MOOSE POPULATION DYNAMICS

AND

HABITAT USE,

SOUTHERN YUKON RIVER BASIN

NORTHERN BIOMES LTD.
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by

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SUMMARY

Moose (<u>Alces alces</u>) inventories were conducted over selected portions of the southwest Yukon, and a portion of northern British Columbia within the Yukon River Basin, during early winter 1981 and 1982, and late winter 1982. The study area encompassed 24,219 km^2 and was divided into seven distinct survey areas: Haines Junction, Whitehorse South, Kluane, Aishihik, Whitehorse North, Teslin Burn and Teslin Burn South. The study objectives were: 1) to determine early winter moose population size; 2) to determine the age and sex composition of moose populations during the early winter period; 3) to assess early and late winter distribution, and 4) to assess early and late winter habitat use by moose.

A stratified block sampling technique was used to aerially census moose in six early winter survey areas: Haines Junction and Whitehorse South (1981 and 1982), Kluane and Aishihik (1981) and Whitehorse North and Teslin Burn (1982). A stratification technique was used to determine relative distribution of moose in the Teslin Burn South (early winter 1982) and Whitehorse South (late winter 1982) survey areas. The results from these two surveys have been dealt with separately.

Within the total study area in the Yukon, the estimated early winter moose population was 4747 or 0.21 moose/km^2. Moose density varied considerably between survey areas, ranging from 0.11 to 0.40 moose/km^2. The largest estimated population and highest density occurred in Teslin Burn.

Within all six early winter survey areas, regardless of year, adult cows (≥30 months old) comprised more than 45% of the population and adult bulls represented more than 19% of a population. During 1981, yearlings comprised approximately 13% of the population within all survey areas. In 1982 the composition of yearlings among all six survey areas had substantially declined to 2.5%. Calves represented 11% of the 1981 survey population and 8% of the 1982 survey population.

The number of bulls/100 adult cows (≥30 months old) ranged from 17-66 over the survey areas during the two years. Ratios of yearlings/100 adult cows ranged from 22-30 in 1981 and from 1-9 yearlings/100 adult cows in 1982. In 1981 the ratios of calves/100 adult cows ranges from 17-28 and in 1982 ranged from 6-24 among the surveyed populations.

From 1981 to 1982, the Haines Junction moose population showed a 19% decrease due to declines in the size of the calf and yearling cohorts. The Whitehorse South population remained stable between the two years. Although a decline in the size of the yearling cohort was apparent from 1981 to 1982, it was balanced by an increase in the size of the calf cohort.

Whitehorse South was surveyed in early winter 1981 and late winter 1982. Moose were more dispersed and less aggregated during late winter. Of the total aggregation areas identified during early and late winter, 36.4% were common to both seasons.

During the early winter, a large proportion of moose in the six survey areas were at high elevations (>1250 m) at or above treeline in shrub vegetation. Tests of relative habitat availability and moose utilization showed that moose used high elevations and shrub zones more than their availability. Moose also showed a non-random distribution with respect to aspect although no pattern of use was common to all survey areas.

Year to year comparisons revealed moose used the same habitat in roughly the same area, suggesting traditional, seasonal use during early winter. Comparisons of moose habitat use from early to late winter showed a slight downward, elevational movement by moose.

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INTRODUCTION

Moose (Alces alces) are common throughout the Yukon and are an indigenous wildlife species to the Territory. However, the relative local abundance of moose varies considerably by region. Within the last decade, a number of moose surveys were conducted in specific areas of the southwest and southcentral Yukon (Lortie 1974, 1976; Hoefs 1976; Foothills 1977, 1978a, 1978b; Larsen and Nette 1980). The aims of these studies were to estimate moose abundance for use in developing wildlife management strategies and hunting regulations or to identify potential conflicts between areas of moose use and a proposed pipeline route.

In recent years approximately 1000 moose have been harvested annually by primarily non-native licensed hunters (Gov't of Yukon files). The number of moose harvested by unlicensed native hunters and poachers is unknown but possibly equals the licensed harvest. Recently, suspected negative trends in regional moose population size and composition coupled with differential hunting pressures associated with human population centres led to the development of six priority moose management areas (Gov't of Yukon files). These priority management areas are associated with population centres (Haines Junction, Whitehorse, Teslin, Watson Lake, Dawson, Mayo and Ross River) where hunting pressure tends to be greatest. Consequently, a moose inventory program was initiated by the Yukon Government in 1981 to determine the impact of hunting on natural population regulation (Larsen 1982).

Concurrently, the Yukon River Basin Study (Y.R.B.S.), concerned with developing a planning framework within which potential development alternatives in the river basin could be evaluated, recognized the lack of baseline information on moose populations. The Wildlife Study Group of the Y.R.B.S. suggested a program to investigate moose abundance and habitat use within the river basin, specifically in floodplain areas. However, inventory studies concentrated on floodplains would not address the most basic research needs concerning Yukon moose populations, namely: the regional abundance, distribution and composition of the species within portions of the river basin. Thus this study was designed primarily to meet government wildlife managment objectives, and secondly, to collect baseline information for the Y.R.B.S. with respect to formulating guidelines for basin development.

This report is a compilation of recent moose inventories in the southwest Yukon (Larsen 1982; Johnston and McLeod 1983; Markel and Larsen 1983). These studies were based on the following objectives:

1. To determine early winter moose population size,
2. To determine the age and sex composition of moose populations during the early winter period,
3. To determine early and late winter distribution of moose,
4. To assess early and late winter moose habitat use.

STUDY AREA

Situated in the central southwest Yukon and northern British Columbia the study area encompasses approximately 24,219 km^2 of habitable moose range (see Methods). The area is divided into seven contiguous yet independent survey areas (Figure 1). Most of the study area is drained by the Yukon River. Major tributaries of the Yukon River within the study area are the Takhini and Teslin Rivers. Large lakes within the study area include Teslin, Marsh, Bennett, Tagish, Laberge and Kusawa. Three of the seven survey areas (Kluane, Aishihik and part of the Haines Junction area) are not within the Yukon River basin but are part of the southerly-flowing Alsek River drainage.

Study area terrain ranges in elevation from approximately 600 m above sea level (asl) to over 2533 m asl. Treeline occurs between 1067-1372 m asl. Permafrost is present yet discontinuous (Oswald and Senyk 1977).

The study area lies within the Central Yukon Section of Boreal Forest Region interspersed with Tundra (Rowe 1972). The subalpine zone from treeline upward to 1524 m asl is largely comprised of shrub birch (Betula sp.) and willow (Salix spp.). White spruce (Picea glauca) may comprise the forest cover on lower slopes, terraces and plateaus. Black spruce (Picea mariana) occurs less commonly, on the moister sites. Regions throughout the study area have a history of wild fires, resulting in a mosaic of habitats, including willow communities and pure stands of lodgepole pine (Pinus contorta) in various seral stages. Aspen (Populus tremuloides) occurs on disturbed or burned

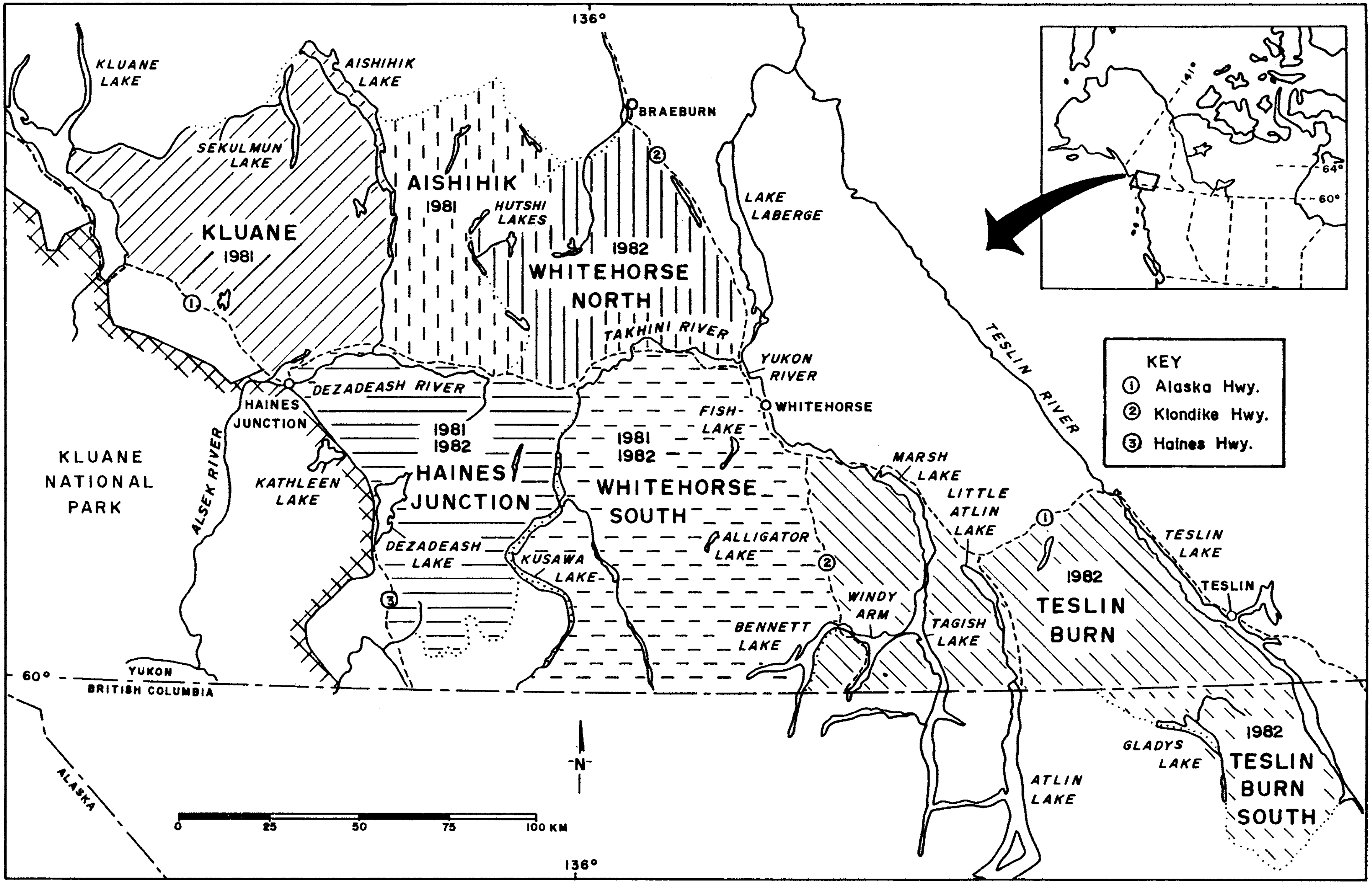

Figure 1. Southern Yukon River Basin Study Area Delineating Seven Survey Areas and Years of Study

