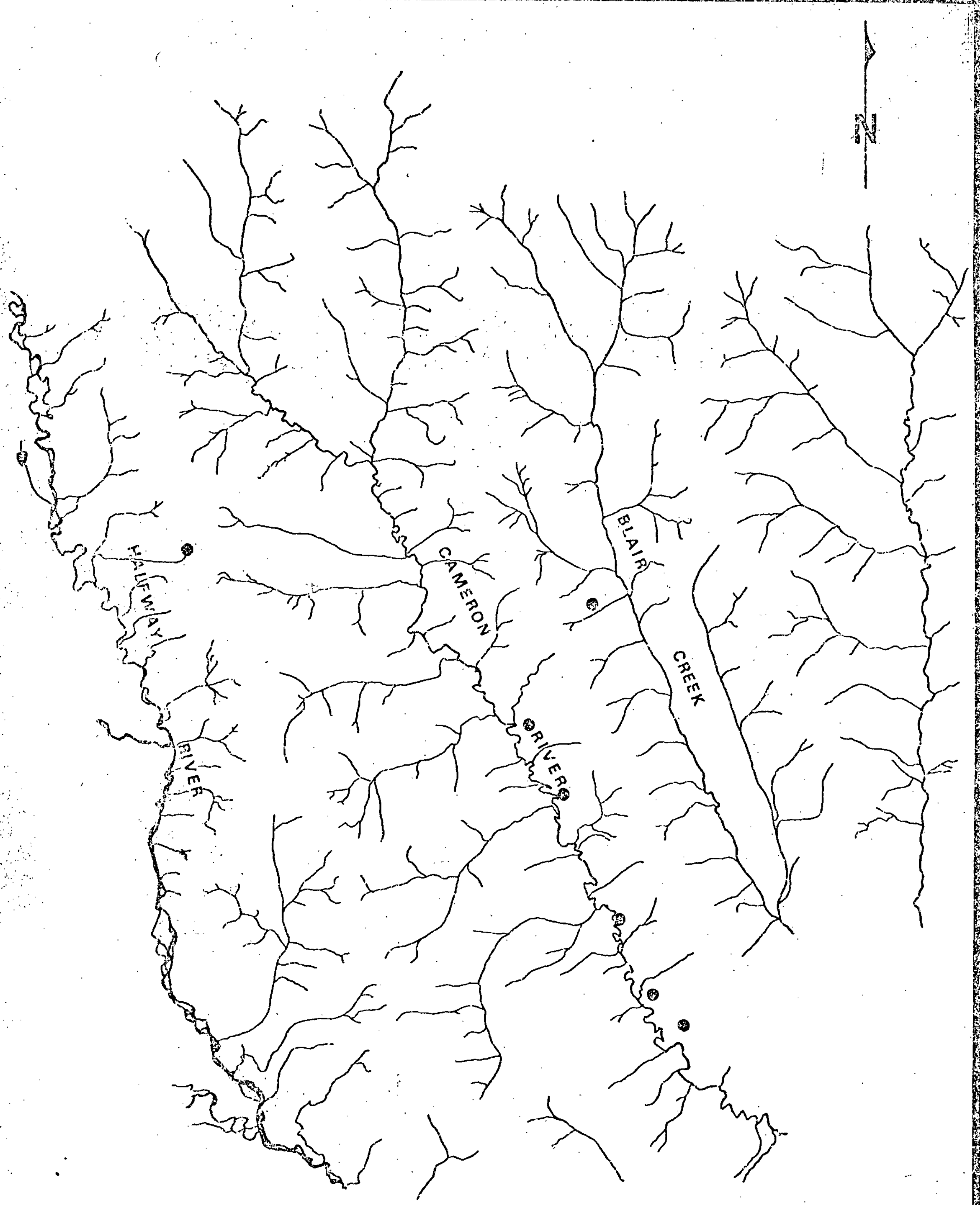
Moose Dispersion Map for Late Winter, 1972-1973 as Determined by Aerial Reconnaissance (1 flight)



