SUMMARY OF 1992 MOOSE SURVEYS IN THE AISHIHIK, ONION CREEK, BIG SALMON, MAYO AND DAWSON AREAS

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ABSTRACT

Moose surveys were conducted over portions of the 1981 Aishihik and Kluane survey areas. The Onion Creek and Talbot Creek areas were surveyed for the first time during November 1992. Summaries of moose population and harvest information for these areas are presented in this report.

The estimated 1992 moose population in the Aishihik south area was 126±26% animals for a density of 64 moose/1000 km^2. This is a 42% decline since 1990 (statistically significant: $P<0.002$) and a 63% decline since 1981. The finite rate of change between 1981 and 1992 was -8.5%. The 1992 recruitment rate (yearlings/yearlings+adults) was 0.08. The calf and yearling:100 cow ratios were 11 and 15 respectively. The mature bull:100 cow ratio was 61. Moose distribution was similar to that observed in past years although a number of post rutting aggregation areas observed in previous years were unoccupied and others had significantly fewer moose. The estimated total mean annual harvest has declined from 17.5 for the 1981-1985 period to 8.5 for the 1987-1991 period. The majority of the reported harvest (91%) has been relatively evenly split between First Nations and non-First Nations residents since 1988 when harvest data for First Nations individuals first became available. Non-residents were responsible for 9% of the annual harvest.

There are an estimated 416±18% moose in the Onion Creek survey area for an average density of 122 moose/1000 km^2. However, moose density in the northwestern portion of the Onion Creek area (GMS 5-14) was significantly ($P<0.05$) higher (259 moose/1000 km^2) than elsewhere in the area (89 moose/1000 km^2). Population composition did not differ significantly throughout the area. Mature cows, mature bulls, calves and yearlings comprised 55%, 27%, 11% and 7%, respectively of the total population estimate. The recruitment rate was 0.08. Based on this recruitment rate and average natural mortality rates of between 10% and 20%, we believe the Onion Creek moose population is likely declining.

The Kluane East and Talbot Creek areas were surveyed using only the stratification portion of the stratified random block technique. Moose were seen at a rate of 0.11 moose/minute of survey time in the Kluane East survey area, intermediate between the 0.08 and 0.16 moose seen per minute of stratification time in the Aishihik south and Onion Creek areas, respectively. Assuming that sightability was similar in the three areas, moose density in the Kluane East area was likely also intermediate between that in the Aishihik south and Onion Creek areas (64 and 122 moose/1000 km^2 respectively). The average reported annual moose harvest in the Kluane East area has exceeded the estimated sustainable annual harvest over the past decade. We speculate that the moose population in this area is declining. Moose in the Talbot Creek area were seen at a rate of 0.13 moose/minute of survey time, slightly lower than the 0.16 moose seen per minute of survey time in the Onion Creek survey area. Again assuming similar sightability in the 2 areas, moose density in the Talbot Creek area was likely between 100 and 122 moose/1000 km^2. We speculate that this population is stable or declining slowly.

Spring population composition surveys were conducted in the Aishihik-Onion Creek, Dawson West, Mayo and Big Salmon areas to assess the effectiveness of the Aishihik wolf population reduction program in increasing recruitment into the Aishihik and Onion Creek moose populations. The percent calves was similar in all four areas, ranging from 7% in the Dawson West area to 12% in the Mayo area. Calves made up 10% of the Aishihik-Onion Creek and Big Salmon area. Based on the number of moose seen per minute of survey time, moose abundance was similar in the Aishihik-Onion Creek and Big Salmon areas. Moose abundance in the Mayo and Dawson West areas was somewhat higher.

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INTRODUCTION

Surveys of the Aishihik area (GMS 5-42, and 5-45 to 5-47) in 1990 indicated a significant decline in moose abundance since the previous survey in 1981. In response to the observed decline in moose abundance, a recommendation was made to the Fish and Wildlife Management Advisory Board in 1991 to close moose hunting in the area. This recommendation was rejected. However, local people continued to express concerns that the decline in moose abundance was continuing and extended well beyond the Aishihik Lake area westward into the region north of Kluane Lake. Surveys in the area indicated that the Aishihik caribou herd and local sheep populations were also declining and that the ungulate biomass:wolf ratios was alarmingly low (Hayes, 1992).

As a result of these concerns about the long term welfare of ungulate and wolf populations in the area, a comprehensive recovery program was implemented during the 1992/93 winter. The intent is to double moose and caribou numbers in the area. A wolf control program is a part of the overall plan. Wolf numbers are to be reduced to approximately 25% of pre-reduction levels for the duration of the recovery program. They will be allowed to increase to naturally regulated levels after ungulate population targets have been reached.

Initially the reduction program was approved for two years. If recruitment into the ungulate populations has not increased sufficiently to cause the populations to grow within the first two years of wolf population reduction, the program will be reevaluated. If the 2 year evaluation determines that recruitment has increased and the ungulate populations are growing, the program may continue for an additional 3 years. Surveys to determine moose and caribou population abundance will be conducted after 5 years of wolf control and the effectiveness of the reduction program in achieving our population targets assessed. It is anticipated that 6 to 8 years of wolf reduction will be required in order to achieve our ungulate population objectives.

In order to assess the success of the recovery program a series of moose surveys were conducted during the winter of 1992/93. These surveys were intended to provide information on moose abundance, distribution and productivity within the recovery area and three comparison areas (Big Salmon River, Mayo and Dawson) prior to wolf control.

Aerial moose surveys were conducted over several portions of the recovery area in November, 1992 in order to assess magnitude and geographic extent of the decline. Complete inventories of moose abundance were conducted southeast of Aishihik Lake (GMS 5-45 to 5-47) and around Onion Creek, north of Burwash Landing (GMS 5-12 to 5-14, 5-19, 5-25 and 5-27). These surveys were done using the standard stratified random block technique routinely used in Yukon (Larsen, 1982). The Aishihik area had been previously surveyed in November 1981 and 1990.

Two additional areas within the recovery area were surveyed in November, 1992 using a modified survey technique. An area east of Kluane Lake (GMS 5-39 to 5-41) and in a second area north of Talbot Creek (GMS 5-29) were surveyed using only the stratification portion of the standard stratified random block technique. This technique does not provide an absolute estimate of moose abundance in the area but does provide in indication of relative abundance. They are used to extend our knowledge of moose abundance outside of the areas surveyed using our standard technique. The Kluane East area was previously surveyed in 1983 (Markel and Larsen, 1984).

Finally, aerial counts to determine the proportion of short yearlings (9 month old individuals) in the populations were conducted in the Aishihik-Onion Creek recovery area, and the Big Salmon River, Mayo and Dawson comparison areas (Figure 1) in late winter. The proportion of short yearlings in the population is used as an approximation of recruitment into the populations. The data will be used as pre reduction controls to assess the effectiveness of the Aishihik wolf population reduction program in increasing recruitment. Our intent is to monitor these areas again in the springs following the wolf population reductions to determine whether recruitment into the Aishihik and Onion Creek moose populations has increased as a result of the wolf reduction program (Hayes 1992). This report summarizes the results of all moose surveys conducted during the winter of 1992/93. A breakdown of the cost of the surveys is presented in Appendix 1.

