MOOSE ABUNDANCE AND HABITAT USE
IN
LIARD WEST, YUKON
DURING EARLY WINTER 1983

by

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SUMMARY

Early winter surveys of moose in Liard West were conducted during 22 November to 3 December 1983, using a stratified block sampling technique.

The study area encompassed 7500 km^2 of which 7236 km^2 were considered habitable moose range. Mean sample unit size was 21.2 ± 4.1 km^2. Total stratification time was 29.2 hours, with a mean search intensity of 0.2 min/km^2. Total census time was 32.8 hours with a mean search intensity of 1.6 min/km^2.

The estimated moose population was 838 ± 180 moose at 90% confidence, representing a population density of 0.116 ± .025 moose/km^2. Population composition was comprised of 35.6% adult bulls, 47.4% adult cows, 8.6% yearlings and 8.4% calves. These proportions represent ratios of 75.3 adult bulls/100 adult cows, 18.1 yearlings/100 adult cows and 17.6 calves/100 adult cows. The ratios of calves/100 cows reflects the population productivity and is comparable with values obtained for moose populations in the southwest Yukon. The proportion of bulls/100 cows is larger than ratios reported for other Yukon moose populations.

The study area was divided into three discrete topographic zones: lowland, foothill and mountain, and the moose within each zone were assessed as local populations. The largest population (319 moose) occurred in the lowland zone, yet population density (0.09 moose/km^2) was least in this zone. The lowland population had the greatest proportion of calves and the mountain population had the greatest proportion of adult bulls. The management implications of these differences in composition, abundance and density among the populations of the different topographic zones could be significant. Further investigations are required to fully assess the differing population parameters.

Sample units with high and medium moose densities were most prevalent in the mountain and foothill zones. However, 50% of the total estimated moose population occurred in low density sample units. Low density sample units, as well as extra low density sample units, were most common in the lowland zone.

The greatest proportion of adult bulls (37.1%) occurred in high density units. In contrast, the greatest proportion of adult cows (48.9%), yearlings (41.7%), and calves (64.3%) occurred in the extra low density units.

Moose composition varied throughout the four density strata. At least 50% of the moose in high and medium density strata were adult bulls. In the extremely low strata, 59% of the moose were adult cows.

Moose commonly occurred in vegetation associations classed as shrub, coniferous, shrub-coniferous or burn. Calves were common in burns and clear-cuts in proportions beyond other age groups. Shrub was used by 5% of the estimated calves, yet 20-30% of the estimated cows, yearling bulls and adult bulls used this class. Yearlings showed the greatest use of the coniferous class. Northern and eastern exposures were used by most moose, with some differences in the exposure used by different age/sex groups. The use of different vegetation and aspect classes by moose was biased by the availability of each class.

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2 Census time and census search intensity for each density stratum in Liard West, early winter 1983.

INTRODUCTION

Recently, the levels of hunting pressure on moose populations in the Yukon Territory have prompted the initiation of a number of studies investigating moose population size and productivity. In 1981, six priority moose management areas were identified by the Government of Yukon for intensive investigations of their respective moose populations (Larsen 1982). These management areas are adjacent to human population centres and consequently receive substantial amounts of moose harvest pressure. As a continuation of this program, Northern Biomes Ltd was contracted by the Government of Yukon to undertake a management related moose inventory study in the Watson Lake area during the early winter of 1983.

Areas of the upper Liard River valley and its associated rivers (Meister and Rancheria) have been considered among the best winter moose ranges in the Yukon (Lortie et al 1978). However, previous moose studies conducted in the general area of Watson Lake and the Liard River have focused on moose abundance within a restricted area, such as riverine areas or along a pipeline corridor (Foothills 1977, 1978; Lortie et al 1978; Donaldson and Fleck 1980; B.C. Hydro unpubl. data). The application of these studies to wildlife management plans is limited since the entire available moose range and accompanying moose abundance have not been considered.

The purpose of this study was to conduct an extensive investigation of the abundance, distribution and age/sex composition of moose in the Watson Lake area. The study results would then be a basis for the formulation of moose management plans for the Watson Lake area. The study area encompassed all habitable moose range from river valley to the subalpine. Additionally, the survey technique employed (stratified random block design) was standard to recent moose surveys conducted in the southeastern and southcentral Yukon, thereby producing comparable results (Larsen 1982; Johnston and McLeod 1983; Johnston *et al* 1984).

Objectives

The study objectives were:

1. to determine the early winter moose population size;
2. to determine the age and sex composition of the early winter moose population;
3. to determine early winter distribution of moose;
4. to assess early winter moose habitat use.

STUDY AREA

Located north of the Yukon-British Columbia border in the southeastern Yukon Territory, the study area extends from the Cassiar Mountains in the west to the Liard and Black Rivers in the east, and north to the Pelly Mountains (Figure 1). The area encompasses approximately 7500 km^2 of which 7236 km^2 is habitable moose range (see METHODS). The area corresponds with Game Management Zone (G.M.Z.) #10, and specifically with Game Management Subzones (G.M.S.) 10-27, 10-28, 10-29, 10-30, 10-31, 10-32, portions of 10-14, 10-15, 10-16 and a small portion of 10-25.

Elevation ranges from 610 m asl in the river valleys to a maximum elevation of 2081 m asl in the Cassiar Mountains. The elevation of treeline occurs between 1371 to 1676 m asl. Most of the study area is drained by the Liard River and its tributaries, although portions of the southwest region of the study area are drained by the Yukon River.

The study area lies in the Liard River Ecoregion (Oswald and Senyk 1977). Forest cover is classed as Boreal Forest, sections B24 and B26c of Rowe's national forest classification (Rowe 1972). Forest growth on alluvial soils in the Liard River valley is extensive, with trees in closed stands reaching heights of 30 m or more. Timber growth in the Liard River basin is commercially valuable and discrete areas of the Meister, Rancheria and Liard River valleys were logged during 1969-1979. Logging activities continue today in the area. The total logged area amounts to less than 1% of the habitable moose range in the