Moose Dispersion Map for Early Winter, 1973-1974 as Determined by Aerial Reconnaissance (2 flights)



Moose Dispersion Map for Late Winter, 1973-1974 as Determined by Aerial Reconnaissance (3 flights)



Moose Dispersion Map for Spring, 1974 as Determined by Aerial Reconnaissance (1 flight)

APPENDIX 19

A Summary of Bedding
Characteristics of Moose

CHARACTERISTICS OF MOOSE BEDS,
CAMERON RIVER RESERVE, WINTER, 1973-1974

Direction of Bed Front	Slope Aspect	Dominant Vegetation Type	Species of nearest tree	Direction to nearest tree	Distance to nearest tree (m)	Diameter at Breast Height nearest tree (cm)	Dominant Browse Species	Maximum Bed Depth (cm)	Average Snow Depth (cm)	Average Depth o Sinking (cm)
December										
West	West	lowland shrub	Willow	West	3	12.7	Willow, Alder	38	46	33
West	West	lowland shrub	Aspen	Southwest	9	10.2	Willow, Alder	38	48	36
South	West	lowland shrub	Willow	Northeast	2.7	10.2	Willow, Alder	41	43	25
South west	West	lowland shrub	Black Spruce	South	6	15.3	Willow, Alder	33	51	28
Northwest	West	shrub-Spruce	Spruce	North	1.5	28.0	Willow, Alder	28	41	31
January										
North	East	lowland shrub (burn)	Aspen	Southwest	10.6	6.4	Willow, Aspen, Birch	46	64	46
South	East	lowland shrub (burn)	Aspen	North	15.3	6.4	Willow, Aspen, Birch	46	66	41
Northeast	East	lowland shrub-Aspen (burn)	Aspen	Southwest	9.2	6.4	Willow, Aspen, Birch	46	64	46

CHARACTERISTICS OF MOOSE BEDS
CAMERON RIVER RESERVE, WINTER, 1973-1974

Direction of Bed Front	Slope Aspect	Dominant Vegetation Type	Species of nearest tree	Direction to nearest tree	Distance to nearest tree (m)	Diameter at Breast Height nearest tree (cm)	Dominant Browse Species	Maximum Bed Depth (cm)	Average Snow Depth (cm)	Average Depth o Sinking (cm)
January-Continued										
North	East	lowland shrub-Aspen (burn)	Aspen	West	6.0	2.5	Willow Aspen,BBirch	48	66	48
February										
North	East	Shrub-Aspen ecotone	Pine	West	36.6	12.7	Willow	28	64	41
North	East	Shrub-Spruce ecotone	Spruce	East	29.0	15.3	Willow	46	56	51
Northwest	East	Shrub-Spruce ecotone	Spruce	East	30.5	15.3	Willow	46	56	51
March										
South	West	Shrub-Conifer Mix	Aspen	East	.9	20.3	Birch	43	64	48
North	West	lowland shrub	Spruce	North	1.5	5.1	Birch, Willow	36	56	43
North	West	lowland shrub	Spruce	North	11.5	5.1	Birch, Willow	46	56	43