sites and on south-facing dry slopes. Subalpine fir (*Abies lasiocarpa*) is encountered near treeline.

Survey Areas

Haines Junction and Whitehorse South

The Haines Junction and Whitehorse South survey areas extend from the Alaska Highway south to the British Columbia border and from the Haines Road (Highway 3) in the west, eastward to the Carcross Road, Highway 2 (Figure 1). Kusawa Lake serves as a natural boundary separating the two areas.

Together the two survey areas comprise 7338 km^2 of habitable moose range, defined as all area other than precipitous slopes, lakes larger than 0.8 km^2, and areas above the 1524 m elevation contour.

Both survey areas are within the Coast Mountains Ecoregion (Oswald and Senyk 1977), and are characterized by precipitous mountains with several peaks extending above 2400 m asl. There is little area below 900 m other than the larger lakes and associated drainage systems. Areas between 900-1500 m feature smooth rolling topography dissected by U-shaped valleys. Treeline is relatively low, occuring at 1050-1200 m asl. More than 50% of the habitable moose range in each survey area lies above treeline; thus, these two survey areas are uniquely characterized by a large proportion of subalpine habitat.

Kluane and Aishihik

Both of these survey areas are situated north of the Alaska

Highway and east of Kluane Lake (Figure 1). Aishihik Lake and River serve as natural boundaries between the two areas. The two survey areas total approximately 7190 km^2 of habitable moose range.

The Kluane area lies within the Ruby Range Ecoregion and the Aishihik area straddles the Ruby Range and Dawson Range Ecoregions (Oswald and Senyk 1977).

Within both survey areas treeline occurs at approximately 1200 m asl but the amount of area above treeline differs between the survey areas with 25% and 11% of the Kluane and Aishihik survey area respectively above treeline. Most of the terrain in Aishihik is rolling, undulating hills, while the Kluane area contains more mountainous areas with several peaks extending above 1950 m asl.

Whitehorse North

The Whitehorse North survey area extends from the Alaska Highway north to Braeburn, and from Hutshi Lakes east to the Klondike Highway (Figure 1). This area encompasses approximately 3182 km^2 of habitable moose range.

Most of the survey area is within the Dawson Range Ecoregion; the southeastern corner is in the Lake Laberge Ecoregion (Oswald and Senyk 1977). Approximately 15% of the habitable moose range is above treeline which lies at 1200 m asl.

Teslin Burn

The Teslin Burn extends from the Carcross Road east to

Teslin Lake and from the Alaska Highway south to the British Columbia border, encompassing approximately 4820 km^2 of habitable moose range (Figure 1). In comparison to the four survey areas to the west (Haines Junction, Whitehorse South, Kluane and Aishihik), the Teslin Burn area is generally lower in elevation, while treeline is comparably higher (1200-1350 m asl). Most of the moose range lies between 600 to 1500 m asl, consisting of rolling hills and plateaus rather than steep valleys. Approximately 11% of the habitable moose range lies above treeline.

This survey area lies within the Lake Laberge Ecoregion (Oswald and Senyk 1977). Approximately 40% of the area was severely burned during a wild fire in 1958. Consequently, extensive areas of willow growth and regenerating lodgepole pine forest of various seral stages occur throughout the survey area.

<u>Teslin Burn South</u>

This area is physically an extension of the Teslin Burn into northern British Columbia. Drained by the headwaters of the Yukon River, this area comprises approximately 1689 km^2 of habitable moose range (Figure 1).

Much of the terrain consists of rolling hills, although several mountain peaks extend beyond 1829 m asl. Treeline begins at 1200 m asl and 13% of the moose range is above this elevation. An extensive wild fire in 1958 and more recent fires have burned approximately 35% of the survey area. Vegetative regrowth by willow and lodgepole pine is similar to regrowth in Teslin Burn.

Weather

The weather within the study area is characterized by cool, short summers and long, cold winters, with Pacific coastal weather systems moderating the extremes in temperatures throughout the year. In Whitehorse, the mean annual temperature is -10 °C, and average temperatures in January and July are -20 and 14 °C respectively (Oswald and Senyk 1977). Annual precipitation at Whitehorse is less than 250 mm while other sections in the study area generally receive more precipitation. Whitehorse lies in the rainshadow of the coastal mountains.

During October, November and December, the Whitehorse 20-year average temperatures are -3.0, -14.2 and -20.5 °C, respectively (Atmospheric Environment Services). In 1981, the November mean monthly temperature was above normal, by 5.5 °C. In 1982, only the December mean monthly temperature deviated noticeably from the normal by 4 °C. The normal prevailing winds are from the south and south-southeast with an average velocity of 15.5 kph.

Average month-end snow depths in Whitehorse are 3, 16 and 25 cm for October, November and December, respectively. Deviations from the norm occurred during both years. In 1981, November and December month-end snow depths were below average, by 6 and 12 cm respectively. In 1982, October and November had slightly more (5 and 2 cm respectively) snow accumulation than average.

Typically, from February to March the normal (1951-1980) Whitehorse mean monthly temperatures increase from -13.2 to -8.2 °C. Normal month-end snow depths are 33 and 22 cm during

February and March respectively. In late winter 1982, February and March mean monthly temperatures were below normal, by 5 and 1 °C, respectively. March month-end snow depth was deeper than normal by 16 cm.

METHODS

Population Estimates, Distribution and Composition

Aerial surveys were conducted during early winter (late October to mid-December) and late winter (mid-March). Early winter surveys were flown in the Haines Junction and Whitehorse South areas both in 1981 and 1982. The Kluane and Aishihik areas were surveyed only in 1981 and the Whitehorse North, Teslin Burn and Teslin Burn South areas were surveyed only in 1982. One late winter survey was conducted in the Whitehorse South area in 1982 (Figure 1).

Early Winter Surveys

Early winter surveys were flown during the post-rut period when moose tend to aggregate in open habitats. The clumped distribution of moose, the presence of snow on the ground and the lack of foliage enhance visibility of moose at this time of year (Peek et al 1974; Larsen 1982). The late winter survey was flown during the period of maximum snow accumulation and thus would delineate critical winter moose habitat.

The early winter aerial survey technique employed was a stratified block sampling technique designed for estimating moose abundance in Alaska (Gasaway et al 1981), with modifications for Yukon terrain and weather conditions (Larsen 1982). These modifications include the use of helicopters, small sample units and no sightability correction factor. Briefly the technique involves two phases: stratification and census. The stratification phase is a cursory survey of all sample units

(S.U.) within the habitable moose range. Its purpose is to stratify sample units 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. Each survey area was stratified and censused independently of the other areas.

Prior to conducting the aerial surveys, each survey area was divided into sample units which 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 considered uninhabitable for moose were not surveyed. Sample units were measured with a polar compensating planimeter and averaged 14 km^2 in size. The same sample units defined in 1981 for the Haines Junction and Whitehorse South areas were re-used in 1982.

Stratification

Sample units were stratified from two fixed-wing aircrafts (Cessna 185, Cessna 206 or a Maule) which were flown simultaneously over different portions of the survey area. Each aircraft contained one front seat observer/navigator, one pilot/observer and two back seat observers. Surveys were flown at 90-100 m above ground level (agl) at approximately 130 kph. Prior to the stratification surveys all front seat observers conducted a preliminary survey together to standardize their methods of search intensity and pattern of flight. The stratification of a survey area was completed before going on to another survey area.

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. On occasion, poor weather conditions interrupted the stratification, necessitating restratification of specific sample units. In 1981, the mean search intensity during stratification (excluding ferry time) was 0.29 min/km^2 (range 0.24-0.35 min/km^2), (Appendix 1). In 1982 the mean search intensity was 0.29 min/km^2 (range 0.21-0.36 min/km^2). Early winter surveys of Teslin Burn South and the late winter survey of Whitehorse South involved only the stratification phase with no subsequent census.

Four strata based on observed moose density and moose sign were defined for most of the survey areas (Table 1). The criteria for the different density strata was independent amongst survey areas except for the "extremely low" stratum which was consistent between areas. The extremely low strata represented no observed moose or moose sign. This stratum was not used in the Haines Junction and Kluane areas in 1981. The same strata criteria was used during both years of surveys in the Haines Junction and Whitehorse South areas and also during the late winter survey of Whitehorse South. However, the amount of area or number of sample units in each stratum differed between years and seasons (Table 2).