STUDY AREA

A summary of study area information is presented in Table 1. Detailed descriptions of each area are presented in the following sections.

Early Winter Survey Areas

Aishihik, South

The Aishihik South survey area (GMS's 5-45 to 5-47) is a subsection of the Aishihik area surveyed in 1981 and 1990 (Figure 2). The area was reduced in size for the 1992 survey due to budget restraints. The southern portion of the Aishihik area was selected for several reasons. Past surveys have shown that the southern portion of the 1981 and 1990 Aishihik survey block contained the majority of the moose in the area. It also experiences the most intense hunting pressure. It should therefore provide the best indicator of overall population trend for the entire area.

The Aishihik South area encompasses 2,500 km^2 of which approximately 1,965 km^2 is habitable moose range. Habitable range is defined by the area below 1,525 m (5,000 ft) in elevation, excluding large water bodies and steep rocky slopes. The vegetation and physiography have been previously described by Oswald and Senyk (1977) and Rowe (1972).

Dall Sheep, woodland caribou, wolves, black and grizzly bears also occur in the survey area. There are approximately 270 Dall sheep (108/1,000 km^2 of total land area; internal files 1993) and individuals from the Aishihik Caribou Herd are present in low numbers (Farnell, pers. comm.). Prior to the wolf population reduction program there were estimated to be approximately 23 wolves (9 wolves/1,000 km^2) occupying the Aishihik South area (R. Hayes, internal files 1993). Both grizzly bear and black bear are common but densities have not been verified. A grizzly density of 10 bears/1,000 km^2 was assigned to this area by

Smith and Osmond-Jones (1991) through a habitat capability assessment.

The Aishihik South area has a high potential for recreational use, although consumptive use has declined recently (see Results and Discussion). We have no measure of non-consumptive use, but because of its location (i.e., near Whitehorse and next to the Alaska Highway) the potential is very high.

Onion Creek

The Onion Creek survey area, within GMS's 5-12 to 5-14, 5-19, 5-25 and 5-27, (Figure 2) encompasses 3,397 km^2 of habitable moose range within a total area of 3505 km^2. Portions of the Aishihik and Kluane caribou herds (approximately 590 and 50 animals respectively) winter in this area (Farnell, pers. comm.). Dall sheep are present in very low numbers (internal files). Wolves, black and grizzly bears also occur in this area. An estimated 34 wolves shared the area at the time of the survey (9.6 wolves/1,000 km^2; Hayes et al. 1993). Grizzly densities of 10 and 20 bears/1,000 km^2 were assigned to the northern and southern portions of this area respectively by Smith and Osmond-Jones (1991) through a habitat capability assessment.

Unlike the Aishihik South area, there is limited potential for recreational use of this area due to its inaccessibility. There are no summer roads into the area, access by river is limited to the Nisling on the northern border and lakes large enough to land on are uncommon.

Kluane east

The Kluane east survey area (within GMS's 5-39 to 5-41; Figure 2) encompasses 2,371 km^2 of which 1,876 km^2 is habitable moose range. Sheep, caribou, wolves, black and grizzly bears also occur in this area. A portion of the Aishihik caribou herd (about 590 animals) summer in this area. There are approximately 210 Dall sheep or 88.6/1,000 km^2 of total land area (internal files). Approximately 26 wolves used the Kluane east area at the time of the survey (14 wolves/1,000 km^2; Hayes et al. 1993). A grizzly density of 20 bears/1,000 km^2 was assigned to this area by Smith and Osmond-Jones (1991) through a habitat capability assessment.

Talbot Creek

The Talbot Creek survey area, within GMS 5-29, (Figure 2) encompasses 1,876 km^2 of habitable moose range within a total of 2005 km^2. Sheep, caribou, wolves, black and grizzly bears also occur in this area. A portion of the Aishihik caribou herd is present in this area throughout the year. Less than 50 Dall sheep occupy in the southeastern corner of the area (internal files). Wolf densities at the time of the survey were 5 wolves/1,000 km^2 (Hayes et al. 1991). A grizzly density of 20 bears/1,000 km^2 was assigned to this area by Smith and Osmond-Jones (1991) through a habitat capability assessment.

The Aishihik, Onion Creek, Kluane and Talbot Creek survey areas lie within the Upper Yukon - Stikine Basin climatic region described by Wahl et al. (1987). The region is generally arid. Total precipitation averages less than 275 mm per year. Kluane area has the lowest mean annual snowfall recorded at Yukon interior monitoring stations, receiving less than 150 mm (water equivalent) annually. It is also the windiest interior region of the territory with winds occasionally reaching destructive velocities. Summers are normally moderate with occasional hot spells. Winters are cold with intermittent mild periods. Winter snow accumulations The mean annual daily temperature is about -1.5° C.

Late Winter Composition Survey Areas

Aishihik -Onion Creek

The Aishihik - Onion Creek late winter survey area encompasses the entire 20,000 Km^2 of the Aishihik Recovery Program. The above sections provide a description of topography, vegetation and wildlife in the area.

Big Salmon

The Big Salmon block encompasses a total of 4,000 Km^2 within GMS 8-03 and 8-05 to 8-11. It lies within the Pelly Mountains and Lake Laberge ecoregions (Oswald and Senyk, 1977). The former ecoregion is comprised of the Pelly and Cassiar mountains. Terrain is of moderately high relief, generally over 1,500 m. The Lake Laberge ecoregion is made up of portions of the Lewes, Nisutlin and Teslin Plateaus. The topography is characterized by dissected plateaus and rolling hills. Elevations are generally between 600 and 1500 m.

White spruce forest is the dominant climax cover type at lower elevations. However, the fire history has been extensive and lodgepole pine stands in post burn sites cover much of the area. Wetter sites are occupied by black spruce or mixed black and white spruce stands. Balsam poplar are common on flood plains. Aspen and paper birch are present on warmer and cooler sites, respectively.

There are no weather observation stations within or immediately adjacent to the survey area. However, the area is located within the Pelly - Cassiar Mountains climatic as described by Wahl et al. (1987). This region lies along an active Pacific storm track. Annual precipitation is relatively high for the south central Yukon, ranging between 500 and 700 mm. The comparatively high elevation results in less severe winter temperatures than adjacent lower elevation areas. Summers, however, are relatively cool. The mean annual daily temperature is -2.7° C.

Woodland caribou are commonly observed in the area but population numbers are unknown. Dall Sheep do not occur in the area. Wolf and Grizzly bear densities are estimated at 10 wolves (YTG Wildlife Branch, unpublished data) and 17 bears (Smith and Osmond-Jones, 1991) per 1000 Km^2 respectively.

Mayo

The Mayo late winter survey area was made up of portions of the Mayo North and South blocks surveyed in 1988. Although all areas were not searched the late winter survey block encompassed approximately 6,000 Km^2. The area is included within the Pelly River ecoregion (Oswald and Senyk 1977). The topography is dominated by rolling hills and plateaus.