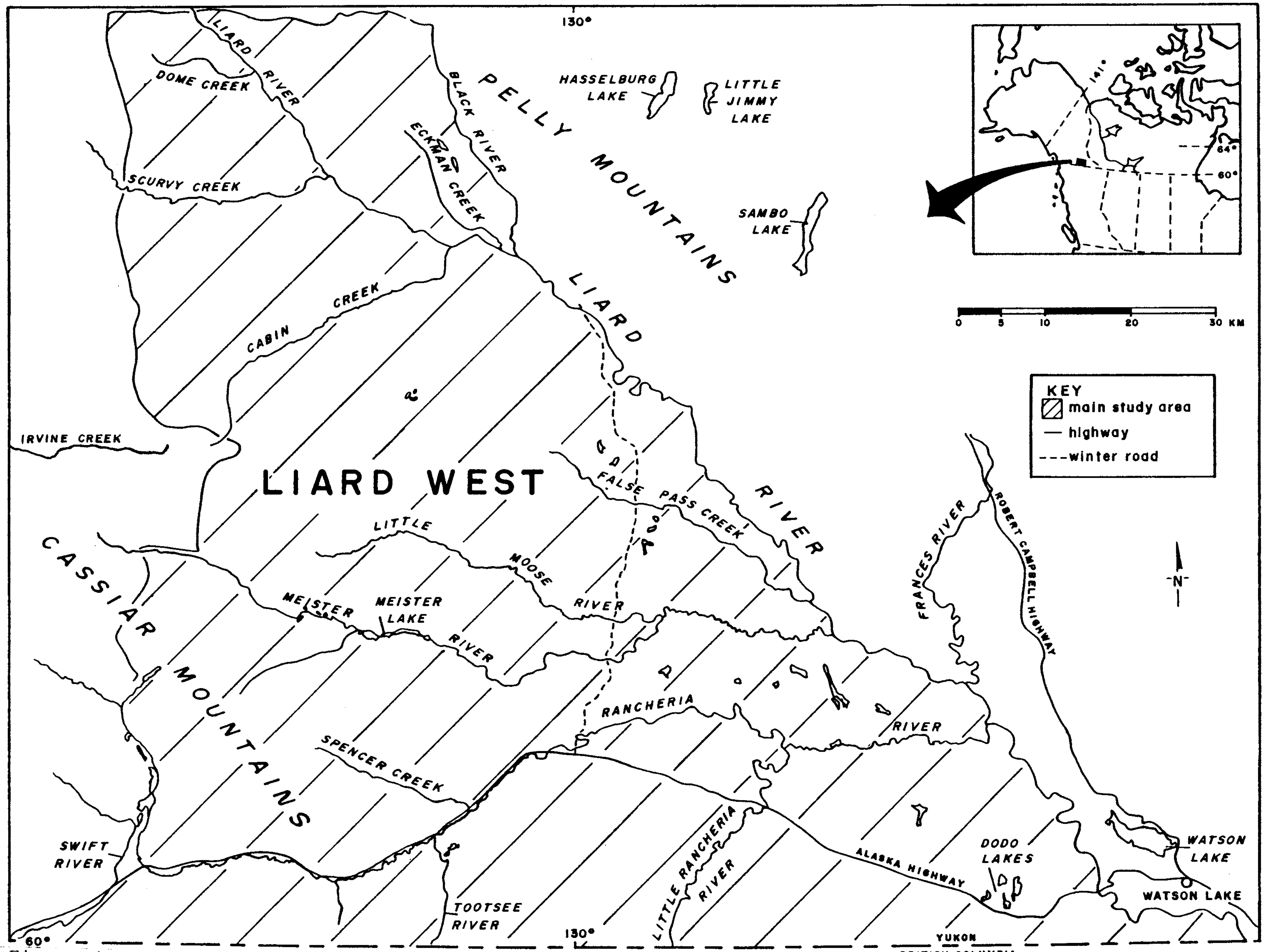

Figure 1. Study area of Liard West, early winter 1983.

study area.

The following general information is from Oswald and Senyk (1977), as well as field observations and topographical maps. Small, open meadow areas are common in the broad valley of the Liard River. White spruce (Picea glauca) and black spruce (Picea mariana) form the predominant forest cover which is usually closed canopy. Lodgepole pine (Pinus contorta) and/or willow shrub (Salix spp.) are common in areas that have been affected by past fires. An extensive burn area occurs along the Rancheria River and Alaska Highway. Aspen (Populus tremuloides) is present on south-facing slopes in either pure or mixed stands. Balsam poplar (Populus balsamifera) occurs along river terraces and as a pioneer species on recent floodplains in association with willow and aspen. Larch (Larix lariciana) occurs in poorly drained situations, along with black spruce, and extends onto gentle slopes with poor seepage. Paper birch (Betula papyrifera) is found scattered on upland plateaus, being most common on north peaks. In subalpine areas, subalpine fir (Abies lasiocarpa) and/or extensive areas of shrub willow and birch (Betula sp.) are common.

Weather

The climate of the study area is continental (Kendrew and Kerr 1955) with a mean January temperature of -25^{o}C and a mean July temperature of 15^{o}C (Oswald and Senyk 1977). During November 1983, the mean monthly temperature in Watson Lake of -14.2^{o}C was similar to the 20 year mean (Atmospheric Environment Services). Although the December 1983, mean temperature of

$-30.2^{\circ}C$ was 7 degrees below normal, the abnormally cold temperatures occurred after the survey period. Low lying ice fog occurred for extended periods during November and December throughout the Liard River valley.

During the survey period, snowfall was generally less than average values. Snowfall measurements for October, November and December 1983 of 7.9, 20.2 and 4.5 cm respectively, were well below the 20 year means of 22.5, 38.1 and 44.8 cm respectively.

METHODS

Aerial Surveys

Aerial surveys were conducted in the early winter from 22 November to 3 December 1983. The aerial survey technique was a modification (Larsen 1982) of the stratified random block sampling technique designed for estimating moose abundance in Alaska (Gasaway et al 1981). Briefly the technique involves two phases: stratification and census. The stratification phase is an extensive yet cursory survey of moose within the total area of habitable moose range. The purpose of stratification is to stratify sample units (S.U.) into classes or strata of similar moose density. The subsequent census phase involves an intensive and thorough survey of moose from randomly selected sample units within each density stratum.

Prior to conducting aerial surveys, the study area was divided into 339 sample units. Sample units were delineated on 1:50,000 scale National Topographic Series (N.T.S.) survey maps, using natural boundaries such as creeks and ridges whenever possible. Areas which were considered uninhabitable moose range and excluded from the actual survey area included: precipitous slopes, waterbodies larger than 0.8 km^2 and terrain above 1676-1737 m asl (depending on the elevation of the subalpine shrub zone). The area of each sample unit was measured by a Planix digital polar planimeter. The mean size of the sample units was 21.2 $\pm$ 4.1 km^2.

Stratification

Stratification was conducted during 22 to 30 November in two fixed-wing aircrafts (Cessna 185, plus a one day replacement by a Maule) flown simultaneously over different portions of the study area. Each aircraft contained one front seat observer/navigator, one pilot/observer and two back seat observers. Prior to the stratification surveys, the chief front seat observer/navigators conducted a preliminary survey to standardize their methods of search intensity and pattern of flight (speed and altitude).

In cases where moose were observed on or near the borders of sample units, the borders were redrawn to avoid the potential problem of moose movement between sample units. When poor weather conditions (extensive ice fog) interrupted the stratification, specific sample units were restratified.

Survey aircraft were flown at 90-100 m agl at approximately 130 kph. Total survey time (excluding ferry time) was 29.2 hours. Stratification search intensity was approximately 0.2 min/km^2.

Four strata of moose density were defined during the stratification of Liard West:

i) high $\geq$0.39 $moose/km^2$

ii) medium 0.20-0.38 $moose/km^2$

iii) low <0.20 $moose/km^2$ or tracks

iv) extra low no sign of moose

Census

Census flights were flown immediately after completion of stratification, during 30 November to 3 December. Two helicopters (Bell 206, Hughes 500D) were flown concurrently in different sections of the survey area. However, a shortage of time and optimal survey weather necessitated three helicopters for one of the four days of census. Survey crew arrangement was similar to stratification flights.

Census surveys were flown between 30-150 m agl at 50-130 kph, depending on terrain features and vegetative cover. Flight patterns varied with the topography. Over flat terrain short parallel transects were flown approximately 0.4 km apart. Flight patterns in mountainous terrain usually followed contour lines or were circular. The intent of censusing was to achieve a total age/sex count of moose within the respective sample units.

Sampling effort, in terms of the proportion of the total area censused, varied between density strata (Appendix 1) and was based on achieving an acceptable level of sampling variance on the total moose population estimate. Total census time was 32.8 hours. Census time and search intensity for individual strata are presented in Appendix 2. Mean search intensity was 1.6 $\pm$0.5 min/km^2.