Census

Census flights were flown immediately after the completion of stratification. Crew arrangement was similar to that of the stratification flights. Usually two helicopters (Bell 206 or

Table 1. Density criteria (moose/km^2) for strata by survey area, early winter 1981 and 1982.

SURVEY AREA	DENSITY STRATUM			
	High	Medium	Low	Ext. Low
1981				
Haines Jct.	>0.58	0.58 - 0.31	<0.31 or tracks	N/A
Kluane	>0.66	0.66 - 0.17	<0.17 or tracks	N/A
Aishihik	>0.37	0.37 - 0.23	<0.17 or tracks	no sign
Whse. South	>0.58	0.58 - 0.31	<0.31 or tracks	no sign
1982				
Haines Jct.	>0.58	0.58 - 0.31	<0.31 or tracks	no sign
Whse. South	>0.58	0.58 - 0.31	<0.31 or tracks	no sign
Teslin Burn	>0.37	0.37 - 0.27	<0.27 or tracks	no sign
Whse. North	>0.14	0.14 - 0.08	<0.08 or tracks	no sign
Teslin Bn. S.	>0.37	0.37 - 0.27	<0.27 or tracks	no sign

N/A: not applicable
no sign: no moose and no tracks

Table 2. Area of habitable moose range and census sampling effort by strata for early winter 1981 survey areas, 1981 and 1982.

SURVEY AREA	AREA OF STRATUM km^2 (% of stratum area censused)				
	High	Medium	Low	Ext. Low	Total
1981					
Haines Jct.	264 (100)	450 (34)	2380 (7)	N/A	3094 (19)
Kluane	44 (100)	181 (100)	3446 (10)	N/A	3671 (16)
Aishihik	142 (100)	214 (100)	895 (20)	2268 (10)	3519 (22)
Whse South	129 (100)	320 (51)	1688 (17)	2091 (10)	4230 (19)
1982					
Haines Jct.	120 (100)	236 (79)	1726 (13)	1026 (4)	3108*(18)
Whse. South	192 (86)	311 (38)	2924 (12)	803 (8)	4230 (17)
Teslin Burn	122 (100)	304 (47)	2281 (8)	2113 (7)	4820 (13)
Whse. North	131 (100)	371 (32)	2191 (24)	489 (15)	3182 (26)

N/A: not applicable

* inclusion of one sample unit omitted in 1981.

Hughes 500) were flown concurrently in different sections of the survey area. However, due to a shortage of both time and extended periods of good weather during the Whitehorse South census in 1981, four helicopters (Bell 206 and Hughes 500) were employed simultaneously.

During census , flight patterns varied with the terrain to ensure thorough and complete coverage of the sample unit. Over flat terrain, short parallel transects were flown approximately 0.4 km apart. Flight patterns in mountainous terrain often followed contour lines or were circular. Surveys were flown between 30-150 m agl at 50-130 kph, depending on the terrain features and vegetative cover. The intent of the census was to achieve total counts of moose in each sample unit.

Sampling effort varied among strata (Table 2) and was based on achieving an acceptable overall level of sampling variance (Siniff and Skoog 1964). For example, 100% of the "high" stratum area of each survey area was censused (except in Whitehorse South in 1982), yielding a sampling variance of zero. All of the other density strata were censused until an acceptable level of variance was obtained. Between 13 and 26% of the total habitable moose range of each survey area was censused (Table 2).

In 1981 the mean search intensity was 1.35 min/km^2 (range 1.26 - 1.43 min/km^2) (Appendix 1). The mean search intensity in 1982 was 1.97 min/km^2 (range 1.30-2.94 min/km^2).

Moose observations within each censused sample unit were recorded by a unique aggregation number and the location plotted onto the 1:50,000 scale N.T.S. survey maps. Antlerless moose with a white vulva patch were sexed as cows (yearlings and adults) while bulls were determined by the presence of antlers or antler pedicels. Male moose were further classified into yearlings (18 months old) and adults ($\geq$ 30 months old) based on antler morphology (Dubois *et al* 1981). Calves were identified by body size and association with a cow. Yearling cows (18 months old) 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 estimate was then calculated by subtracting the estimated number of yearling cows from the total number of cows.

The moose population estimate and age and sex composition were derived by extrapolation from censused sample units to uncensused sample units within each density stratum (Gasaway *et al* 1981). The population estimate and associated variance for each stratum were then added together to obtain an overall population estimate (with variance) and composition.

Late Winter Surveys

The late winter distribution of moose relative to early winter distribution in the Whitehorse South area was determined from a stratification survey, flown during 11-18 March 1982. The stratification flights were flown using similar methods employed in the early winter 1981 survey and using the same moose density criteria for each stratum. A population estimate could not be determined because census surveys were not conducted; however, relative distribution patterns between seasons could be assessed.

Habitat

An assessment of moose habitat utilization was of secondary importance to obtaining a moose population estimate and composition. For each observed moose aggregation on census flights, the corresponding habitat features, (prominent vegetation cover, elevation and aspect), within 200 m were recorded. Vegetation cover was visually assessed and recorded according to broad predefined vegetation classes. Elevation and aspect were measured from the 1:50,000 scale N.T.S. survey maps. Habitat utilized by moose during the late winter survey in Whitehorse South was similarly recorded during the stratification flights.

Vegetation classes defined prior to the aerial surveys were: herbaceous, shrub, deciduous, coniferous, conifer-shrub, coniferous-deciduous-shrub and burn. "Herbaceous" represented areas devoid of trees and shrubs and vegetated by forbs and graminoids. "Shrub" represented essentially treeless areas where willow and birch predominated above the snow. The shrub class applied both to the subalpine zone and areas below treeline. The "deciduous" class represented stands of aspen, birch (Betula papyrifera) or balsam poplar (Populus balsamifera), while the "coniferous" class represented stands of spruce, pine or fir. "Conifer-shrub" and "coniferous-deciduous-shrub" were perhaps the broadest classes, representing a mixed composition of trees and shrubs. Burn applied to areas obviously burned by former wild fires.

Elevation was defined by six classes of 152 metre increments from 640-1524 m asl and identified from aircraft altimeters and recorded on survey maps. Aspect was categorized into five classes: northwest-north (293-22°), northeast-east (23-112°), southeast-south (113-202°), southwest-west (203-292°), and no aspect or flat terrain. Aspect was determined from survey maps following the census flights.

Two methods were employed to assess moose habitat utilization. The first method determined the percent of total moose estimated within each of the habitat features. This method yielded a general overview of how the moose were distributed. The second method assessed the utilization of a habitat feature (in terms of relative moose abundance) to its availability. The latter method employed Marcum and Loftsgaarden's (1980) nonmapping technique for determining habitat availability - utilization. The technique was applied to all areas for aspect and elevation but only to Haines Junction and Whitehorse South for vegetation.

The relative availability of habitat features within the survey areas was estimated from the associated features of 150 random points defined by military grid reference locations drawn on acetate. For Haines Junction and Whitehorse South the random point locations were overlayed onto vegetation classification maps from the East Kluane Land Use (Oswald _et al_ 1981) and the Vegetation Southern Lakes Project (Boyd _et al_ 1983). For all survey areas, the point locations were overlayed onto 1:50,000 scale N.T.S. maps to determine elevation and aspect.

A chi-square goodness-of-fit test at $P<.05$ was used to determine any significant difference occurring between the observed distribution of moose within a habitat feature and the expected distribution, as determined by the distribution of the random points. Two criteria were recommended when using the availability-utilization test: (1) there should be at least one expected observation in each class and, (2) no more than 20% of all classes should contain less than five expected observations (Neu et al 1974). In following these criteria the "herbaceous, "deciduous" and "burn" vegetation classes were deleted from the analysis.

If the calculated chi-square value was significant, (implying that moose were non-randomly distributed), then the null hypothesis (that the moose followed an expected distribution pattern among the classes of a given habitat parameter) was rejected. A Bonferoni Z statistic was then used to calculate simultaneous confidence intervals to determine whether the moose occurred more than, less than, or in equal proportion to the habitat class's availability. We choose not to use the terms "preference" and "avoidance" relative to the moose's use of a habitat feature because the conclusions about how the moose used the habitat are dependent on the choice of features deemed available to the moose, which is an arbitrary decision by the investigator (Johnson 1980).

RESULTS

Population Estimate

Estimated moose abundance by strata and survey areas are listed in Appendix 2. Total moose population estimates by survey area ranged from 377 to 1946 moose (Figure 2). The Teslin Burn population estimate (1946 ± 501 moose) was more than twice the size of any other population estimate. The smallest population estimate was in Aishihik (377 ± 78 moose). Moose population density was also greatest in Teslin Burn (0.40 moose/km^2) and least in Aishihik (0.11 moose/km^2).

A precise estimate of the moose population from the six censused areas was difficult to determine because of the overlap in survey areas (Haines Junction and Whitehorse South) between years. However, a reasonable population estimate was calculated employing the four 1982 estimates plus the 1981 estimates for Kluane and Aishihik. Within the 22,530 km^2 area, 4747 moose were estimated, or 0.21 moose/km^2.

Since the Teslin Burn South survey area was only stratified, a population estimate was extrapolated using two different techniques which yielded two greatly differing estimates (Table 3). Depending on the extrapolation, the Teslin Burn South moose population estimate ranged from 369 to 1025 moose or 0.22-0.67 moose/km^2 of habitable moose range. The higher density estimate exceeds density estimates of all other survey areas.