Vegetation at lower elevation is dominated by black spruce (Picea mariana) forest, which is replaced by white spruce (P.glauca) on drier sites. Lodgepole pine (Pinus contorta) frequently invades the burnt-over areas, but is often in competition with aspen (Populus tremuloides) and balsam poplar (P. balsamifera) on wetter sites. Paper birch (Betula papifera) occurs on cooler sites. Treeline occurs around 1350-1500 m, and is characterized by a limited subalpine zone with willow (Salix spp), shrub birch (Betula spp). and alpine fir (Abies lasiocarpa).

Weather data are available from two permanent stations within the survey area (Elsa at 504 m ASL, and Mayo at 814 m ASL; Environment Canada). Mean annual daily temperatures are similar (-4° C). Snowfall is substantially higher in Elsa (203 cm) than Mayo (131 cm), with maximum snow depths occurring in March in Mayo and April in Elsa.

Other ungulates and large predators occur in the area. Woodland caribou from the Ethel Lake Herd numbers are estimated at about 200 animals. Wolf densities were estimated at 10 wolves/1000 Km^2 in late winter 1988. Grizzly bear and black bear occur at unknown densities.

Dawson

The Dawson area encompasses GMS 3-04 and covers 2005 Km^2 of which about 1,870 Km^2 is habitable moose range. About 2% of the area has burned since 1966.

Historically, mining activity and harvest pressure have been light, presumably due to lack of access. However, a new mining road from the Top of the World Highway to Matson Creek may change this.

Oswald and Senyk (1977) describe the area as having smooth, rolling topography, with moderate to deep incised valleys. Most of the terrain lies between 1,000 m and 1,500 m elevation. Lakes are uncommon. Black and white spruce stands occur in valleys and on lower slopes. Mixed stands of white spruce, aspen, balsam popular, and paper birch are common along drainages. Shrub birch and willow are common in the understorey, extending beyond treeline (1,200 m).

Caribou, bears and wolves occur in the area. Part of the Forty Mile caribou herd use the area seasonally. Wolf densities have not been determined but 8 wolves/1,000 km^2 were recorded across the Yukon - Alaska border near Tok, Alaska (Gasaway et al. 1986b). Grizzly Bear densities are unknown in the survey area. Smith and Osmond-Jones (1991) estimates 12 grizzly bears/1,000 km^2 based on an evaluation of habitat capability, while in a nearby area in Alaska estimates of 16 grizzly bears/1,000 km^2 has been made using radio collars (boertje et al. 1987). Black bears are abundant in the study area but densities are unknown.

METHODS

Early Winter Surveys

As in past surveys, the stratified random block aerial survey technique developed by (Gasaway et al. 1986) was used to estimate moose abundance, composition, and distribution in the Aishihik South and Onion Creek survey areas. This technique was modified by substituting helicopters for fixed-wing aircraft for the census portion (Larsen 1982). Briefly, the technique involves three phases; 1) the stratification portion of the survey in which sample units (SU's) are classified into high, medium, and low strata based on relative moose abundance observed from fixed wing reconnaissance flights; 2) the census portion in which all moose within a randomly selected sample of SU's within each stratum are counted; and 3) a sightability correction factor (SCF) for moose not observed on the census survey was developed for each area censused in 1990 and 1992. SCF's were developed by re-surveying a portion of a SU at a higher search intensity. The difference between the number of moose observed on the census and the SCF surveys is used to correct for moose missed on the remaining SU's censused. An SCF was not calculated during the 1981 survey of the Aishihik area.

For between-year comparisons of population estimates in the Aishihik South area, moose population abundance and composition estimates were recalculated for the Aishihik South portion of the entire survey area using data from the 1981 and 1990 surveys. No correction for sightability is used for between year comparisons because no SCF is available for the 1981 population estimate.

Recording procedures for moose observations and age-sex determination have been previously described (Larsen 1982, Larsen et al. 1989b). Twinning rates were calculated as the number of cows with twins ÷ cows with calves in November. As such, twinning rates are a reflection of both birth rates and calf survival to 6 months of age. Harvest estimation procedures have also been previously described (Kale 1982, Quock and Jingfors, 1989).

Density categories, used to describe moose distribution (Figures 3 and 6; Table 6) are based on census rather than stratification data. Census data is more accurate than stratification data due to the lower variation in sightability associated with the census data relative to stratification data.

Changes in population size within an area between surveys were tested using two-tailed student's t-tests. Unless otherwise indicated, we use an alpha level of 0.20 to determine significance in populations suspected of having declined and an alpha of 0.05 for populations which may have increased. We accept a higher probability of committing a Type 1 error (i.e. concluding that a change in numbers had occurred when in fact it may have not) for declining populations so as to give the benefit of doubt to conservation of the moose population. We feel this is justified given the extremely low density of moose in the Aishihik South area. A nonparametric Chi-square test was used to test for significant differences in population composition between areas.

The finite rate of population change (net change after recruitment and mortality) was calculated between the 1992 and the previous population estimates (1981 and 1990 in Aishihik South area) and estimated using only the 1992 data. Finite rates involving more than one population estimate were calculated by $\lambda = e^r$, where e=constant 2.7183 and r=exponential rate of increase, following Gasaway et al. (1986). Rates involving only one population estimate were calculated by $\lambda = (1-M) \div (1-R)$ where M=the adult natural mortality rate and R=the proportion of recruits in the population, following Gasaway et al. (1990). Adult and yearling natural mortality rates were assumed to be either 10% or 20%. These values bracket the range of natural survival rates reported for moose in Alaska (Gasaway et al. 1990) and the Yukon (Larsen et al. 1989a). Recruitment rates were calculated as estimated number of yearlings ÷ estimated yearlings and adults.

Sustainable harvest rates were estimated by ([adult + yearling] x adult and yearling natural survival) - adults. Again, natural survival rates are assumed to be between 80% and 90%. Differences in age-sex proportions between surveys were tested using contingency table analysis. Changes in moose distribution was assessed by comparing the proportion of SU's containing the majority of the population between surveys, and the location of the SU's.

The Kluane east and Talbot Creek areas were surveyed using only the stratification portion of the stratified random block technique. Relative abundance of moose between survey areas was estimated by the number of moose seen/minute of survey time on fixed-wing stratification flights. It was necessary to use a common denominator (minutes flown) for between-area comparisons as search intensity varied slightly between survey areas.

Late Winter Surveys

Late winter moose population composition was assessed in four areas. The Aishihik-Onion Creek, Dawson West, Mayo and Big Salmon Creek areas (Figure 1) were surveyed in March, 1993 to assess the proportion of calves in the population and relative moose abundance. The Aishihik-Onion Creek area was monitored to assess changes in the proportion of calves in the population prior to and after the wolf population reduction. The remaining three areas are being monitored as controls for the Aishihik-Onion Creek experimental area.