Population Composition

Moose observations within each censused sample unit were recorded by a unique aggregation number and the location was plotted onto the survey maps. Antlerless moose with a white vulva patch were sexed as cows (yearlings and adults) and bulls were determined by the presence of antlers or antler pedicels. Male moose were further classified into yearlings (18 months old) and adults (≥30 months old) based on antler morphology (Dubois *et al* 1981). Calves were identified by body size and association with a cow. Yearling cows could not be identified in the field but were assumed to occur in the population in the same proportion as yearling bulls. The adult cow (≥30 months old) estimate was then adjusted by subtracting the assumed number of yearling cows.

Population Estimate

The moose population estimate and age/sex composition were derived by extrapolation from counts in the censused sample units to uncensused sampled units within each density stratum using a ratio estimator. The population estimate and associated variance for each stratum were then added together to obtain an overall population estimate (with variance) and age/sex composition.

Topographic Zones

Moose population estimates and age/sex composition were further assessed (post priori) by division of the survey area into three topographic zones; lowlands, foothills and mountains. Each sample unit was assigned to a topographic zone on the basis of elevation. The lowland zone included areas at 610 to 1067 m asl; the foothill zone extended from beyond 1067 to 1372 m asl; and the mountain zone extended from beyond 1372 to approximately 1676 m asl. In cases where sample units bordered two zones, the zone with more than 50% of the sample unit was assigned the unit.

The topographical zones implied different terrain and vegetation characteristics. The lowland zone was essentially river valley bottom, had generally low relief and extensive meadow areas as well as tall, closed canopy forest. The foothill zone represented drier upland vegetation communities, while the mountain zone implied xeric conditions and represented extensive expanses of subalpine areas.

Habitat

Moose habitat was defined in terms of vegetative cover and aspect. During census, for each moose sighting or aggregation, the immediate surrounding vegetative cover was visually assessed and classified using a predefined scheme of classes. Aspect was measured from the 1:50,000 scale N.T.S survey maps.

Vegetation

The vegetation classes included: shrub, deciduous, coniferous, shrub-coniferous, burn, meadow and clear-cut. "Shrub" represented essentially treeless areas where shrubs, usually shrub willow and birch, predominated. The shrub class was applied both to subalpine shrub areas as well as shrub areas below treeline. The deciduous class represented stands of aspen, birch and/or balsam poplar, while the coniferous class represented stands of white or black spruce, lodgepole pine or subalpine fir. The shrub-coniferous class represented coniferous forests with a relatively open canopy and a prominent shrub understorey. Areas without tree cover and no predominant, above-snow shrub growth were classed as "meadow". Areas affected by forest fires were classed as "burn". These areas had vegetative regrowth of shrubs or regenerating pine forest. "Clear-cut" was applied to commercially logged (clear-cut) areas.

Aspect

Aspect was categorized into five classes: northwest-north (293-22^{o}); northeast-east (23-112^{o}); southeast-south (113-202^{o}); southwest-west (203-292^{o}); and no aspect or flat.

Habitat Use

Moose habitat use was assessed by moose distribution among the classes of vegetation and aspect. The distribution of the estimated moose population among the habitat features was achieved by extrapolation of observed moose distribution within each density stratum to the total estimated population and study area. Additionally, the distribution of observed moose among habitat features within each topographic zone was assessed. This evaluation was post priori and was applied only to the observed moose within each zone.

Biases and Limitations

The moose population estimate was based on a census incorporated into a stratified block design, with blocks representing classes of moose density. Within each sample unit censused, aerial search patterns, search intensity and survey height of the aircraft were adjusted to ensure that all moose were counted. However, an unknown but small percentage of moose, particularly in the low and extremely low density strata, may have been overlooked.

Although no correction factor for sightability of moose was calculated using high intensity searches (see Gasaway *et al* 1981), intuitively we believe fewer than 3% of the moose were overlooked. In Alaska, using the same technique, but flying the census phase with fixed-wing aircraft and two observers Gasaway *et al* (1981) observed 97% of the moose present based on resighting radio-collared moose. Since we were using helicopters and four observers during the census phase, our sightability of moose should be as high if not higher than calculated by Gasaway *et al*.

The estimates of the size and composition of moose populations occurring in the three topographic zones were made *post priori*, thus they are biased because the stratified block design did not account for topographic area, only density strata. However, we believe that potential bias associated in deriving the population composition by topographical zones does not change the major patterns evident in the data analysis.

RESULTS

Population Estimate and Composition

Liard West

The moose population estimate and 90% confidence interval was based on a stratified random census of 61 sample units representing 18% of the total habitable moose range. Estimated number of moose, coefficients of variation (expressed as a percentage of the mean), and 90% confidence intervals are given for each age/sex group identified in the field (Table 1). A total of 838 ± 180 moose was estimated in the 7236 km^2 study area. Moose density was estimated at 0.116 ± 0.025 $moose/km^2$.

The greatest proportion of the estimated moose population consisted of adult cows (47.4%) and adult bulls (35.6%). Calves and yearlings represented 8.4 and 8.6% of the estimated moose population, respectively.

The distribution of each age/sex group among the four density strata is presented in Table 2. Slightly more adult bulls (37.1%) occurred in the high density stratum than in the medium (22.4%), low (20.4%) or extremely low (20.1) strata. The greatest proportion of the adult cows (48.9%), yearlings (41.7%) and calves (64.3%) occurred in the extremely low density stratum. Over 80% of the estimated number of both yearlings and calves occurred in the low and extremely low density strata.

Ratios of adult bulls, yearlings and calves per 100 adult cows were 75.3, 18.1 and 17.6 respectively (Table 3). The ratio

Table 1. Moose population estimate by age/sex groups for Liard West, early winter 1983.

AGE/SEX GROUP	NO.OF MOOSE CENSUSED	ESTIMATED NO. OF MOOSE (90% CI)	C.O.V.*	DENSITY (moose/km²)
Cows+	134	433 ±130	30	0.060 ±0.031
Adult Bulls	142	299 ±68	23	0.041 ±0.009
Yearling Bulls	9	36 ±28	78	0.001 ±0.001
Calves	19	70 ±34	48	0.010 ±0.001
All Age/Sex Groups	304	838 ±180	21	0.116 ±0.025

* Coefficient of Variation - standard deviation expressed as a percentage of the mean

+ Includes yearling and adult cows

Table 2. Distribution of the estimated moose population by age/sex groups and density strata in Liard West, early winter 1983.

	AGE/SEX GROUP (%)				
DENSITY STRATA	Adult Bulls n= 299	Adult Cows n= 397	Yearlings n= 72	Calves n=70	Total n= 838
High	37.1	18.9	11.0	15.7	24.5
Medium	22.4	15.1	8.4	0	15.9
Low	20.4	17.1	38.9	20.0	20.4
Ext. Low	20.1	48.9	41.7	64.3	39.2

Table 3. Numbers of adult bulls, yearlings and calves per 100 adult cows by density strata, early winter 1983.

	NO. OF MOOSE/100 ADULT COWS		
DENSITY STRATA	Adult Bulls	Yearlings	Calves
High	148.0	10.7	16.0
Medium	111.7	10.0	0
Low	89.7	41.2	20.6
Ext. Low	30.9	15.0	23.2
All Strata	75.3	18.1	17.6

of adult bulls/100 adult cows was large within the high density stratum and decreased progressively through the medium, low and extremely low density strata. The number of calves/100 adult cows was highest in the extremely low density stratum.

The age/sex composition of moose within each density stratum differed among the strata (Table 4). In the high and medium density strata, at least half of the moose were adult bulls. In sharp contrast to this is the composition of the extremely low stratum where 59% of the moose were adult cows. The low and extremely low strata had a greater proportional representation of calves and yearlings than the high and medium strata.