No change in the size of the Whitehorse South estimated moose population (815 moose) occurred between early winter 1981

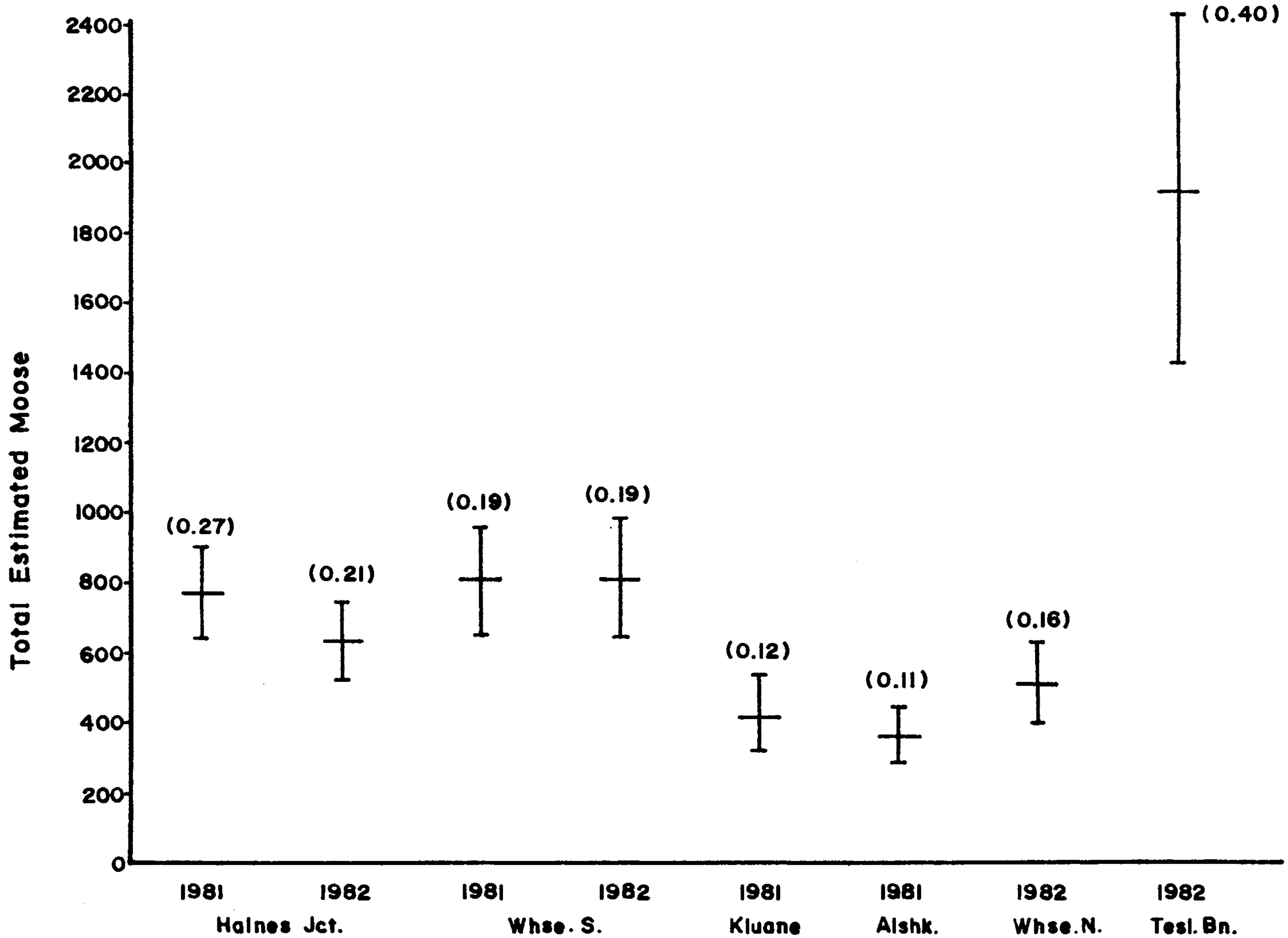

Figure 2. Estimated Moose Population Size With 90% Confidence Interval and Density for Early Winter Survey Areas, 1981 and 1982.

Table 3. Observed and estimated moose abundance in the Teslin Burn South survey area, early winter 1982.

	STRATUM				
	High	Medium	Low	Ext. Low	Total
Total area (km^2)	102	403	1017	167	1689
Stratified moose	53	113	35	0	201
Estimated moose					
i)	239	314	436	35	1024
ii)	N/A	N/A	N/A	N/A	369

i) estimates extrapolated from density strata values of moose/km2 in Teslin Burn (ie. density of high strata [Teslin Burn] X area of high strata [Teslin Burn South]). Strata density values were calculated from Table 2 and Appendix 2.

ii) estimated using correction factor (0.54) derived from the mean difference in percentage of moose observed during stratification versus census, from the four moose surveys conducted in early winter 1982.

N/A: not applicable

and early winter 1982 (Figure 2). In the Haines Junction area a 19% decrease ($t=17.3$, $P<0.1$) occurred between 1981 and 1982 in the size of the moose population.

Age and Sex Structure

Population composition estimates of bulls, cows and calves, with associated confidence intervals, are given in Appendix 3. The widest confidence intervals occurred around the calf cohort estimates ranging from the mean in each survey by 32 - 82%.

In all survey areas and during both years, adult cows represented over 45% of the estimated moose population (Figure 3). The greatest representation of cows was 68.8% of the estimated population in the Haines Junction area in 1982. Adult bulls represented the second largest proportion of the population within all survey areas. The proportion of bulls within the populations ranged from 19-30%. The yearling cohort (bulls and cows) represented 13% of moose populations estimated in 1981, with little variation between survey areas. In 1982, the proportion of the yearlings in the population was substantially lower. The mean abundance of yearlings in 1982 was 2.5% of a population (range 0.6-5.1%). During the two survey years, calves comprised from 4.1 to 15.9% of the estimated moose populations. The composition of the estimated moose population for the entire study area (data from all survey areas in 1982, and Kluane and Aishihik in 1981) was 26% adult bulls, 50% adult cows, 6% yearlings and 9% calves.

The 19% population size decline in the Haines Junction area

KEY - SURVEY AREAS

- HJ Haines Junction
- K Kluane
- A Aishihik
- WS Whitehorse South
- TB Teslin Burn
- WN Whitehorse North

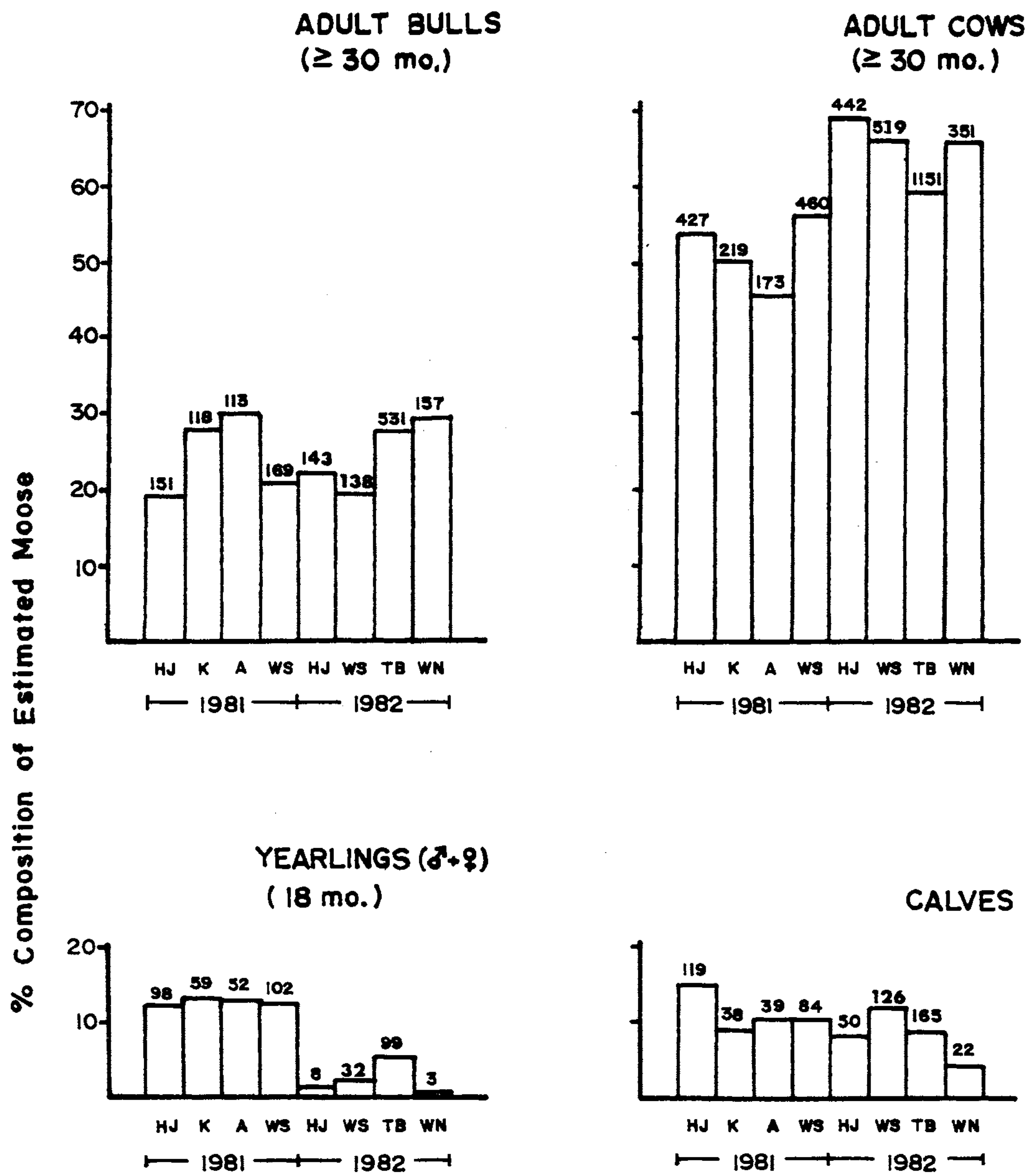

Figure 3. Estimated Age and Sex Composition of Moose Populations for Early Winter Survey Areas, 1981 and 1982.

was apparently caused by a reduction in the size of all age/sex classes except adult cows, and was most pronounced in the yearling and calf cohort. These latter two groups declined by 95 and 56% respectively, over the one year period (Figure 4). In Whitehorse South, the yearling cohort was reduced by 70% from early winter 1981 to early winter 1982, but this decline was offset by increases in the calf (50%) and adult cow (15%) cohorts, thus the population remained stable.