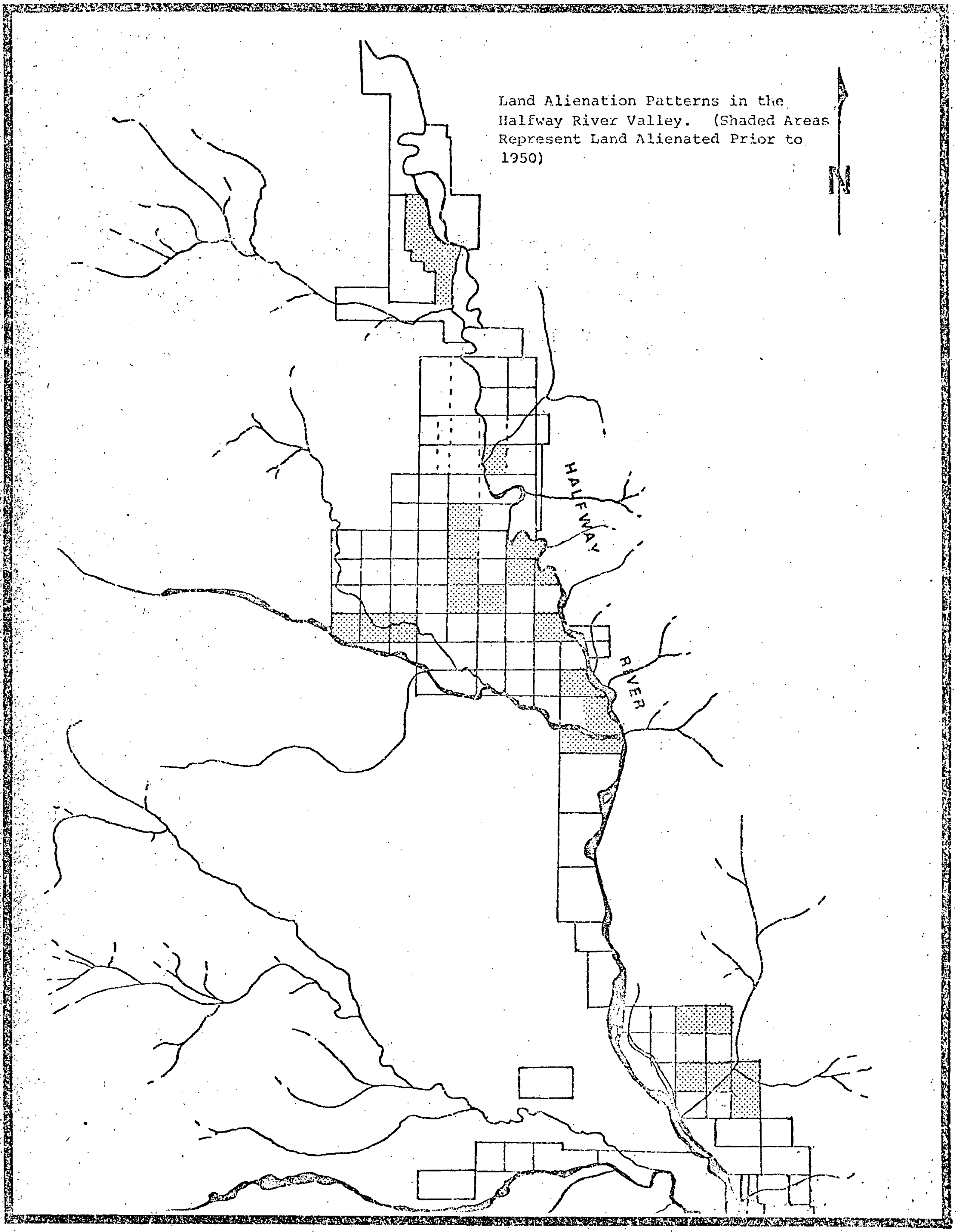
CHARACTERISTICS OF MOOSE BEDS,
CAMERON RIVER RESERVE, WINTER, 1973-1974

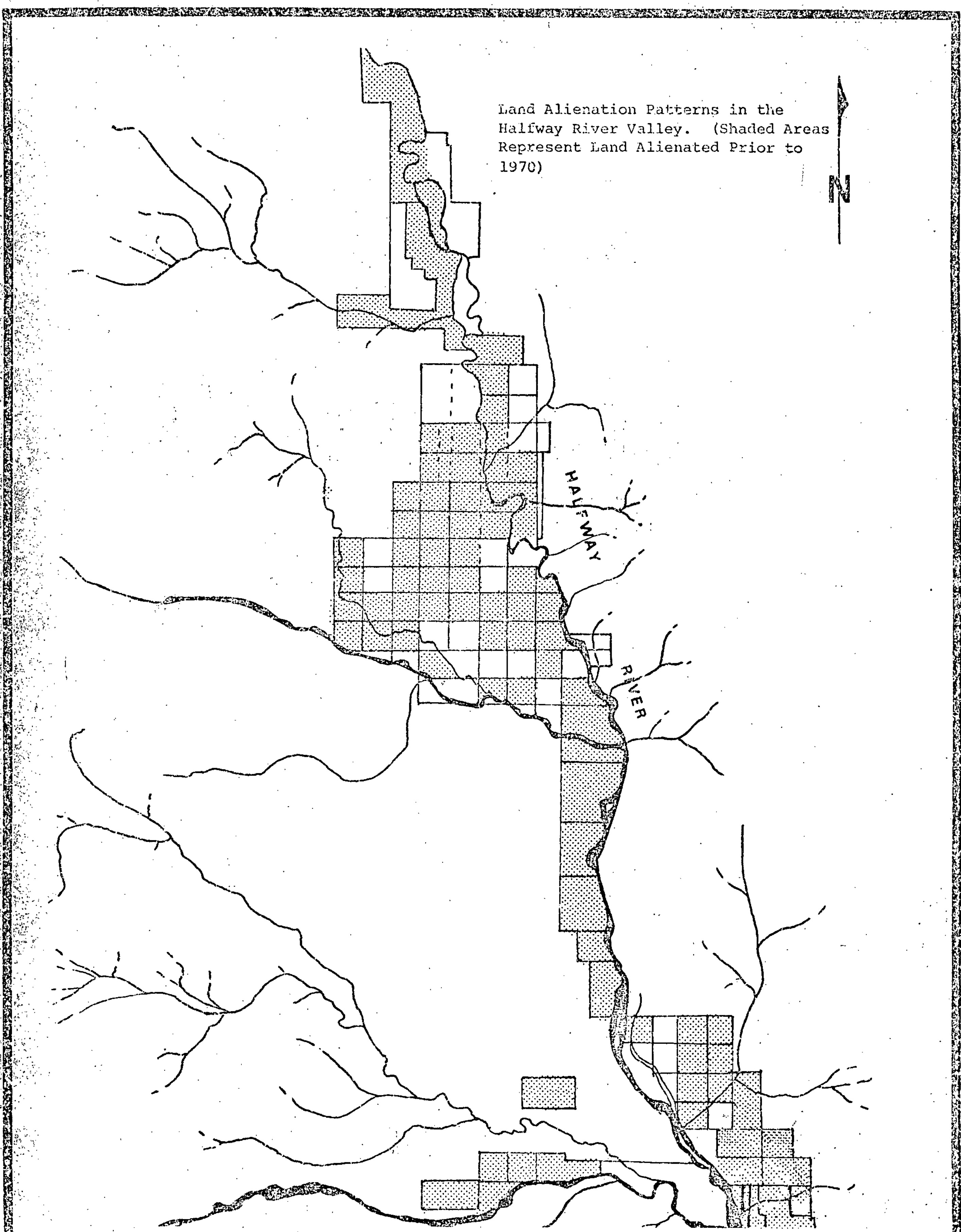
Direction of Bed Front	Slope Aspect	Dominant Vegetation Type	Species of nearest tree	Direction to nearest tree	Distance to nearest tree (m)	Diameter at Breast Height nearest tree (cm)	Dominant Browse Species	Maximum Bed Depth (cm)	Average Snow Depth (cm)	Average Depth o Sinking (cm)
March-Continued										
Southeast	East	Black Spruce	Spruce	Northwest	.3	7.6	Willow	48	56	43
Northeast	East	lowland shrub	Spruce	North	.9	20.3	Willow	46	51	43
Southeast	East	lowland shrub	Spruce	Northwest	1.2	10.2	Willow	31	56	43
West	West	regeneration (Aspen)	Aspen	Southeast	1.5	7.6	Willow, Aspen	53	66	51
Averages:					8.8	11.4		41	56	41