Late winter composition counts were conducted using Piper Super-cub or equivalent aircraft flown at an altitude of 60-90 meters agl and an airspeed of approximately 130 km/h. No attempt was made to cover the entire area but habitats expected to contain concentrations of moose were thoroughly searched. Once sighted, each moose or group of moose was plotted on a 1:50,000 scale map and each individual classified as either a calf or an adult. No attempt was made to distinguish between yearlings and older age classes or between bulls and cows.

The proportion of calves was calculated as a percentage of the total population observed. A minimum sample of 100 moose was recorded in each area. Search times were recorded and moose seen per minute of survey time calculated. Moose seen per minute of survey time was used to assess relative moose abundance in each of the four areas surveyed.

Population Modelling

We developed a population simulation model to investigate the possible impact of the historic harvest rate on the dynamics of the Aishihik population. Annual population estimates were calculated using the formula:

$T_2 = T_1+(T_1*R_2)-((T_1*M_2)+H_2)$

where:

T_2 = The adult (> 12 months) population estimate for the year

T_1 = The adult (> 12 months) population estimate for the previous year

R_2 = The yearling recruitment rate for year T_2

M_2 = The natural mortality rate for year T_2

H_2 = The harvest for year T_2.

During the simulation runs, observed yearling recruitment rates were used for years when surveys were conducted. The average of the recruitment rates observed during the closest two surveys was used when the actual recruitment rate was not available. The reported harvest values were used for year when reliable harvest information is available for the Champagne - Aishihik First Nation through the Native Harvest Survey Program (1988, 1989, 1991). For other years the First Nations harvest was assumed to be equal to the non-First Nations resident harvest. This assumption is based on the fact that the reported First Nations and non-First Nations resident harvests were roughly equal within the survey area in those years when Champagne - Aishihik First Nation harvest information is available (YTG internal Files).

In the initial simulations, natural mortality rates were manipulated until the dynamic of the simulated population mimicked those the observed in the real population (Table 2). Once a model that accurately mimicked the observed population dynamics had been developed , we ran the model again setting the harvest to zero. The results of the two simulations were compared to assess the impact of the harvest on population dynamics.

An assessment of the sustainability of the historic harvest rate in certain areas was done by determining the recruitment rate necessary to sustain the population given the observed harvest. The required recruitment rate was then compared to the average recruitment rate observed during moose surveys throughout the territory. A derivation of the formula used in the above population simulation was used to calculate the required recruitment rate:

$R = [(T_2-T_1)+((T_1*M)+H)]/T_1$

where:

R = The required yearling recruitment rate

T_2 = The adult (> 12 months) population estimate for the year

T_1 = The adult (> 12 months) population estimate for the previous year

M = The yearling and adult natural mortality rate

H = The harvest rate.

RESULTS AND DISCUSSION

Search and Sampling Intensity during Early Winter Surveys

Search intensity during the stratification phase of the surveys was similar for all areas (0.34 to 0.48 min./km^2; Table 3). These values are within the range normally used for the stratification portion of surveys in the Yukon but are substantially higher than the 0.17 min./km^2 suggested by Gasaway et al. 1986.

The intent of using a higher search intensity during stratification is to reduce the chances of assigning sample units to the wrong stratum (density class). This should reduce the number of sample units that must be searched during the census phase of the survey to obtain a final population estimate with acceptable confidence intervals (90% C.I. ± 20%). This should, in turn, reduce the overall cost of the survey.

The benefits of a higher search intensity during the stratification are offset to some extent, however, by the increase in the length of time required to complete the stratification. The longer the time between the stratification and the census of sample units provides more opportunity for moose to move between sample units. This can result in sample units that are assigned to one density class during the stratification having more or less moose than expected when censused. In general, however, increased search intensity during the stratification phase of the survey should reduce the overall survey costs (McNay 1993).

Search intensity during the census phase of the Aishihik South and Onion Creek surveys were virtually identical at 1.81 and 1.82 min./km^2 respectively (Table 3). These values are within the range normally used for the census portion of moose surveys in the Yukon but are slightly less than the 2.0 min./km^2 recommended by Gasaway et al. 1986. We assume that our slight reduction in search intensity is compensated for by our substitution of helicopters with three observers for fixed wing aircraft with one observer recommended in the Gasaway technique. The validity of this assumption is supported by the fact that sightability correction factors (SCF's) for our helicopter surveys average 1.06 (range 1.00 to 1.13) while SCF's for surveys conducted in Alaska using Piper Super Cubs are generally somewhat higher, averaging 1.15 (McNay 1993).

Search intensity during the calculation of the sightability correction factor (SCF) was 3.72 and 4.12 min./km^2 in the Aishihik South and Onion Creek survey areas respectively (Table 3). This is roughly double that used for the initial census. The resulting SCF's were 1.07 and 1.11 for Aishihik South and Onion Creek respectively.

Mean sample unit size was somewhat smaller in the Aishihik South area (15.1 km^2) than in the Onion Creek area (23.1 km^2). A higher proportion of the Aishihik South area was censused (59% of sample units and habitable moose range) than in the Onion Creek area (50% of sample units and habitable moose range (Table 4).

Population Characteristics and Distribution during Early Winter Surveys

Aishihik South Area

The estimated total moose population in the Aishihik south area, incorporating an SCF of 1.068, was 126$\pm$25.9% (90% C.I.) for a density of 64 moose/1000 km^2 (Table 5). This is the second lowest moose density recorded in the Yukon to date (Appendix 2). It also indicates a continuation of the decline in moose abundance noted between the 1981 and 1990 surveys of the area (Appendix 3). A 36% decline (significant $P<0.001$) in the uncorrected (no SCF incorporated) mean population estimates was recorded between 1981 (322$\pm$8%) and 1990 (205$\pm$19%; Appendix 3). This represents a finite rate of population change between the 1981 and 1990 surveys of -4.9% per year. A further 42% decline (significant $P<0.002$) occurred in the uncorrected mean population estimates between the 1990 and 1992 surveys (205$\pm$19% to 118$\pm$16% moose respectively; finite rate of change of -24.1% per year). Overall moose in the Aishihik South area have declined by 63% between

1981 and 1992 for a finite rate of change of -8.6% per year.

The decline in moose abundance indicated by the above population estimates is corroborated by several other sources. The number of moose actually seen during the stratification and census portions of the survey declined consistently between the 1981, 1990 and 1992 surveys (Appendix 3). The number of moose seen during the stratification portion of the survey declined from 237 in 1981 to 98 in 1990 to 64 in 1992. The number of moose seen during the census portion of the surveys declined from 238 in 1981 to 140 in 1990 to 91 in 1992. This declining trend is in spite of the fact that the percentage of the total area censused increased from 26% in 1981 to 43% in 1990 to 59% in 1992. The number of moose seen per minute of search time declined from 0.34 in 1981 to 0.09 in 1990 to 0.04 in 1992. In addition to the above survey data, local residents have also indicated that they believe that moose numbers in the areas have declined over the last decade (personal communications).