Ratios of the number of adult bulls, yearlings and calves to 100 adult cows, as indices of population stability, were calculated for each survey area (Table 4). Among the six areas the ratio of adult bulls/100 adult cows ranged from 27-66/100. The highest bull ratios were 54 and 65/100 cows, in Kluane and Aishihik respectively in 1981. The lowest bull ratio (27 adult bulls/100 adult cows) was in Whitehorse South, 1982. The number of yearlings per 100 adult cows was markedly different between the two years. In 1981, the yearling ratio ranged from 22-30 yearlings/100 adult cows. By contrast, in 1982 the ratio ranged from 1 to 9 yearlings/100 adult cows. Among the six survey areas and between the two years, the calf ratio ranged from 6-28 calves/100 adult cows. The higher ratios were in Haines Junction 1981, Aishihik 1981 and Whitehorse South 1982.

Moose Concentration Areas

During the early winter, moose were concentrated in sample units of the high and medium density (HMD) strata. In all the censused areas (except the Teslin Burn) at least 51% and as much as 80% of the estimated moose population occurred in less than

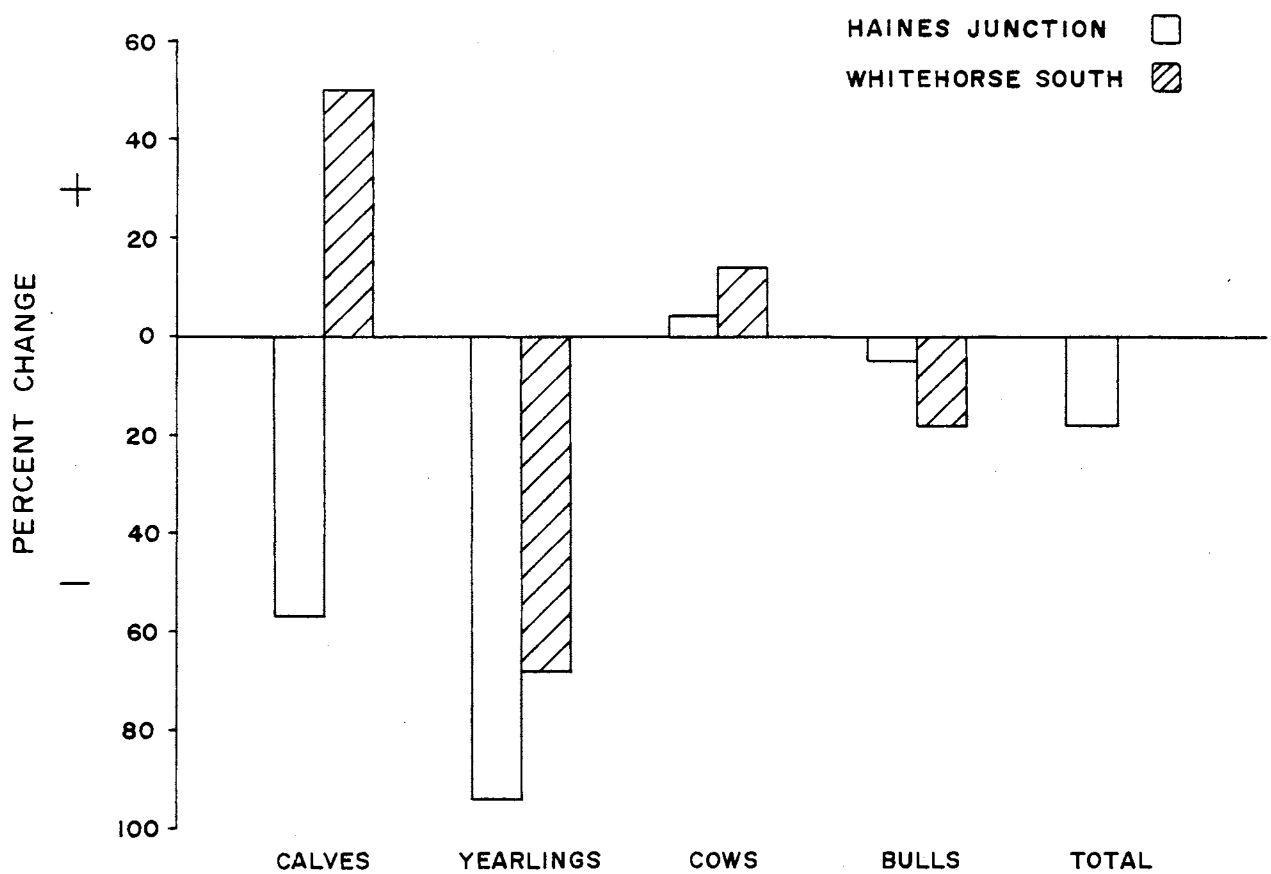

Figure 4. Percent Change in Moose Cohort Sizes From 1981 to 1982 in Haines Junction and Whitehorse South Survey Areas.

Table 4. Estimated number of adult bulls, yearlings and calves per 100 adult cows for early winter survey areas, 1981 and 1982.

	ESTIMATED NO. OF MOOSE/100 ADULT COWS (≥30 months)		
SURVEY AREA	Adult Bulls (≥30 mo. old)	Bull & Cow Yearlings (18 mo. old)	Calves
1981			
Haines Jct.	35	23	28
Kluane	54	27	17
Aishihik	65	30	23
Whse. S.	37	22	18
1982			
Haines Jct.	32	2	11
Whse. S.	27	6	24
Teslin Burn	46	9	14
Whse. N.	45	1	6

24% of the habitable moose range (Table 5). Only 27% of the moose population in the Teslin Burn occurred in the HMD strata. The proportion of moose in the HMD strata between early winter 1981 and early winter 1982 was similar in Whitehorse and 15% less in 1982 than in 1981 in Haines Junction.

Comparisons in the distribution and fidelity of moose to specific sample units throughout the winter were drawn using stratification data from early winter 1981 (EW81) and late winter 1982 (LW82) from the Whitehorse South area. Although the stratification technique used during each survey was similar (same crew, aircraft and search intensity) 39% fewer moose (430 vs 262) were noted during the late winter survey (Table 6). More sample units were placed into the low density stratum and fewer in the extremely low and HMD strata in late winter than early winter (X^2=36.87, df=3). Similarly, proportionally more moose were in the low stratum and fewer in HMD strata during late winter than early winter. Thus the distribution of moose was relatively more dispersed (fewer moose concentrated in HMD strata) in late winter than early winter.

Although the distribution of moose by density strata was different between EW81 and LW82, the mean density of moose in sample units considered as aggregation areas (>0.3 moose/km^2) was similar between seasons (Table 7). Similar numbers of sample units were considered aggregation areas during surveys in EW81, LW82 and EW82 (early winter survey 1982); however the degree of overlap (common sample units with >0.3 moose/km^2 on successive surveys) between surveys was not high. The highest overlap

Table 5. Distribution of estimated moose population by strata for early winter survey areas, 1981 and 1982.

SURVEY AREA	% OF ESTIMATED POPULATION BY STRATA (% of habitable moose range)			
	High	Medium	Low	Ex. Low
1981				
Haines Jct.	55(9)	25(15)	20(76)	N/A
Kluane	20(1)	45(5)	35(94)	N/A
Aishihik	35(4)	23(6)	39(24)	3(66)
Whse. South	27(3)	27(8)	43(40)	3(49)
1982				
Haines Jct.	30(4)	35(8)	35(55)	0(33)
Whse. South	31(5)	20(7)	49(69)	0(19)
Teslin Burn	15(3)	12(6)	50(47)	23(44)
Whse. North	22(4)	31(11)	43(69)	4(16)

N/A: not applicable

Table 6. Early and late winter moose distribution observed on stratification flights in the Whitehorse South area, 1981-1982.

		DENSITY STRATUM				
		High	Medium	Low	Ex. Low	Total
Total Observed Moose	Early Winter	163	127	140	0	430
	Late Winter	69	55	138	0	262
Sample Units in Strata	Early Winter	8	20	107	143	278
	Late Winter	4	15	156	103	278
% Moose By Strata	Early Winter	38%	29%	33%	0%	100
	Late Winter	26%	21%	53%	0%	100
% Sample Units By Strata	Early Winter	3%	7%	38%	52%	100
	Late Winter	1%	5%	56%	38%	100

Table 7. Number and distribution of sample units considered moose aggregation areas (>0.3 moose/km2) during early and late winter, Whitehorse South, 1981 and 1982.