Sample units classed into the high and medium strata were considered moose aggregation areas. These areas represented only 9% of the habitable moose range yet contained 40% of the total estimated moose population. Mean moose density in the high and medium density strata was 0.67 and 0.37 moose/km^2 respectively, compared to 0.09 and 0.07 moose/km^2 in the low and extremely low density strata.

A total of 31 sample units were classified as moose aggregation areas (high and medium density strata). Sample units classed as aggregation areas are presented in Figure 2. Although aggregation areas occurred throughout the Liard West study area, 63% were concentrated in the foothill and mountain zones between Scurvy Creek and the Meister River.

Table 4. Age/sex composition (%) of moose within each density strata, early winter 1983.

AGE/SEX GROUP	STRATA			
	High n=206	Medium n=132	Low n=171	Extremely Low n=329
Adult Bulls	53.9	50.0	35.7	18.2
Adult Cows	36.4	45.5	39.7	59.0
Yearlings	3.9	4.5	16.4	9.1
Calves	5.8	0	8.2	13.7

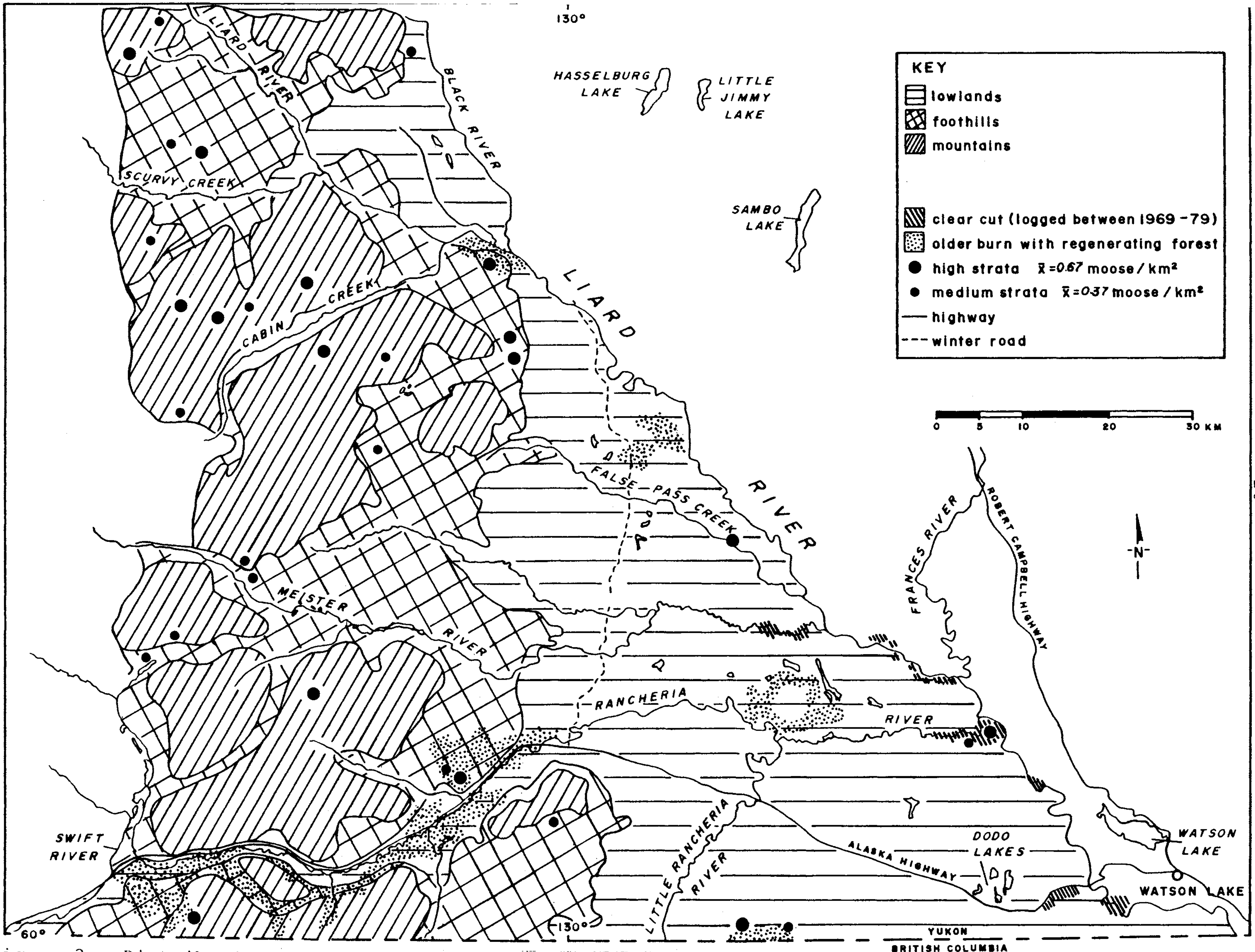

Figure 2. Distribution of topographic zones and medium and high density strata (aggregation areas) in Liard West, early winter 1983.

Topographic Zones

Preliminary analysis of the Liard West data indicated that moose population density, age/sex composition, and distribution was different between the mountains, foothills and lowlands (Table 5). A greater proportion of the Liard West moose population occurred in the lowlands (38%) than in the foothills (33%) or the mountains (29%). However, moose density was highest in the mountains (0.159 moose/km^2) and lowest in the lowlands (0.090 moose/km^2). These density values reflect the different proportions of habitable moose range within each topographic zone: 21% in the mountains, 30% in the foothills and 49% in the lowlands. Both the density and the total number of moose occurring in the foothills were intermediate between values calculated for moose from the lowlands and mountains.

The age/sex composition of moose differed significantly among the three topographic zones. Adult bulls represented 51.9% of the moose occurring in the mountain zone and only 35.4% of the moose in the lowlands. The representation of adult cows was least in the mountain zone, however, the differences between the three zones were small. The proportion of yearlings and calves was lowest in the mountain zone and highest in the lowland zone. Over half of the estimated calves in the Liard West area occurred in the lowland zone.

The bulls/100 adult cows ratio was low in the lowlands and extremely high in the mountains (135.3 bulls/100 cows). The number of calves/100 cows was more than twice as high in the lowlands than in the mountains as was the yearlings/100 adult

Table 5. Density, age/sex composition and numbers of moose within topographic zones of Liard West, early winter 1983.

	TOPOGRAPHIC ZONE			
	Lowlands	Foothills	Mountains	Liard West
No. of Observed Moose	48	95	161	304
No. of Estimated Moose	319	277	242	838
<u>Composition</u>				
% Adult Bulls	35.4	43.2	51.9	35.6
% Adult Cows	43.8	44.2	38.7	47.3
% Yearlings	8.3	6.3	5.0	8.6
% Calves	12.5	6.3	4.4	8.5
Adult Bulls/100 Adult Cows	81.0	97.6	135.3	75.3
Yearlings/100 Adult Cows	19.0	14.3	12.9	18.1
Calves/100 Adult Cows	28.6	14.3	11.3	17.6
Total Area (km^2)	3535	2177	1524	7236
Moose Density (#/km^2)	0.090	0.127	0.159	0.116

cows ratio.

The distribution of moose among density strata within each topographic zone differed, especially between the lowlands and the mountains (Table 6). In the mountains, the greatest proportion of moose (37.6%) were in the high density stratum, compared to only 12.2% in the high density stratum within the lowlands. In contrast, 60.5% of the moose occurring in the lowlands were in the extremely low density stratum, compared to 17.8% in the mountains. The number of moose aggregation areas (high and medium density strata sample units) occurring in the mountains, foothills and lowlands was 14, 11 and 6 areas respectively (Figure 2).