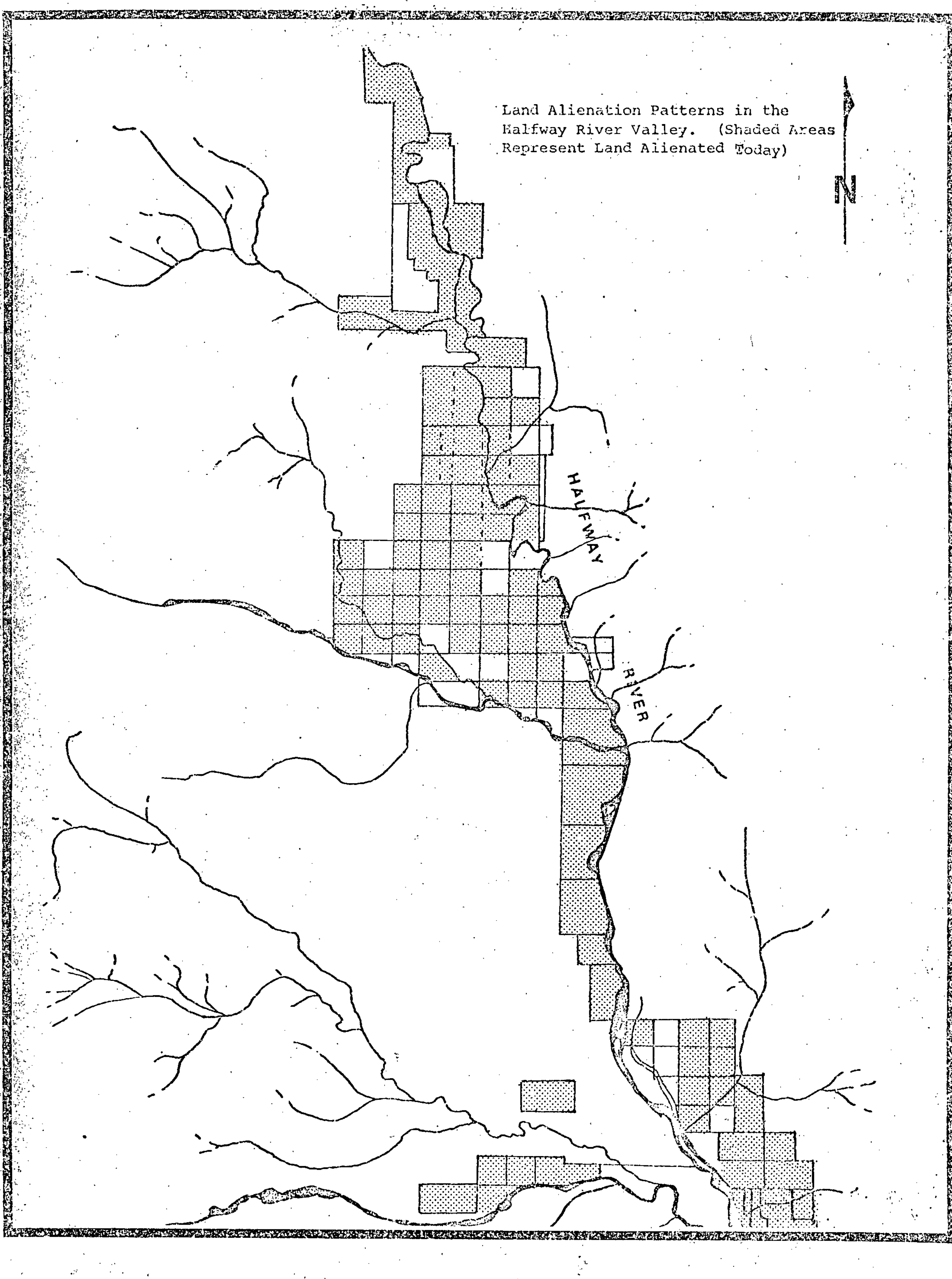
APPENDIX 20

A History of Land
Alienation Patterns in the Halfway River Valley

(Lands Branch files)


Land Alienation Patterns in the Halfway River Valley. (Shaded Areas Represent Land Alienated Prior to 1950)
N
HALFWAY
RIVER