Based on estimated abundance data (Table 5), estimated calf and yearling per 100 adult cow ratios were 11 and 15 respectively. We believe that a ratio of at least 30 calves per 100 cows during autumn is normally necessary to maintain stable moose populations, based on past surveys and population trends (internal files). The low calf:cow ratio noted in 1992 suggest a continuation for at least one year of the trend towards decreasing recruitment seen in the 1981 and 1990 surveys (Appendix 3). An adult bull:100 cow ratio of 61 was observed during the 1992 survey, similar to that recorded during the 1981 and 1990 surveys (60 and 43 respectively; Appendix 3). These values are all well above the ratio of 30 adult bulls/100 adult cows that we use as the lower acceptable limit for management purposes. Based on studies in Alaska, we feel that 30 bulls per 100 cows should ensure effective breeding. Bishop and Rausch (1974) reported pregnancy rates of about 90% in Alaskan moose populations with as few as 4-20 bulls per 100 cows. We therefore do not believe that the sex ratio is responsible for poor recruitment into the population.

The calculated 1992 recruitment rate for the Aishihik South area was 0.08. This is within the range of values associated with rapidly declining and "near stable" moose populations. Gasaway et al. (1990) documented recruitment rates of 0.03-0.16 (mean=0.09) in rapidly declining, 0.06-0.16 (0.12) in near stable, 0.09-0.17 (0.13) in slowly increasing, and 0.10-0.28 (0.22) in rapidly increasing moose populations in east-central Alaska.

Moose were unevenly distributed throughout the survey area during the 1992 survey. Approximately 48% of the estimated moose population was located in the medium stratum which comprised only 7% of the total area (Tables 4 and 6). Moose distribution in 1992 was similar to that observed in 1981 and 1990. The majority of relatively high density sample units ($\geq$ 0.26 moose/km^2) were located in subalpine zones around the south end of Long Lake and the Mt. Shaneinbaw area (Figure 3). The proportion of moose in high and moderate sample units was not different ($P>0.05$) between the surveys. In addition, approximately 67% of sample units identified as having a moderate to high moose density during the 1992 census were also identified as having a moderate to high density during at least one previous census (1981 or 1990) (Table 6). Although the relative distribution of moose was similar between surveys, there has been a decrease in the number of high and moderate density sample units and a strong trend towards declining moose density within other sample units (Table 6).

Numerous roads and trails provide relatively easy access into the Aishihik South area. This ease of access and the area's proximity to Whitehorse and Haines Junction have resulted in intense hunting effort. Non-First Nations residents hunted an average of 256 days per year in the Aishihik South area between 1981 and 1991. However, there has been a strong trend towards decreased hunting effort in the area over the past decade, declining from a high of 450 days in 1982 to a low of 93 days in 1991 (Figure 4).

The annual moose harvest in the Aishihik South area (GMS 5-45, 5-46, 5-47) has also shown, in general, a steady decline over the past decade (Figure 4). Excluding the harvest by First Nations people, the mean minimum annual harvest has declined from 9.9 moose between 1981 and 1985 to 3.6 between 1988 and 1992 (5 year averages). The harvest by First Nations members is excluded from this comparison because harvest data are not available for the Champagne Aishihik First Nation prior to 1988 or for 1990. Since 1988 the majority of the harvest (91%) has been relatively evenly split between First Nations and non-First Nations residents (Figure 4). Non-residents have harvested an average of less than one moose per year in the area since 1988. Nearly all of the moose harvested are bulls. Non-First Nations residents and non-residents are required by law to harvest bulls only. Quock and Jingfors (1988) reported that, Yukon wide, bulls comprise 80% of the harvest by First Nations members.

If we assume that the harvest by First Nations was roughly equal to the harvest by non-First Nations residents in the early 1980's, as it has been in recent years (Figure 4), the mean annual harvest between 1981 and 1985 was 17.5 moose. This is equal to the sustainable harvest limit of 17.8 moose/year calculated assuming a natural mortality rate of 0.15 (studies in Yukon and Alaska have found that natural mortality rates normally range between 0.1 and 0.2 annually) and the yearling recruitment rate observed in 1981. Using information on the moose harvest by First Nations individuals when available and assuming their harvest equalled the harvest by non-First Nations residents in 1990, the estimated total mean annual harvest between 1988 and 1992 was 6.2 moose. Based on the observed 1990 yearling recruitment rate and a natural mortality rate of 0.15, the calculated annual sustainable harvest rate was 1 moose. There was no sustainable harvest based on the 1992 recruitment rate.

Our population simulations for the Aishihik south area suggest that harvest may have been sufficient to initiate the population decline observed since 1981 (Figure 5). Initial simulations using observed and estimated recruitment and natural mortality rates mimicked the population dynamics observed in the Aishihik south area accurately. Removing the estimated total harvest from the equation was sufficient to result in the simulated population remaining stable until 1990. The population in the model declined from 1990 to 1992 in spite of the elimination of the harvest due to the lower recruitment rates observed in 1990 and 1992.

Although an excessive harvest may have been a significant factor in initiating the decline, predation was likely a stronger force driving the dynamics of the population. While a natural adult mortality rate of 0.18 to 0.2 had to be assumed in order for the simulated population dynamics to mimic the observed population decline in the Aishihik south area, the annual harvest rate ranged between 0.03 and 0.12. These simulations deal only with losses from the adult population. In addition, predation, primarily by grizzly bears, has been found to be responsible for the loss of 66% calves born prior to their first birthday (Larsen et al. 1989b). Overall, predation and harvest have been shown to be responsible for approximately 76% and 9% of annual moose mortality respectively in the southwest Yukon (Larsen et al. 1989b).

Further exacerbating the situation, there was an apparent imbalance in the predator:prey ratio prior to the wolf population reduction during the 1992/93 winter. Surveys in the Aishihik area during the winter of 1992/93 show the lowest ungulate biomass/wolf ratio among 27 wolf/prey studies reported to date in North America (Hayes 1992). The imbalance was likely due to a lag in the numerical response of wolves as the prey population declined. Given the very low recruitment rate combined with the high predator:prey ratio, the moose population would likely have continued to decline even in the absence of a harvest.

Onion Creek Area

The Onion Creek survey area has an estimated 416±18% (90% C.I.) moose (Table 7). An SCF of 1.109 was incorporated into this estimate. This population estimate corresponds to a mean density of 122 moose/1000 km^2 (90% C.I. 100-144). This is well below the mean density of approximately 173 moose/1000 km^2 for all areas surveyed to date in the Yukon (Appendix 2).