Habitat Use

Vegetation

Within the total habitable moose range, 91% of the moose population were distributed among four of the seven vegetation classes: shrub, coniferous, shrub-coniferous, and burn (Figure 3). The class with the largest proportion of moose was "shrub-coniferous", in which 33% of the moose population occurred.

The pattern of vegetation class use by moose noted for the entire study area was not reflected within each topographic zone (Figure 3). In the lowlands, the 46 observed moose were evenly distributed throughout six of the vegetation classes, with the least use (<5% of the moose) of the deciduous class. Seventeen percent of the lowland moose occurred in " clear-cut". Clear-cut areas occur only in the lowlands, adjacent to the Liard, Meister

Table 6. Distribution of the estimated moose population by density strata and topographic zone in Liard West, early winter 1983.

	TOPOGRAPHIC ZONE			
DENSITY STRATA	Lowlands n= 319	Foothills n= 277	Mountains n= 242	Liard West n= 838
High	12.2	27.1	37.6	24.5
Medium	9.4	20.2	19.4	15.9
Low	17.9	19.1	25.2	20.4
Ext. Low	60.5	33.6	17.8	39.2

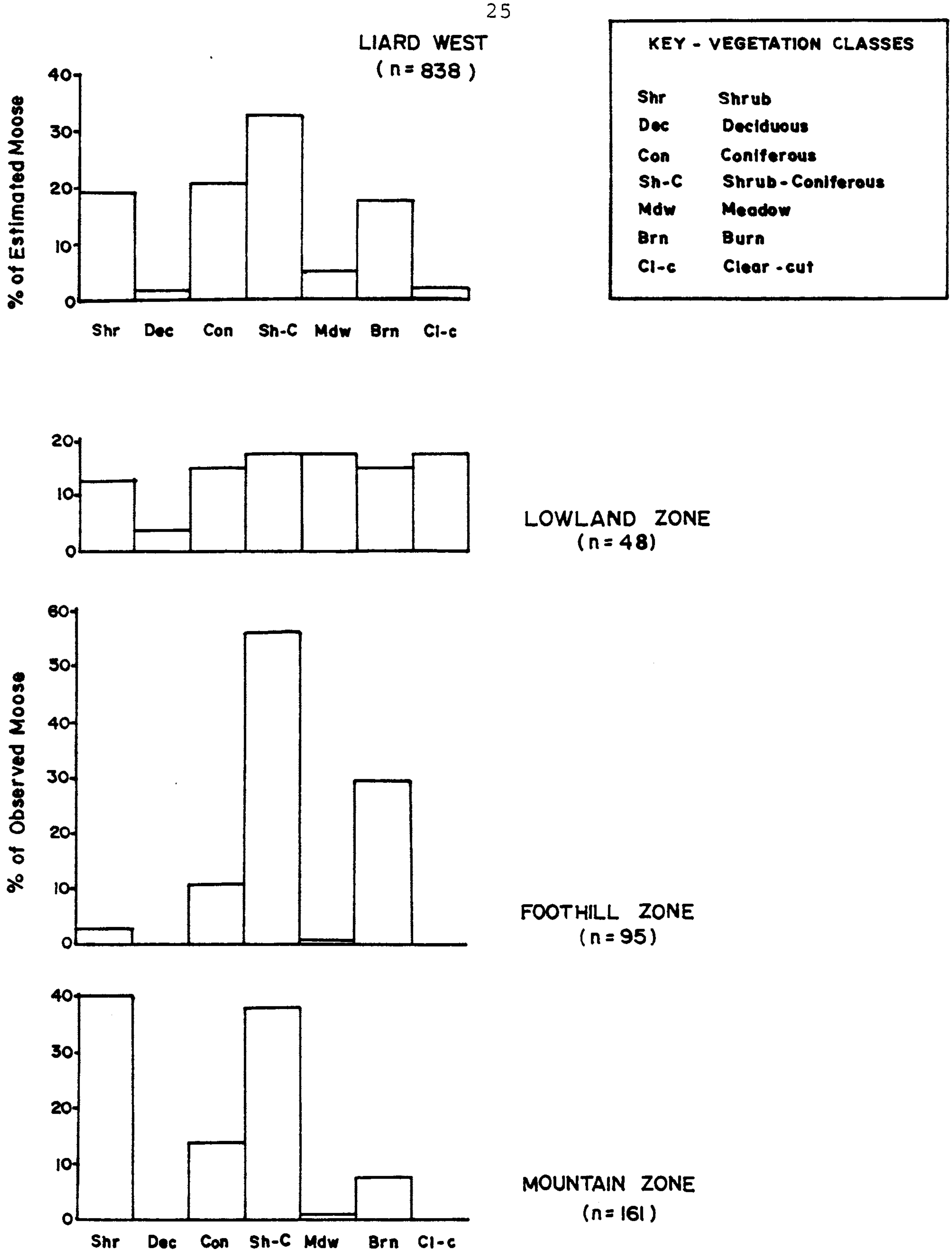

Figure 3. Distribution of moose among vegetation classes in Liard West and by topographic zones, early winter 1983.

and Rancheria Rivers and Alaska Highway (Figure 2). All moose observed in clear-cuts were aggregated and the associated sample units represented either high or medium density stratum (Figure 2). "Meadow", where 17% of the lowland moose were observed, were characteristic of the lowlands. Meadow areas were seldom used by moose in the foothills and were not present in the mountains.

Most (56%) of the 95 moose observed in the foothills occurred in "shrub-coniferous". Also well used by moose in the foothills were burn areas representing the largest proportion of moose in burns within the three topographic zones. An extensive burn exists in the foothills in the general area of the Alaska Highway and Rancheria River (Figure 2). Predominant vegetative regrowth in the burn areas is either shrub willow and shrub birch or regenerating pine forest. Within the foothill zone, two of the five high density stratum sample units and one of the six medium density stratum sample units occurred in burn areas (Figure 2). In the mountain zone, most of the observed moose were in "shrub" and "shrub-coniferous", 40% and 38% respectively.

Adult bulls and cows (which include yearling cows) showed high proportional use of shrub-coniferous areas (Figure 4). Other vegetation classes where more than 10% of the bulls or cows occurred include: "shrub", "burn" and "coniferous". More than twice the proportion of cows (26%) than bulls (12%) were in "coniferous". "Deciduous" and "clear-cut" were used by few bulls or cows.