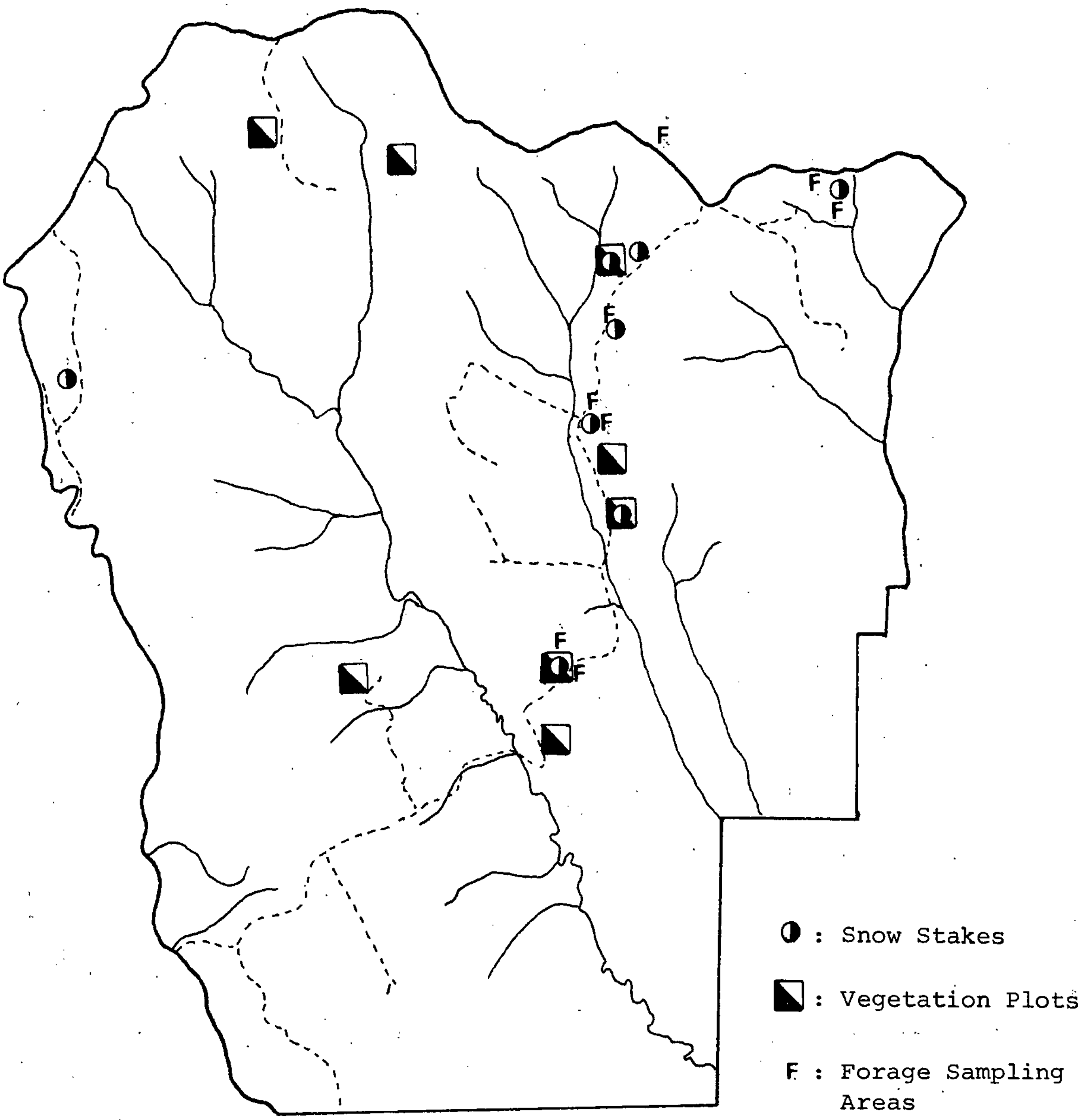

Land Alienation Patterns in the Halfway River Valley. (Shaded Areas Represent Land Alienated Prior to 1970)
N
HALFWAY
RIVER


Land Alienation Patterns in the
Halfway River Valley. (Shaded Areas
Represent Land Alienated Today)
N
HALFWAY
RIVER