	AGGREGATION AREAS*	
	Number of S.U. (% of total S.U.)	Mean Moose Density (moose/km^2)
Early Winter 1981 (EW81)	71 (25.5)	1.2
Late Winter 1982 (LW82)	74 (26.6)	1.3
Early Winter 1982 (EW82)	74 (26.6)	0.8

	Total	Number Common to Both	% Common to Both
Comparisons of S.U.			
EW81 and LW82	107	39	36.4
EW81 and EW82	108	21	19.4
LW82 and EW82	110	23	20.9
EW81 and LW82 and EW82	136	15	11.0

* as defined by moose observed during stratification

occurred between EW81 and LW82 (36.4%) while only 11.0% of the sample units were aggregation areas common to all three survey periods.

In summary, in late winter (Whitehorse South) more moose occurred in the low density strata than in the HMD strata. Although the mean density of moose in sample units with moose aggregations was similar between EW81 and LW82, the actual units used as aggregation areas were not exactly similar. Moose did not show a high degree of fidelity to specific sample units as aggregation areas either between seasons or successive years, in Whitehorse South.

Habitat

Availability of Habitat Features

On the basis of 150 random point locations in each of the Haines Junction and Whitehorse South areas, at least 45% of the available moose range was classed as shrub (Table 8). Mixed stands of shrub and coniferous and/or deciduous trees jointly represented 20% of the moose range in Haines Junction and 41% in Whitehorse South. The "coniferous" vegetation class comprised the balance of the moose range.

The 1250 m asl elevation corresponds to the elevation class which most closely approximates treeline. In all survey areas the area above 1250 m asl represents a minimum estimate of subalpine habitat available to moose. In the Haines Junction, Whitehorse South, Kluane and Aishihik areas, at least 29% of the habitable moose range was at high elevations >1250 m asl

Table 8. Estimated availability (%) of habitat features within each survey area, 1981 and 1982. Determined from 150 random point locations.

HABITAT FEATURE	% AVAILABILITY BY SURVEY AREA					
	Haines Jct.	Kluane	Aishihik	Whse. S.	Teslin Burn	Whse. N.
Vegetation						
Shrub	54	N/A	N/A	45	N/A	N/A
Coniferous	26	N/A	N/A	14	N/A	N/A
Conifer-shrub	18	N/A	N/A	37	N/A	N/A
Con.-dec.-shrub	2	N/A	N/A	4	N/A	N/A
Elevation (m asl)						
640 - 792	10	2	4	8	14	9
793 - 944	19	13	13	12	25	31
945 - 1097	17	28	26	17	25	28
1098 - 1249	13	24	28	21	21	22
1250 - 1402	24	21	18	20	11	6
1403 - 1524	17	12	11	22	4	4
Aspect						
E,NE (23-112°)	25	23	15	21	34	17
S,SE (113-202°)	16	15	15	17	10	16
W,SW (203-292°)	18	25	17	18	16	24
N,NW (293-22°)	28	15	20	24	24	21
Flat	13	22	33	20	16	22

N/A: not applicable

(Table 8). In the Haines Junction and Whitehorse South areas, 41 and 42% of the moose range was at and above 1250 m asl. In contrast, Teslin Burn and Whitehorse North had the least proportion of range at such high elevation, 15 and 10% respectively, and thus had less subalpine area. Most of the habitable moose range in these two survey areas (71 and 81% respectively), lay between 793-1249 m asl.

The percentage availability of specific aspect classes in the survey areas varied from 10-34% (Table 8). The availability of flat terrain varied from 13-33% among the survey areas.

Moose Distribution Among Habitat Features

Within five of the six survey areas, moose occurred predominantly (>50% of the estimated population) in the shrub vegetation class (Table 9). In the Haines Junction, Whitehorse South, Kluane and Aishihik areas, 70-98% of the estimated moose occurred in "shrub". Most of this "shrub" was in the subalpine area as these five survey areas had a relatively large area above 1250 m. In Whitehorse North, a lesser percentage of moose used the shrub class and a greater percentage used the other available classes. Areas of mixed shrub and coniferous trees were also used by relatively large portions of the various moose populations. The coniferous class was not used by many moose in any survey area except in Teslin Burn where 18% of the estimated population occurred.

In the two areas where utilization was compared to

Table 9. Distribution of total estimated moose among available habitat features for early winter survey areas, 1981 and 1982.

HABITAT FEATURE	Haines Jct '81	Haines Jct '82	Kluane '81	Aishihik '81	Whse.S. '81	Whse.S. '82	Teslin Bn '82	Whse.N '82
	% OF ESTIMATED TOTAL MOOSE							
Vegetation								
Shrub	74	70	98	87	70	70	32	56
Decidous							5	
Coniferous	1	5			3	5	18	7
Conifer-shrub	23	25	1	11	27	25	33	22
Con.-dec.-shrub	2	0	1	2	0	0	0	0
Other*							12	15
Elevation (m asl)								
640 - 792	3	5	0	0	0	1	2	0
793 - 944	7	5	0	0	2	2	10	11
945 - 1097	25	17	0	0	19	6	16	6
1098 - 1249	20	36	13	21	14	20	18	38
1250 - 1402	37	30	44	43	45	46	36	34
1403 - 1524	8	7	43	36	20	24	18	11
Aspect								
E,NE (23-112°)	22	30	26	26	40	28	28	18
S,SE (113-202°)	29	21	12	27	21	16	24	10
W,SW (203-292°)	19	27	19	25	5	19	22	20
N,NW (293-22°)	27	14	34	13	18	36	16	20
Flat	3	8	9	9	16	1	10	32

* undefined vegetation class or combination of classes applied only to Teslin Burn and Whitehorse North areas.

availability (Haines Junction and Whitehorse South), the distribution of moose among vegetation classes was non-random. A greater than expected proportion of moose occurred in "shrub" vegetation, within both areas (Table 10). In Haines Junction the proportion of moose that occurred in the class of mixed shrub and coniferous trees significantly exceeded the availability of this class. In Whitehorse South the proportion of moose in the class of mixed shrub and coniferous trees was less than the class's availability.

Within all survey areas, the greatest proportion of moose during the early winter surveys was found above 1098m asl (Table 9). Minimum estimates of the proportion of moose in the areas of approximate subalpine (>1250m asl) ranged from 37% of the population in Haines Junction to 87% in the Kluane area. Among all survey areas, the proportion of moose that occurred at 1250-1402 m asl (subalpine), significantly exceeded the availability of terrain at those elevations (Table 10). In other words, the proportion of moose in the subalpine was more than expected according to the availability of subalpine areas. The use of terrain at high elevations (near or above treeline) was most pronounced in the Kluane and Aishihik areas where no moose occurred below 1098 m asl or approximately 100 m below treeline. No more than 12% of any moose population occurred below 945 m asl (Table 9), which was significantly less than the proportion of lowlands available (Table 10).

The use of specific aspects by moose in any survey area varied from 1-40% of the total estimated moose population (Table

Table 10. Utilization of available habitat features by total estimated moose for early winter survey areas, 1981 and 1982.

	HABITAT UTILIZATION*							
HABITAT FEATURE	Haines Jct '81	'82	Kluane '81	Aishihik '81	Whse.S. '81	'82	Teslin Bn '82	Whse.N. '82
<u>Vegetation</u>								
Shrub	>	>	N/A	N/A	>	>	N/A	N/A
Coniferous	<	<	N/A	N/A	<	<	N/A	N/A
Conifer-shrub	>	>	N/A	N/A	<	<	N/A	N/A
Con.-dec.-shrub	=	NU	N/A	N/A	NU	NU	N/A	N/A
<u>Elevation</u> (m asl)								
640 - 792	<	=	NU	NU	NU	<	<	NU
793 - 944	<	<	NU	NU	<	<	<	<
945 - 1097	>	=	NU	NU	=	<	<	<
1098 - 1249	=	>	<	<	=	=	=	>
1250 - 1402	>	=	>	>	>	>	>	>
1403 - 1524	<	<	>	>	=	=	>	>
<u>Aspect</u>								
E,NE (23-112°)	=	=	=	>	>	=	=	+
S,SE (113-292°)	>	=	=	>	=	=	>	+
W,SW (203-292°)	=	>	=	>	<	=	>	+
N,NW (293-22°)	=	<	>	<	=	>	<	+
Flat	<	=	<	<	=	<	<	+

* calculated from Marcum and Loftsgaarden's (1980) non-mapping technique of habitat availability:utilization.

+ no significant difference (P =.05)

Key: > used more than expected according to class's availability
< used less then expected
= used in proportion to class's availability
NU not used
N/A not applicable

9). In all areas but Whitehorse North, the distribution of moose was significantly different from the distribution of available aspects (Table 10). Among all survey areas, the proportion of moose occupying flat terrain did not exceed the availability of flat terrain, but was either equal or less than its availability. Otherwise, the distribution of moose among aspect classes varied between survey areas, with little similarity in the pattern of

Year to Year Comparisons of Moose Habitat Use

In the Haines Junction and Whitehorse South survey areas, year to year comparisons of habitat use for early winter 1981 and early winter 1982 were possible. The distribution of moose among the available vegetation classes was similar between years for both survey areas. Differences in elevational distribution between the two years were subtle. In both survey areas, most of the moose (65-90%) were at high elevations (1098-1524 m asl) during both years, while slight year to year differences occurred at elevations slightly below or at treeline (945-1097 and 1098-1249 m asl). The distribution of moose by aspect was different between years and among survey areas with no consistent differences in pattern (Table 10).