As in the Aishihik South area, moose were not distributed evenly throughout the Onion Creek survey block. Approximately 44% of the estimated moose population were located in the high and medium strata which comprised only 14% of the total habitable moose range (Tables 4 and 7). In addition, moose were much more abundant in the northwestern portion of the Onion Creek area (GMS 5-14) than elsewhere in the survey block. Four of 5 (80%) high density SU's were located in GMS 5-14 which makes up only 24% of the total area (Figure 6). Overall moose density was also higher ($P<0.05$) in GMS 5-14 than elsewhere. The surveyed portion of GMS 5-14 had an estimated moose population of 208 for a density of 259 moose/1000 km^2 (90% C.I. 186-331) while the population in the remainder of the area is 232 moose for a density of 89 moose/1000 km^2 (90% C.I. 66-112). The reasons for this large difference in moose abundance within the survey area are unknown. One may speculate, however, that the difference is at least partially due to the apparently high quality habitat which as resulted from wide spread fires in the northern portion of the Onion Creek survey area.

Population composition did not differ significantly in GMS 5-14 and the remainder of the area (Chi squared $P>0.05$) and will be combined for presentation. Mature cows (at least 30 months old) were the most abundant age-sex group in the population, comprising 55% of the total estimated population (Table 7). Mature bulls were the second abundant age-sex group making up 27% of the total. Calves and yearlings were not well represented in the population at 11% and 7% of the total respectively. No twin calves were observed in the survey area. Calf production and survival was also relatively poor as indicated by calf/cow and yearling/cow ratios of 21/100 and 12/100 respectively. The recruitment rate was 0.08.

The Onion Creek area had not been surveyed previously so the population status can only be inferred. The finite rate of increase for the survey area, based on the observed recruitment rate of 0.08 and assuming adult natural mortality rates of between 10% and 20%, was calculated to be between 0.968 and 0.860. These values suggest that the population is likely stable or declining slowly. They suggest that there is no sustainable harvest in the Onion Creek survey area.

Although the above recruitment rates raise a warning flag that these populations may not be able to sustain a harvest, the data must be interpreted with caution. Survey results from a single year provide only a "snapshot view" of the population. Recruitment rates based on just one year's data can give a false indication of overall population trend. Recruitment rates can vary considerably from year to year due to a wide range of environmental factors such as weather and predation. Based on the draft moose management guidelines, the surveyed portion of GMS 5-14 should be able to sustain an annual harvest of 6 moose (3% of 208 moose). The remainder of the area should sustain a harvest of 2 moose (1% of 210 moose), similar to that calculated on the basis of the 1992 recruitment.

The Onion Creek survey area is relatively inaccessible and as a consequence, harvest pressure is low. The total mean (1982-1991) annual harvest for the entire survey area is 5.4 moose/year (3.4 in GMS 5-14 and 2.0 moose/year in GMS 5-19 and 5-27 combined). Non-residents are responsible for 90% - 91% of the reported harvest throughout the survey area. The Onion Creek survey lies within the Kluane First Nation (KFN) Traditional Territory. Harvest information for the KFN has only been available since 1988. Only 1 moose has been reported harvested in the survey area (GMS 5-27) since 1988. However, this likely substantially under-represents the total harvest by First Nations individuals (Quock and Jingfors 1988).

<u>Kluane East Area</u>

A total of 93 moose (87 adults and 6 calves) were seen in 839 minutes of stratification time in the Kluane east survey block (Tables 3 and 8). This translates to 0.11 moose/minute of survey time, intermediate between the 0.08 and 0.16 moose/minute of stratification survey time recorded in the Aishihik South and Onion Creek survey areas respectively. Assuming that sightability was similar in the three areas, moose density in the Kluane east area was likely also intermediate to that in the Aishihik and Onion Creek blocks (65 and 127 moose/1000 km^2 respectively).

The Kluane east block was previously surveyed in 1981 as a part of the Kluane block (Survey Unit 2; Larsen, 1982). The moose density in the 1981 Kluane survey block was 120 moose/1000 km^2, suggesting that moose abundance has remained stable or declined since that time.

The mean annual reported harvest (1982-1991) in the Kluane east area is 12 moose. The total harvest for the area is undoubtedly substantially higher. The single largest factor responsible for under-estimating the harvest is probably the fact that there is no information on the harvest by First Nations individuals prior to 1988 and the Champagne-Aishihik First Nation did not participate in the First Nations harvest survey program in 1990. First Nations individuals were responsible for an average of 55% of the total reported harvest in the Kluane east area in 1988, 1989 and 1991, the three years for which we have estimates of the harvest by First Nations people. If we assume that First Nations individuals have been responsible for a constant proportion of the total harvest over the past decade the mean annual harvest be approximately 20 moose for Kluane east area.

An annual harvest of 20 moose would likely be beyond the sustainable limit for the Kluane east area. Starting with the 1981 population estimate of 337 adult moose (Larsen, 1982) and assuming a natural adult mortality rate of 15% per year, the mean annual recruitment would have to have been at least 0.2 in order to sustain an annual harvest of 20 moose. The mean recruitment rate calculated from past surveys in Yukon is 0.12 (Appendix 2). Based on this apparently excessive harvest, moose seen per minute of survey time and population trends in adjacent areas, we speculate that the Kluane east moose population is declining.

Talbot Creek Area

A total of 31 moose were seen in 246 minutes of stratification in the Talbot Creek area (Tables 3 and 8). This translates to 0.13 moose seen/minute of survey time, slightly lower than the 0.16 moose seen/minute of survey time observed in the Onion Creek survey area (Table 3). Based on this, the moose density in the Talbot Creek survey area is likely similar to that observed in the Onion Creek block (127 moose/1000 $km^{2)}$.

We have no information on calf:cow or yearling:cow ratios in the area so an assessment of population trend is not possible. It is reasonable to assume that the same forces driving moose populations dynamics in adjacent areas are also operating in the Talbot Creek area, however. Based on this assumption, we speculate that this population is stable or declining slowly.

The mean annual reported harvest (1982-1991) for GMS 5-29 is 2.0 moose. Non-residents are responsible for the entire harvest.

Late Winter Population Composition Counts

The percent calves in the 4 populations surveyed in late winter (the Aishihik - Onion Creek recovery area, and the Big Salmon, Mayo and Dawson comparison areas) were similar, ranging from 7% in the Dawson West area to 12% in the Mayo area (Table 8). These values are all within the range normally associated with declining moose populations based on early winter survey composition information. The mean proportion of calves from November surveys of 16 moose populations assessed as stable or declining was 11.2% (Appendix 2). Fifteen stable or increasing moose populations had an average of 18.7% calves during fall surveys.

The fact that all four areas had low proportions of calves suggests some widespread environmental factor must have been acting to reduce survival of the 1992 cohort. One possible explanation is weather. The 1992 spring and fall were unusually wet and cold (Monthly meterological summaries, Environment Canada). May and early June temperatures were below normal and a new record minimum temperature of -5.2 degrees Celsius was set on May 21. Snowfall for the month of May also exceeded normal.

Numerous records for bad weather were also set during the fall. September was the coldest on record, the mean monthly average temperature being nearly 5 degrees Celsius below normal. A record amount of precipitation also fell in September. A total of 41.7 cm of snow fell during the month, exceeding the average September snowfall of 4.5 cm by nearly an order of magnitude. Rainfall for the month also exceeded the monthly norm.