APPENDIX 21

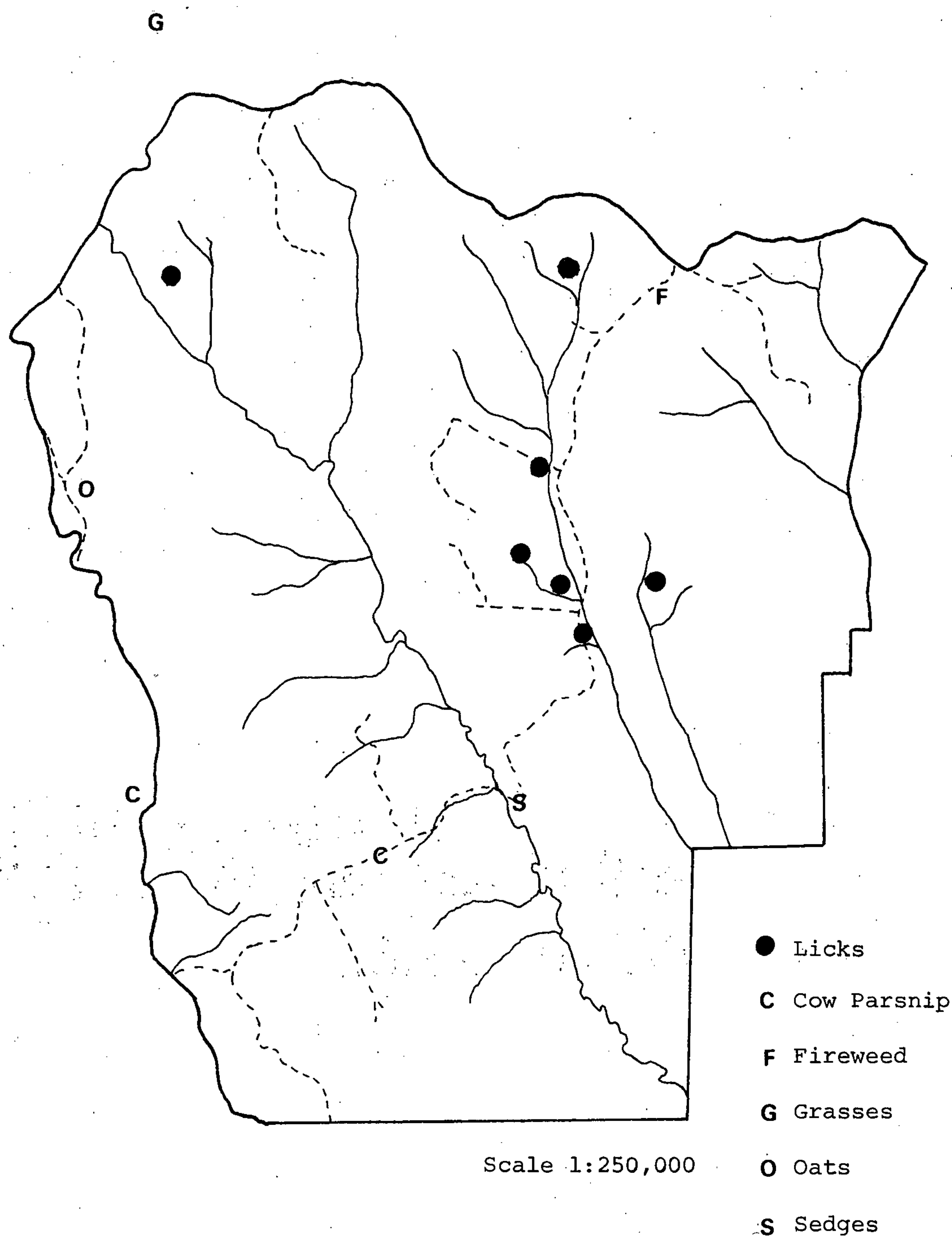
The Location of Vegetation Plots, Snow Stakes and Forage Sampling Areas

SAMPLING LOCATIONS IN THE STUDY AREA



Scale 1:250,000

KNOWN LICK AND CRATERING
LOCATIONS IN THE STUDY AREA



Scale 1:250,000