Early and Late Winter Moose Habitat Use in the Whitehorse South Survey Area

The Whitehorse South area was surveyed in early winter (stratified and censused, November 1981) and again in late winter (stratified only, March 1982) to assess seasonal differences in moose habitat use patterns. During the November survey, moose habitat use was recorded during census and not during stratification, unlike the March survey. The comparison between seasons represents a gross assessment since the March estimates were determined from more cursory stratification results, involving a sightability bias. Thus one would expect that moose were underestimated during the late winter survey.

During both seasons, moose distribution among available habitat features was non-random, but the use of the various habitat features (vegetation and elevation) varied between seasons (Tables 11 and 12). The greatest proportion of moose were in "shrub" during both survey periods. Despite the sightability bias associated with observing moose in treed areas, during late winter relatively more moose used the "conifer-shrub" and "conifer-deciduous-shrub" areas than in early winter.

Seasonal differences in elevational distribution of moose were also apparent. A smaller proportion of moose was noted in subalpine areas in the late winter than in the early winter. The lower areas (1098-1249 m asl) were used in greater proportion than their availability during March, as were even lower elevations (793-944 m asl) used disproportionately more than their availability. In contrast, during early winter almost all moose (apart from 2%) occurred at elevations above 946 m asl.

Table 11. Early and late winter moose distribution among available habitat features in the Whitehorse South survey area, 1981-1982.

HABITAT FEATURE	% OF TOTAL ESTIMATED MOOSE Early Winter	% OF TOTAL OBSERVED MOOSE Late Winter
<u>Vegetation</u>		
Shrub	70	58
Coniferous	3	2
Conifer-shrub	27	34
Con.-dec.-shrub	0	6
<u>Elevation</u>(m asl)		
640 - 792	0	5
793 - 944	2	17
945 - 1097	19	26
1098 - 1249	14	32
1250 - 1402	45	17
1403 - 1524	20	3

Table 12. Early and late winter moose habitat use in the Whitehorse South survey area, 1981-1982.

	HABITAT UTILIZATION*	
HABITAT FEATURE	Early Winter	Late Winter
<u>Vegetation</u>		
Shrub	>	>
Coniferous	<	<
Conifer-shrub	<	=
Con.-dec.-shrub	NU	=
<u>Elevation</u>(m asl)		
640 - 792	NU	=
793 - 944	<	>
945 - 1097	=	=
1098 - 1249	=	>
1250 - 1402	>	=
1403 - 1554	=	<

* calculated from Marcum and Loftsgaarden's (1980) non-mapping habitat availability:utilization technique

Key:
- > used more than expected according to feature's availability
- < used less than expected
- = used in proportion to feature's availability
- NU not used

DISCUSSION

Population Estimate

The estimated moose population in the six Yukon survey areas was 4747 moose, representing 0.21 moose/km^2. Moose population densities among the six discrete survey areas were not similar, ranging from 0.11-0.40 moose/km^2. The range of densities is striking in view of the contiguous nature of the survey areas. The area of highest moose density is only 250 km from the area of lowest density. However, the topography, available habitat, area of burned regions, and hunting pressure vary considerably between survey areas.

Compared to estimates of other Yukon moose populations where the same survey technique was employed, the overall population estimate and some of the local population estimates are relatively high. In 1982, moose density in the Pelly and MacMillan Rivers area averaged 0.06 moose/km^2 (Johnston and McLeod 1983), and in the Liard River area in 1983, moose density averaged 0.11 moose/km^2 (Johnston and McEwen 1984). Near Fort Simpson, Northwest Territories, the density of the moose population in the lower Liard River area was estimated at 0.13 moose/km^2 (Donaldson and Fleck 1982).

Moose population densities in northern Alberta and Alaska are higher than the overall population density of the six contiguous areas, yet similar to some of the individual estimates. Moose densities in northern Alberta ranged from 0.18-0.24 moose/km^2 during a three year period (Hauge and Keith 1981).

The density of a moose population in interior Alaska ranged from 0.20-1.2 moose/km^2 during the years 1956-1978 (Gasaway et al 1983). Density estimates in the Haines Junction and Whitehorse South areas were similar to the lower end of the range of densities documented in Alberta and Alaska. The Teslin Burn population density estimate exceeded the full range of densities documented by Hauge and Keith (1981) and was much higher than any other density estimates from elsewhere in the Yukon (Hoefs 1976; Lortie 1976; Lortie et al 1978; Johnston and Mcleod 1983; Johnston and McEwen 1984).

The local and regional variations in moose density are attributable in part to the cyclic and eruptive nature of moose populations (Coady 1982). Moose can respond rapidly to changes in habitat conditions, particularly moose that are utilizing temporary seral burn communities (Coady 1982) such as the Teslin Burn. Even moose which inhabit rather stable permanent climax communities such as the subalpine areas of Whitehorse South and Haines Junction may fluctuate widely in numbers. Moose population size declined in the Haines Junction area by 19% in just one year.

In addition to structural changes in forage quality brought about by vegetation senescence or burning, other conditions can account for differences in local moose densities (see Coady 1982). The dynamic and synergistic effect of habitat alterations, annual differences in winter weather conditions and changing levels of natural predation and hunting pressure within local areas may cause large changes in moose population size, density and composition. Environmental conditions can act on moose density by nutritionally depressing or stimulating ovulation, pregnancy and natality rates. Varying levels of predation (including hunting) as well as environmental conditions may effect moose density by increasing mortality rates of specific age/sex cohorts.

Moose density varies considerably between and within ecoregions of the Yukon. The extreme differences found in moose densities from contiguous survey areas and elsewhere in the Yukon are due in part to localized limiting factors. However, the factors are not well understood. The variability in moose densities between areas suggests that extrapolation of density estimates from this study to other areas of the Yukon River basin is not justifiable.

Population Composition

Theoretically, in an unhunted moose population the sex ratio of adult animals approaches 100:100 (Coady 1982). The hunting strategy of licensed hunters in the Yukon has been to selectively harvest the males of a population, thus skewing the sex ratio in favour of cows (Gov't of Yukon files). The bull/cow ratios from each of the six Yukon survey areas, ranging from 27-65 bulls/100 adult cows, suggest high to moderate levels of hunting on bulls. The Whitehorse South and Haines Junction areas had the lowest bull/cow ratios, while the highest ratios were in the Aishihik and Kluane areas.

Hunting of moose has had a decided effect on moose populations within the study area. Larsen and Kale (1982) suggested closure of 17% and permit hunting in 47% of 47 Game Management Subzones (G.M.S.) within the Haines Junction, Kluane, Aishihik and Whitehorse South survey areas. Their conclusions were based on a computer simulation model using density and composition data from the 1981 early winter surveys. More than twice as many bulls were harvested from this composite area than the estimated allowable harvest.

In the Teslin Burn area a ratio of 91 bulls/100 cows was estimated in 1974 but two years later, the ratio had declined to 47 bulls/100 cows, the level at which it now exists (Lortie 1976). Lortie stated that hunter harvest levels were similar over the two years and he could not account for the rapid decline in bulls. However, the aerial survey technique Lortie used may have underestimated the cow cohort. In the Nisutlin River delta area, the estimated bull/cow ratio in the mid 1970's approached 100 bulls/100 cows (Hoefs 1976). Recently, the only known area within the Yukon where the bull cow ratio approximates 100:100 is in the Liard River basin, and then it is only in the more inaccessible mountainous areas (Johnston and McEwen 1984).

The proportions of calves within the populations of the six survey areas were low, compared to populations in Alaska, northern Alberta and the Northwest Territories. In Alaska, from 1956-1978, early winter calf/cow ratios varied from 15-61 calves/100 cows, averaging 40 calves/100 cows (Gasaway et al 1983). Similarly high ratios from early fall surveys were reported from northern Alberta which ranged from 25-76 calves/100 cows over a two year period (Hauge and Keith 1981). Recent moose surveys in the Yukon, including this study, all indicate calf/cow ratios generally falling in the range of 10-30 calves/100 adult cows (Johnston and McLeod 1983; Johnston and McEwen 1984). Lortie (1976) found calf/cow ratios of 18 calves/100 cows in the Teslin Burn during 1974 and 1976. Surveys from an unhunted population in Kluane National Park have documented calf/cow ratios of 15-25 calves/100 cows (Kluane National Park unpublished files).

The low numbers of calves occurring in many areas of the Yukon suggests a moose population in a stable or declining phase of population growth. Coady (1982) suggested that moose populations in the last 10 years in interior and southern Alaska and eastward are at low or still declining levels.

Habitat

Concentration Areas

Within the survey areas, moose distribution during the early winter (post-rut) period was highly clumped into mixed age and sex concentrations in the subalpine. The subalpine concentration areas accounted for 50-80% of the moose populations in only 10-12% of the habitable moose ranges. The formation of aggregations during the post-rut period has been attributed to intrinsic behavioural influences associated with breeding and possibly the establishment and maintenance of social systems, as well as access to high quality forage (Peek *et al* 1974).

The similarities in habitat use by moose between early winter 1981 and early winter 1982 in both the Haines Junction and Whitehorse South areas suggest that specific habitat (subalpine) is used annually during the post-rut period. Moose aggregations did not occur in all the same sample units between years, but in Whitehorse South at least 19% of the early winter aggregation areas were used from one year to the next.