Calves comprised 10% of the combined Aishihik-Onion Creek area during the late winter composition counts. Calves made up 12% of the combined Aishihik and Onion Creek early winter population estimates, suggesting an overwinter calf mortality rate of about 2%.

Numbers of moose seen per minute of survey time during the late winter composition counts were similar in the Aishihik-Onion Creek and Big Salmon areas at about 0.07-0.08 moose/minute (Table 8). The moose sighting rate in the Mayo and Dawson areas was higher at about 0.12 moose/minute of survey time. However, early winter intensive survey results indicate that all the comparison areas had higher moose densities than the Aishihik-Onion Creek area (Appendix 2).

Zone 5 Overview

Past surveys in GMZ 5 have consistently shown lower than average moose densities. The average density from past Yukon moose surveys is 173 moose/1000 km^2 (Appendix 2). By comparison, densities in GMZ 5 have ranged from 40 to 170 moose/1000 km^2. A survey in the Casino Trail area, west of Carmacks found 40 moose/ 1000 km^2, the lowest moose density recorded to date in areas surveyed in the Yukon. The Casino Trail area was closed to moose hunting in 1989 due to the low moose density. Surveys in the Aishihik and Kluane Lake areas in the early 1980's showed moose densities of 107 and 120 moose/1000 km^2 respectively. The area between Fox Lake and Hutshi Lakes had about 170 moose/1000 km^2 during a survey in 1982.

A repeat survey of the Aishihik Lake area in 1990 indicated that moose numbers had declined 23% to 82 moose/1000 km^2 since 1981. Recommendations were made to restrict moose hunting in the Aishihik and Kluane Lakes area as a result of the decline. The recommendations were rejected by the Fish and Wildlife Management Board (January, 1991), largely due to concerns about extrapolating moose abundance and population trends from surveyed areas to adjacent unsurveyed areas and concerns about the continued economic viability of big game outfitters in the area.

In response to local and departmental concerns that moose numbers in the area were continuing to decline, a portion of the Aishihik and Kluane Lake areas were resurveyed in the fall of 1992. The survey area was also expanded to include adjacent, previously unsurveyed, areas as far west as Tin Cup Lake and Grayling Creek to overcome the concerns about extrapolating information from surveyed to unsurveyed areas. The results of the 1992 surveys confirmed that most of the Aishihik - Kluane moose populations were at low density and probably declining. The Aishihik South moose population in particular had declined by 63% over the past decade and is currently in rapid and potentially catastrophic decline.

While predation by grizzly bears and wolves is undoubtedly the predominant mortality factor causing the decline of the Aishihik moose population to continue, hunting may have been a significant factor in initiating the decline. Removal of the harvest during computer simulations of adult moose population dynamics in the Aishihik area was sufficient to eliminate the decline. In recent years, the harvest has continued to exceed the estimated sustainable harvest rate. The estimated mean annual harvest rate between 1988 and 1992 was 6.2 moose, compared to an estimated sustainable annual harvest rate of 1.0 moose or less. The proximity of the Aishihik area to the population centres in the southwestern Yukon and its' high degree of accessibility by road and water are likely key factors contributing to the high historic harvest rates.

The consequences of excessive harvest in accessible areas near population centres are well known. The declines in moose populations in the Granite Lake area following the construction of a mining road and in the southern lakes area in general, are examples. They underline the need for tighter control over the harvest of moose in accessible areas close to population centres. In areas where hunting pressure is intense the traditional 3 month open season does not provide managers with an effective means of ensuring that the harvest does not exceed sustainable limits. In the future we must look for innovative management strategies that will ensure that sustainable harvest limits are not exceeded while continuing to optimize recreational opportunities. We recommend the development and implementation of such management systems in those portions of the Yukon with traditionally high hunter demand.

Although a moose harvest in excess of sustainable limits may have been significant in initiating the decline, research in the southwestern Yukon and Alaska indicates that predation alone can be sufficient to prevent population recovery once predator and prey numbers become unbalanced (Ballard and Larsen 1987, Gasaway et al. 1992). As previously mentioned, the ungulate biomass:wolf ratio in the Aishihik Lake-Onion Creek area during the early winter, 1992 was the lowest recorded from 27 wolf/prey studies in North America (Hayes, 1992) and would likely have been sufficient to cause the moose and caribou populations to continue to decline even in the absence of a harvest.

In contrast to most of the Aishihik - Kluane area, the northwestern corner of the survey area (GMS 5-14) continues to support a relatively high density moose population. While a number of factors may be responsible for this anomaly, the low harvest due to the areas inaccessibility and recent burns resulting high quality habitat in the area are likely key. However, the poor recruitment documented in this population during the 1992 survey raise concern for even this population. As discussed previously, this poor recruitment may have been the result of bad weather during the spring and fall of 1992 or some other environmental factor. As a result we do not recommend complete closure of the subzone at this time. Rather we recommend implementing tight control over the harvest in the area through a permit hunt or similar harvest system and careful monitoring of the population over the next 3 to 5 years.

In response to the further decline of the Aishihik moose population since 1990 we recommended severe harvest restrictions or complete closure of the area as part of an integrated program to rebuild the moose and caribou populations in the area. These recommendations were accepted and a limited (1% of the moose population) harvest in 1993. A complete non-First Nations moose hunting closure was implemented for the area in 1994. The local First Nations have voluntarily agreed to curtail their moose harvest in the area.

In addition to harvest restrictions, the plan calls for a reductions in wolf numbers in the area to 20% of their pre-reduction levels. Initially wolf numbers were to be reduced for a two year period. Recruitment into the moose population, as measured by the proportion of calves in the spring population must be sufficient to cause the population to increase. If this does not occur the program will be re-evaluated.

The overall objective of the moose recovery program is to increase the moose population in the wolf reduction area from approximately 1,800 to 4,000 animals. Our population projections indicate that if the wolf reduction is successful in increasing recruitment to 22% yearlings in the fall population (similar to that seen in the Ross River area during wolf control), annual adult survival rates averages 90% and harvest in the area is eliminated, the moose population should reach 4,000 (a density of about 200 moose/1000 Km^2) in approximately 6 years (1999). It is anticipated that a conservatively managed harvest will be reinstated at that time.