Yearling bulls were noted in only four vegetation classes

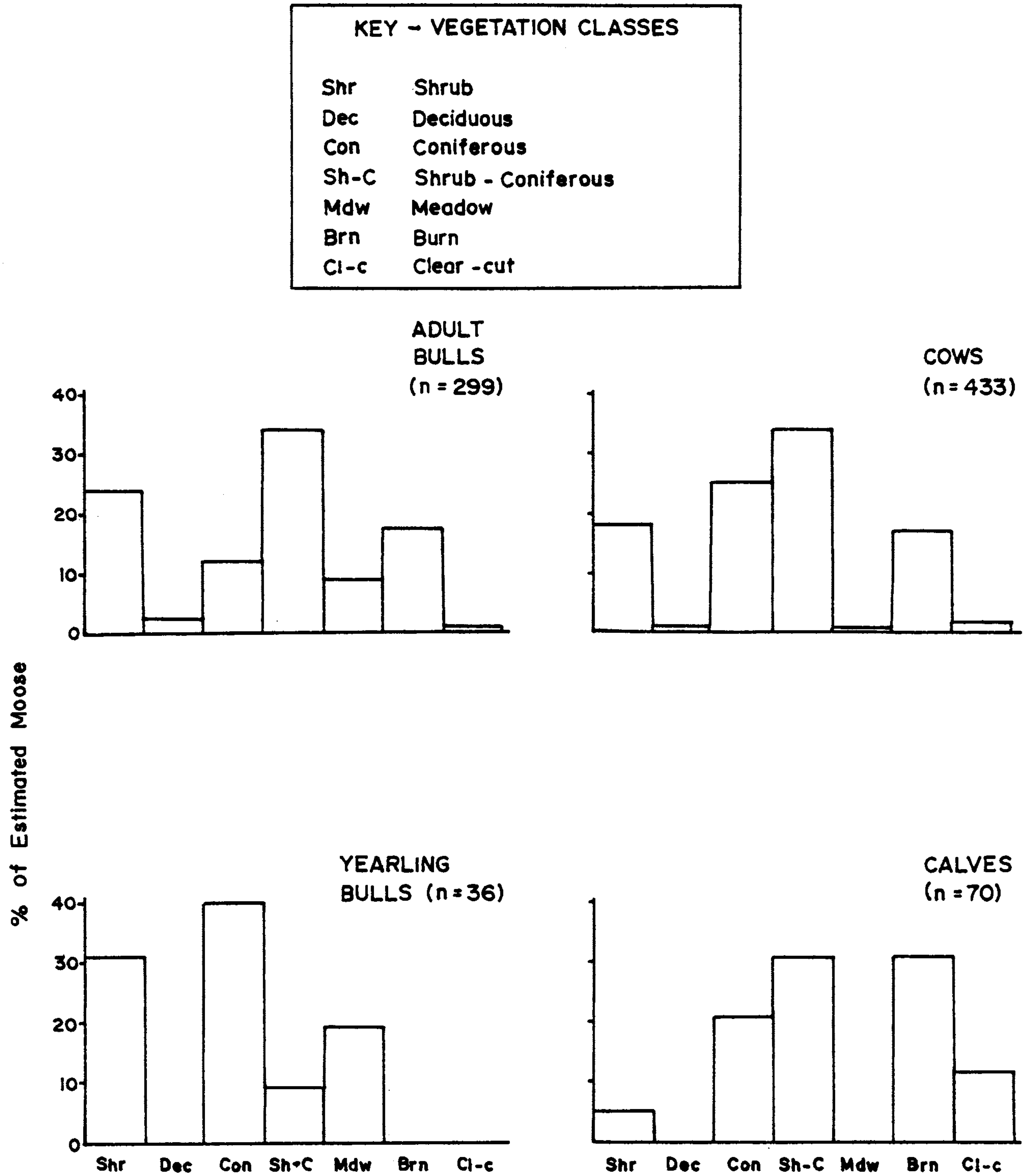

Figure 4. Distribution of moose among vegetation classes by age/sex groups in Liard West, early winter 1983.

(Figure 4). This is not surprising for although 36 yearling bulls were estimated for the population, only nine were actually observed, among a possible seven vegetation classes.

Most noticeable about the use of vegetation classes by calves was the high use of burn areas. Thirty-one percent of the estimated calves used burn areas. No other age or sex group of moose showed so high a proportional use of burns. The "shrub-coniferous" class was also used by an equally high proportion of calves as in "burn". The proportional abundance of calves in shrub-coniferous areas compliments the proportional abundance of cows in this vegetation class. The proportional use of clear-cut areas by calves (12%) exceeded the use of this vegetation type by any other moose group.

Aspect

Aspects used by the greatest proportion of the estimated moose were northern and eastern exposures (Figure 5). The high use of eastern aspects (>30% of all moose), was shared by cows, yearling bulls and calves. Adult bulls were most common on northern exposures. Most yearling bulls were on eastern and western exposures. The high use of western exposures by yearling bulls (>40%) was specific to this age/sex group.Flat terrain was used by all age/sex groups with the greatest proportional use by calves.

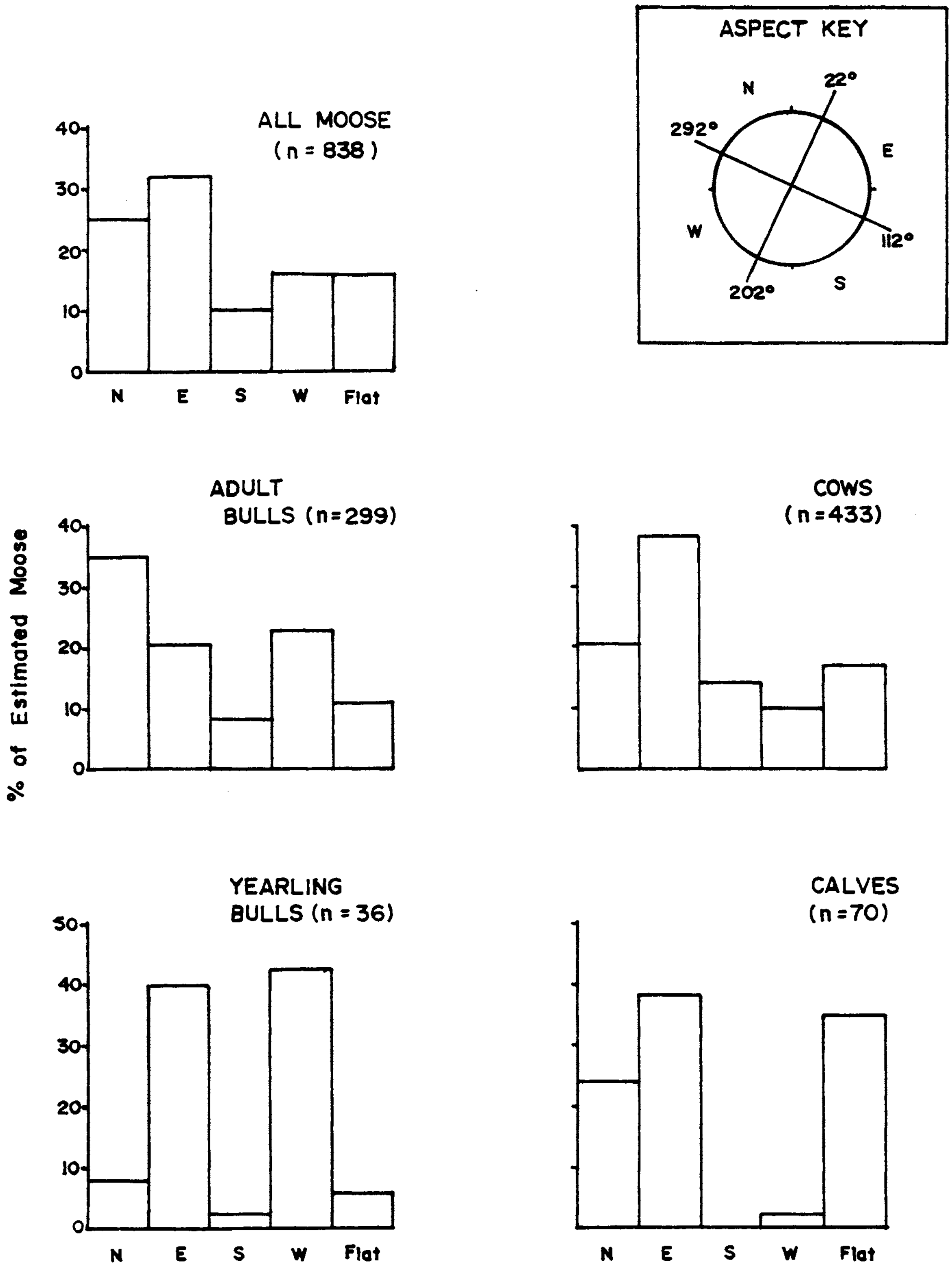

Figure 5. Distribution of moose among aspect classes by age/sex groups in Liard West, early winter 1983.