The use of similar habitat between years, combined with the overlap in specific aggregation areas used between years suggests traditional use of the subalpine shrub areas. Thompson and Welsh (1981) found that moose in northern Ontario during November and December traditionally occupy areas which are topographically discrete upland, mesic habitat with large amounts of browse. Other studies of moose from western North America suggest that individual moose can show a high degree of fidelity to specific winter range (Van Ballenberghe 1977).

Vegetation

Although willow is not the only source of moose forage it is the preferred and predominant forage of most moose populations (Bryant and Kuropat 1980). The winter use of willow species for forage by moose is well documented (Knowlton 1960; LeResche and Davis 1971; LeResche et al 1974; Phillips et al 1973; Hauge and Keith 1981; Wolff and Cowley 1981). High quality forage in early winter is particularly important to bulls who must replenish body reserves expended during the rut. Weight losses of 6-12% body weight have been reported for captive rutting bulls (Kellum 1941).

Willow can occur as the predominant forage in shrub communities of essentially two different growth stages: seral and climax growth stages. Seral stages of willow communites, often in association with aspen and pine, occur in riparian and previously burned areas. Subalpine shrub willow communities represent a climax growth stage. The browse productivity of the two willow communities is very different. Post-fire seral stages of willow have a high annual productivity whereas annual productivity is comparably much lower in a climax community.

Although the fall calf population in the Teslin Burn (calves/100 cows) was comparable to that in the other populations censused, the moose density was twice that of many of the other populations. It is conceivable that the high productivity of seral communities in the Burn have increased the potential moose carrying capacity of the area. Prime moose range is characterized by early seral stages of mixed forest succession, usually following fire (LeResche et al 1974; Cairns and Telfer 1980).

In contrast, the subalpine shrub zone in the Haines Junction, Kluane, Aishihik and Whitehorse South areas represents a climax vegetation community. In Mount McKinley National Park, a region of similar subalpine habitat, Wolff and Cowley (1981) speculated that the climax subalpine willow browse community could potentially limit the moose population by definition of the carrying capacity of the habitat. Within our survey areas and with existing conditions, hunting pressure (which is not a factor in McKinley Park) and natural predation do not allow the moose populations to reach carrying capacity. Thus the low productivity of the climax subalpine willow community is sufficient to maintain the present moose populations under currently existing conditions.

Elevation

The distribution of moose by elevation is partially related to the distribution of vegetation, particularly shrub willow communities. Other than shrub communities created by wildfires, seral willow and aspen growth is usually associated with lowland floodplains (riparian). Floodplains have been documented as important wintering areas for moose in the Yukon and Alaska. (Lortie and Jack 1975; Hoefs 1976; Lortie et al 1976; Foothills 1977, 1978b; Coady 1982). An equally important and elevation - dependant habitat, in areas of Alaska and the southern Yukon, is the climax subalpine shrub community (Wolff and Cowley 1981; Larsen 1982).

The Haines Junction, Whitehorse South, Kluane and Aishihik survey areas are unique moose ranges for the Yukon because so much of the range is above treeline, in the subalpine. Extensive lowland riparian habitat does not occur in these areas. Riparian habitat in these areas is generally at high elevation although some lowland riparian habitat does occur along the floodplains of major rivers. The study survey areas were identified as priority moose management areas because of the intensive hunting pressure that the local moose populations receive annually. Access roads, which are numerous in the survey areas, are traditionally used by hunters in search of moose. These roads are most common in the lowlands and often follow river courses. Although speculative, it is quite conceivable that moose have been hunted out of the lowland areas, hence the relative low occurrence of moose in these areas.

Within other areas of the Yukon, moose have been found in floodplain areas during early and mid-winter. During early December surveys in the central Yukon, most moose (59%) were found below 944 m asl in treed areas (Johnston and McLeod 1983). In the same area, Lortie and Jack (1975) found heavy mid-winter moose utilization of the aspen and willow areas of the floodplains of the MacMillan and Pelly Rivers. During moose surveys conducted in 1974-76 the lower reaches of the Nisutlin River were important moose wintering areas in late winter. Few moose occurred in the lowlands of the Nisutlin River during the early winter but were aggregated in adjacent areas above 1200 m asl (Lortie 1974, 1976; Hoefs 1976). The floodplains of the Liard and Rancheria Rivers, to the east of this study area, also support early winter moose aggregations (Johnston and McEwen 1984), as well as providing important mid and late winter habitat (Lortie et al 1978). In addition, floodplains serve as calving and summering areas, although the extent of this use in the Yukon has not been assessed.

Aspect

Although the use of aspect by moose showed a non-random distribution (except in the Whitehorse North survey area) no general pattern of aspect use was common among the survey areas. Proulx and Joyal (1981) and Proulx (1983) found no aspect preference by wintering moose. Ruttan (1974) reported that south-facing slopes were preferred by wintering moose in the northern Yukon and MacKenzie River valley. The use of differing aspect is related to the aspects' associations with vegetation, snow cover, radiant sunlight, temperature, prevailing winds and valley orientations.

Early and Late Winter Habitat Use

Moose were more dispersed during late winter than in early winter, the result of social influences and possibly the reduced availability of food due to snow accumulations (LeResche *et al* 1974). Differences in habitat use between early and late winter suggested a slight downward elevational movement into shrub-conifer areas. Numerous studies have noted elevational changes in moose distribution between early, mid and late winter (Phillips *et al* 1973; Peek *et al* 1974; Thompson and Welsh 1981). During this study, aerial surveys were too infrequent during late winter to ascertain if the noted changes in habitat use were associated with seasonal changes as movement from early winter range to mid and late winter range can be very gradual, sometimes lasting most of the winter (Stevens 1970; Van Ballenberghe 1977; Hauge and Keith 1981).

The timing and extent of seasonal moose movement is partially affected by snow depth and snow quality (Knowlton 1960; Telfer 1970; LeResche 1974; Phillips *et al* 1974; Van Ballenberghe 1977; ; Hauge and Keith 1981; Thompson and Welsh 1981). During winter 1977 in areas west of Kluane Lake, moose did not descend from subalpine areas of fall or early winter range as anticipated from their traditional patterns, presumably because of unusally mild winter temperatures and shallow snow depths (Foothills 1977).

Additionally, seasonal range migrations by moose are specific to populations and individuals within a population and need not involve all of the population. Phillips et al (1973) found that only 20% of a moose population in Minnesota was migratory between its summer and winter range; Mytton and Keith (1981) reported 5 of 9 cows were migratory; and Hauge and Keith (1981) found 76% of a moose population showed a seasonal shift in range. LeResche (1974) described three types of seasonal moose migration, one of which involves little elevational change and a short distance between seasonal ranges, which may apply to the moose in the Whitehorse South area. Surveys would have to be conducted frequently throughout the course of winter to determine the occurrence and extent of seasonal shifts in moose distribution.

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APPENDICES

Appendix 1. Time and search intensity of stratification and census of survey areas, early winter 1981 and 1982.

	STRATIFICATION		CENSUS	
	Total Time (hr)	Mean Search Intensity (min/km2)	Total Time (hr)	Mean Search Intensity (min/km2)
1981				
Haines Jct.	16.20	0.31	13.92	1.42
Kluane	14.80	0.24	13.98	1.43
Aishihik	20.40	0.35	16.23	1.26
Whse. South	18.00	0.26	17.28	1.29
Mean	17.35	0.29	15.35	1.35
1982				
Haines Junction	16.00	0.31	12.10	1.30
Whse. South*	25.20	0.36	15.80	1.32
Teslin Burn	17.38	0.22	30.72	2.94
Whse. North	17.69	0.33	32.06	2.33
Teslin Bn. South	5.90	0.21	N/A	N/A
Mean	16.43	0.29	22.67	1.97

* late winter stratification time was similar

N/A: not applicable

Appendix 2. Estimated moose populations by strata for early winter surv areas, 1981 and 1982.

SURVEY AREA	ESTIMATED MOOSE POPULATION (90% C.I.) Stratum				
1981	High	Medium	Low	Ex. Low	Total
Haines Jct.	440(0)	201(±79)	154(±101)	N/A	795(±123)
Kluane	87(0)	194(0)	153(±113)	N/A	434(±113)
Aishihik	131(0)	87(0)	149(±76)	10(±17)	377(±78)
Whse. S.	220(0)	222(±71)	353(±131)	20(±34)	815(±150)
1982					
Haines Jct.	192(0)	227(±44)	223(±107)	0(0)	642(±115)
Whse. S.	256(±30)	162(±45)	397(±158)	0(0)	815(±165)
Teslin Burn	286(0)	237(±48)	978(±415)	445(±309)	1946(±501)
Whse. N.	118(0)	166(±45)	229(±105)	20(±35)	533(±114)

N/A: not applicable

Appendix 3. Estimated number of moose by age/sex classes for early winter survey areas, 1981 and 1982.

	ESTIMATED MOOSE (90% C.I.)					
SURVEY AREA	Bulls (≥18 mo)	C.O.V.*	Cows (≥18 mo)	C.O.V.	Calves	C.O.V.
1981						
Haines Jct.	199±37	19%	477±67	14%	119±44	37%
Kluane	148±46	31%	251±71	28%	38±31	82%
Aishihik	138±43	31%	199±50	25%	39±17	44%
Whse. S.	218±53	24%	512±97	19%	84±26	31%
1982						
Haines Jct.	147±50	34%	446±83	19%	50±22	44%
Whse. S.	153±33	22%	535±108	20%	126±52	41%
Teslin Burn	577±214	37%	1204±336	28%	165±68	41%
Whse. N.	158±40	25%	353±94	27%	22±14	64%

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