DISCUSSION

Population Estimate and Composition

Liard West

The population density in Liard West (0.116 ± .025 moose/km^2) is amongst the lowest calculated for moose populations anywhere in the southern Yukon. Densities of moose from discrete areas in the southwestern Yukon have ranged from 0.11 moose/km^2 to 0.40 moose/km^2 during early winter surveys conducted in 1981-82 (Johnston _et al_ 1984). Moose population density in Liard West is also lower than early winter estimates from Alaska (Gasaway _et al_ 1983) and northern Alberta (Hauge and Keith 1981). However, the Liard West population density estimate is comparable to a density estimate calculated for moose in a 5512 km^2 study area on the lower Liard River valley near Fort Simpson, N.W.T. (Donaldson and Fleck 1980).

Aerial survey studies of moose in the Liard River basin which focused on the immediate river valleys found high moose abundance (Lortie _et al_ 1978; BC Hydro unpubl. data). Lortie _et al_ (1978) surveyed areas below 762 m asl along the Meister and Rancheria Rivers in February and reported densities of 1.2 and 5.6 moose/river mile, respectively. BC Hydro (unpubl. data) employed Gasaway _et al_'s (1981) moose survey technique in river valley areas of the lower Liard River and reported a moose density of 0.7 ±1.4 moose/km^2.

The calf/cow ratio for the Liard West population suggests a high index of productivity relative to other populations in the

Yukon. In seven areas surveyed in the southern Yukon during 1981-1982, the early winter ratio of calves/100 adult cows ranged from 6-28 and averaged 13.8 calves/100 adult cows (Johnston et al 1984), compared to 17.6 calves/100 adult cows for Liard West. Donaldson and Fleck (1980) derived a ratio of 30.7 calves/100 cows during moose surveys of the lower Liard River basin in midwinter.

Another index of productivity is the proportion of calves within the total population. In the Liard West moose population the proportion of calves (8.4%) was within the range of 4-15% calculated for other moose populations in the southern and central Yukon (Larsen 1982; Johnston and McLeod 1983b; Johnston et al 1984).

The ratio of adult bulls/100 adult cows (75.3/100) was considerably higher in this population than reported for any other moose population in the southern and central Yukon (Larsen 1982; Johnston and McLeod 1983a, 1983b; Johnston et al 1984). Only in the Aishihik study area does the adult bulls/100 adult cows ratio approach the size determined for the Liard West population. High adult bull /adult cow ratios (approaching 100:100) are indicative of moose populations which receive little or no hunting pressure (Coady 1982). Moose are hunted within Liard West, however most of the harvest is concentrated only in specific G.M.S. Large areas of the study area receive little or no hunting pressure which may help explain the high proportion of bulls in the population. This matter is further discussed under Topographic Zones.

Topographic Zones

Differences noted in population structure, abundance and density between moose in the lowlands and mountains have two possible explanations; 1. seasonal migrations of select age/sex groups (ie. cows with calves) occur between the lowland and mountain areas, or 2. two local "populations" exist and are under different regulatory parameters.

Seasonal migrations of moose between lowlands and mountains are well documented in the literature (Edwards and Ritcey 1956; Phillips et al 1973; LeResche 1974; Peek et al 1974; Van Ballenberghe 1977; Mytton and Keith 1981). In Alaska, seasonal movements of moose are characterized by a downward elevational migration to winter range over a period of 10-12 weeks commencing in early November (Van Ballenberghe 1977). Cows with calves generally migrate before bulls or cows without calves. In Alberta, Mytton and Keith (1981) also noted both migratory and non-migratory cows within the same moose population, although they did not indicate the respective cow/calf associations. The large proportion of cows with calves and yearlings noted in the lowlands during our early winter surveys could represent an early migration of these age/sex groups from the foothills and mountains to wintering range in the lowlands. However, during this survey period from mid November to early December, there was little evidence (tracks, movement of moose out of sample units) of movement of moose in the study area. If movement out of the mountains by cows with calves and yearlings had occurred, then it must have taken place prior to our surveys.

The alternative hypothesis suggests regulatory mechanisms acting differently on moose in lowlands from moose in the mountains. The use of topographic zones by specific age/sex groups may involve tradeoffs between predator avoidance and forage quality. Cows with calves and yearlings may seek out low moose density, heavy cover areas (lowland zone) at the expense of low cover, high quality forage areas (mountain zone) as a predator avoidance tactic. Conversely, bulls (energy stressed by the rut) and barren cows, both at less risk to predation, may concentrate in subalpine mountain areas because of high forage quality during early winter. Whether two relatively discrete populations exist, or age/sex distribution of the entire population is skewed along topographic zones is a matter of conjecture.

Regardless of the causes of differing population parameters between moose in the lowlands and mountains, the implications to moose management are important. If the populations are relatively isolated, then wildlife management practices should reflect differences in population productivity by managing on geographic zones rather than at the G.M.S. level. The large differences between population parameters in the mountains and lowlands at the very least suggests the need for further studies which investigate these differences.

Hunter Harvest Implications

Differences in the bull/cow ratio between topographic zones and specifically between the lowlands and mountains may also be attributable to differential hunting pressure. Over 84% of the moose harvest by sport hunters in the study area occurs in G.M.S. which are entirely or partially in the lowland zone. Correspondingly, the bulls/100 adult cows ratio was lowest in the lowlands. Hunting in the lowlands is easily facilitated by access routes such as the Alaska Highway, the Liard River and the numerous logging roads which extend through the lowlands to clear-cut areas on the Liard, Rancheria and Meister Rivers. In contrast, hunter access to moose in the mountain zone is limited, as there exist few tote roads and few lakes suitable for landing floatplanes.

During 1979-81 and 1983 the mean annual moose harvest by sport hunters in those G.M.S. within Liard West was 30.5 moose (Table 7).

Table 7. Estimated number of moose harvested by sport hunters in Game Management Subzones of Liard West.

	G.M.S. of G.M.Z. #10									
YEAR	14	15	16	27	28	29	30	31	32	Total
1979	1	3	0	3	9	5	1	6	18	46
1980	0	3	0	1	8	5	1	0	6	24
1981	0	1	0	2	9	3	1	0	14	30
1983	0	6	0	1	7	1	1	2	4	22
Mean	0.5	3.3	0	1.8	8.3	3.5	1.0	2.0	10.5	30.5

The number of moose harvested by natives and taken by poachers is unknown, but likely equals or exceeds the sport hunter harvest (Larsen pers. comm.). Therefore, approximately 61 moose or 7.3% of the moose population has been harvested annually within the four year period. On average, eighty-two percent of the total moose harvest by sport hunters was in G.M.S. which are adjacent to the Alaska Highway (G.M.S. 10-28, 10-29, 10-30, 10-31 and 10-32). Presumably native hunting and poaching also occurs in similar concentrations in these more easily accessed areas.

From this early winter survey of the Liard West moose population, fall recruitment in terms of the number of calves surviving to age 6 months was 8.4%. Therefore, the harvest of moose by sport hunters, natives and poachers is slightly less than fall recruitment. If natural mortality of adults is conservatively estimated at 10% (Larsen pers. comm.), then the total annual mortality of moose from all sources excedes 17%. Assuming that hunting pressure, natural mortality, and the moose population estimate approach true values, then moose mortality rates (including both natural and hunting) exceed recruitment rates in Liard West.

Areas of particular management concern are the G.M.S. adjacent to the Alaska Highway. Since most of the hunting pressure and success occurs in these G.M.S., overall annual mortality is undoubtedly much higher in these G.M.S., than in the G.M.S. more distant from such easy access points. Past and present harvest pressures may in part be responsible for the paucity of the high and medium moose density aggregations in the southern half of the study area where easy access for hunters is available.

Habitat Use and Distribution

Between zone differences in moose distribution among the vegetation classes can partially be attributed to the differences in vegetation class availability. Clear-cuts were used only in the lowlands - the only zone where they were available. Similarly, the low use of meadows, in both the foothill and mountain zones, and low use of burns in the mountain zone, likely reflected the limited availability of these vegetation classes. However, the non-use of deciduous stands in the foothill and mountain zones likely represented a non-preference by moose for this vegetation class, as well as reflecting the limited coverage of deciduous stands within the study area. In the southwestern Yukon, a measure of the relative availability of stands of deciduous trees and their associated use by moose during early winter was estimated (Johnston *et al* 1984). It was concluded that moose used the deciduous vegetation class less than its availability or not at all.

Clear-cuts were used by moose beyond their availability; although clear-cuts represented only 0.3% of the habitable moose range, they were used by 3% of the total moose population. The greatest users of clear-cuts were cows with calves. Moose use of clear-cuts is dependent on the age of the vegetation seral regrowth, the type of vegetation regrowth and the size of the clear-cut area (Peterson 1955; Eastman 1974; Telfer 1974; Hamilton *et al* 1980; Thompson and Vukelich 1981). Moose may favour areas with a heterogeneous environment such as clear-cuts which offer seral shrub growth for browse and adjacent mature forest for protection and shelter (Peterson 1955; Hamilton *et al* 1980). Hamilton *et al* (1980) found a positive correlation between winter browsing activity in clear-cuts and the distance to cover, although the significant distance differed between years (80 vs 260 m). The maximum recommended size of clear-cuts for moose usage ranges from 80 ha (Peek *et al* 1976) to 130 ha (Telfer 1974). In the Liard West study area the average size of the clear-cuts is 13.5 ha (White, pers. comm.). However, the size of an individual clear-cut at the mouth of the Rancheria River where two moose concentrations were noted is 148 ha. This area was clear-cut in 1972, thus the age of the vegetation regrowth at the time of the survey was approximately 11 years old. This agrees with findings by Eastman (1974) and Hamilton *et al* (1980) that the preferred age of regrowth for moose browse is from 10 to 20 years old.

The timber growth in the Liard River valley is considered the best in the Territory, consequently future logging activity in the area is foreseeable. Current Forestry policy recommends clear-cut areas no larger than 25 to 35 ha with site specific consideration given to each application for cutting (White, pers. comm.). Given the restricted allowable size of clear-cut area, future logging activity in Liard West may serve to improve moose habitat through browse quality enhancement.

Burn areas can provide prime moose range by enhancing browse quality represented in early seral stages of mixed forest succession (Peterson 1955; LeResche *et al* 1974; Cairns and Telfer 1980). Burn areas in the Liard West study area were responsible for five moose concentrations: four high density concentrations and one medium moose density concentration. Moose density in burn areas in the lower Liard River during February 1984 was 1.0 moose/km^2 (BC Hydro, unpubl. data). Considering the limited availability of burn areas in the Liard West study area (less than five percent of the moose range) the use of burn areas by moose, and specifically the five moose concentrations noted, suggests a selective use of burns. During moose surveys of the lower Liard River in February 1984, moose showed a significant preference for burn areas (BC Hydro, unpubl. data). During this study, burn areas were especially important to calves.

Forestry's current policy with respect to fighting forest fires is based on a classification of four zones of differential fire fighting priority. Zone 1 areas include populated areas and communities and highways. Zone 2 areas include stands of marketable timber (Bowlby, pers. comm.). Both of these zones are given fire fighting priority. The Liard River valley and Rancheria River (along the Alaska Highway) would fall within these two priority zones. Consequently, future fires within the area will be given priority by Forestry to be fought and restricted, thus enhancement of moose habitat through wildfire is unlikely.

The use of shrub vegetation by moose was common to all age/sex groups. The high proportion of moose in "shrub" in the mountain zone represented use of the subalpine shrub. Numerous studies have documented the occurrence of moose during early winter in high elevation shrub areas (LeResche and Davis 1971; Phillips et al 1973; Wolff and Cowley 1981; Larsen 1982; Johnston and McLeod 1983a; Johnston et al 1984).

Moose use of aspect is not independent of vegetation types as influenced by aspect or topographic zone. Differences in aspect use between adult bulls, cows, yearling bulls and calves may reflect their different uses of vegetation classes and their distribution among the topographic zones. Most of the calves occurred in the lowland zone where one would expect a high representation of flat terrain. More than 30% of the calves did occur in flat terrain and this contrasts with the low use of flat terrain by the other age/sex groups. The proportionally high distribution of calves in flat terrain was also found in a study of early winter moose distribution in the southcentral Yukon (Johnston and McLeod 1983b).

Other moose studies in the southern Yukon have found a non-random pattern of moose distribution by aspect, however, among the specific survey areas no general pattern of use was apparent (Johnston et al 1984). The proportionally low use of south, southeast slopes by the total moose population during early winter in Liard West agrees with findings of moose populations in the southcentral Yukon (Johnston and McLeod 1983b) and the southwestern Yukon (Johnston et al 1984). South, southeast facing slopes are relatively dry areas, often vegetated with deciduous trees, a vegetation class found to be used least by moose during early winter.

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APPENDICES

Appendix 1. Sample unit size, total area and censused area of moose range by density strata in Liard West, early winter 1983.

	DENSITY STRATA				
	High	Medium	Low	Ext. Low	Total
<u>Area</u>					
Total (km^2)	329	337	1918	4652	7236
Censused (km^2)	307	97	281	621	1306
(%)	93	29	15	13	18
<u>Sample Units (S.U.)</u>					
Total (#)	15	16	86	222	339
Censused (#)	13	6	13	29	61
(%)	87	38	15	13	18
<u>Mean Size</u>					
All S.U. (km^2)	22.0 ±4.1	21.0 ±4.4	22.3 ±4.7	21.0 ±3.6	21.2 ±4.1
Censused S.U. (km^2)	22.0 ±4.1	19.9 ±3.1	21.5 ±3.6	21.5 ±3.9	21.2 ±3.7

Appendix 2. Census time and census search intensity for each density stratum in Liard West, early winter 1983.

	DENSITY STRATA				
	High	Medium	Low	Ext. low	Total^/Mean*
Total census time (hr)	8.8	3.9	6.3	13.8	32.8^
Survey time per S.U. (min)	40.4 ±7.1	38.8 ±18.7	28.9 ±7.6	28.5 ±9.2	32.5 ±10.5*
Search intensity (min/km^2)	1.9 ±0.4	2.1 ±0.9	1.4 ±0.5	1.4 ±0.3	1.6 ±0.5*
Search intensity ($min/mile^2$)	4.9 ±1.0	5.3 ±2.3	3.6 ±1.3	3.5 ±0.8	4.0 ±1.4*