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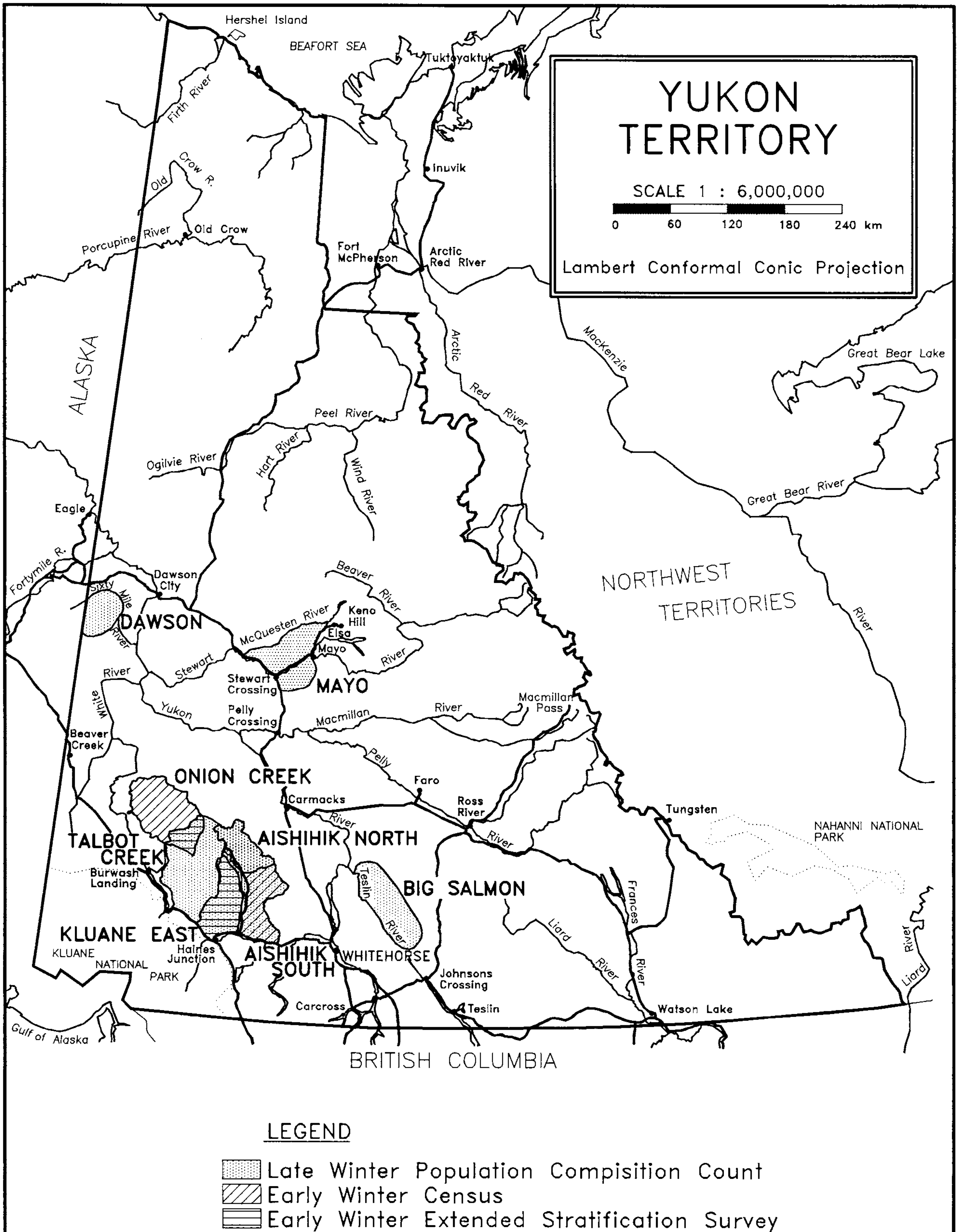


Figure 1. MOOSE SURVEY AREAS 1992

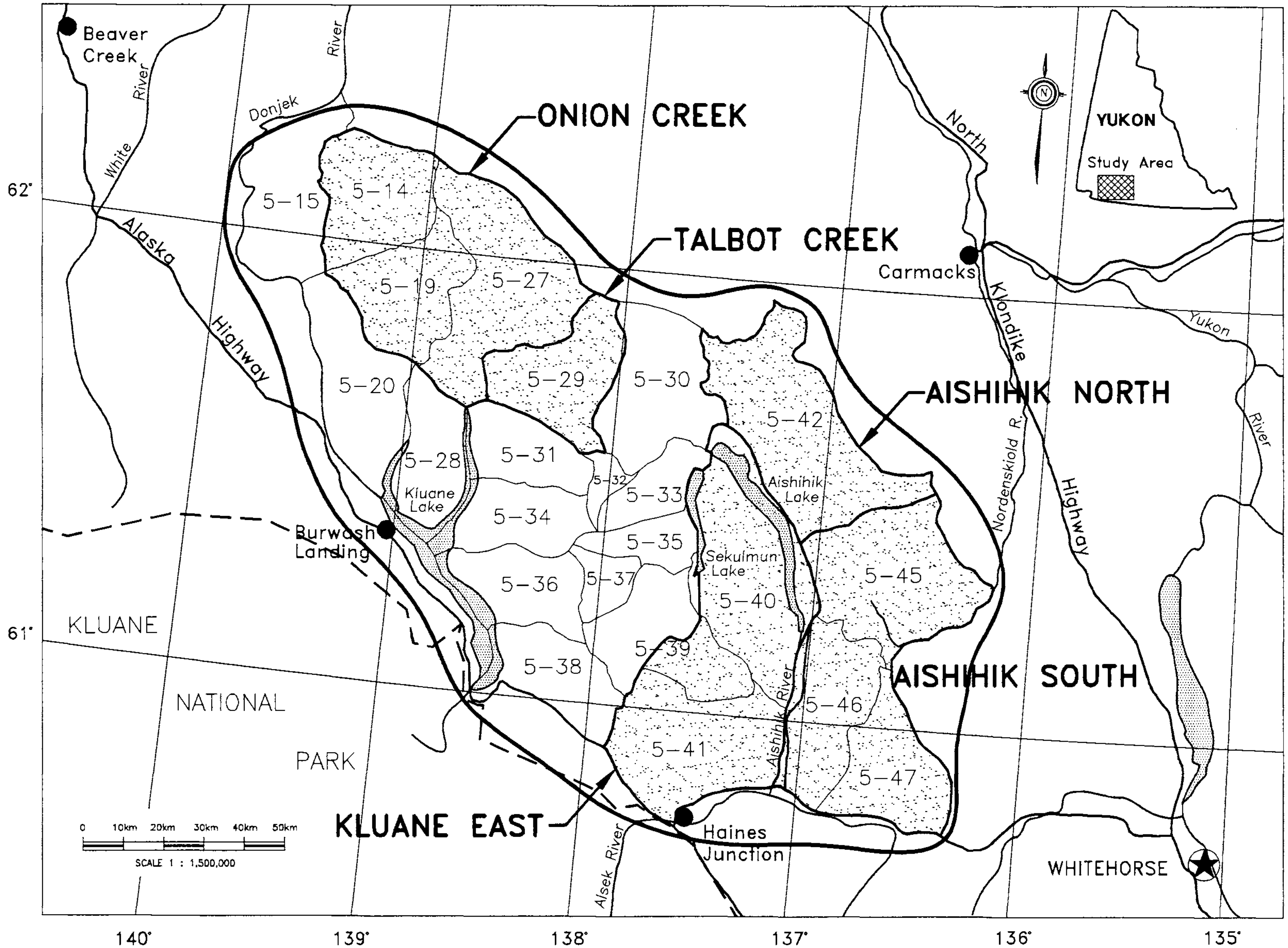


Figure 2: Aishihik Experimental Area, Game Management Subzones and 1992 Moose Survey Areas

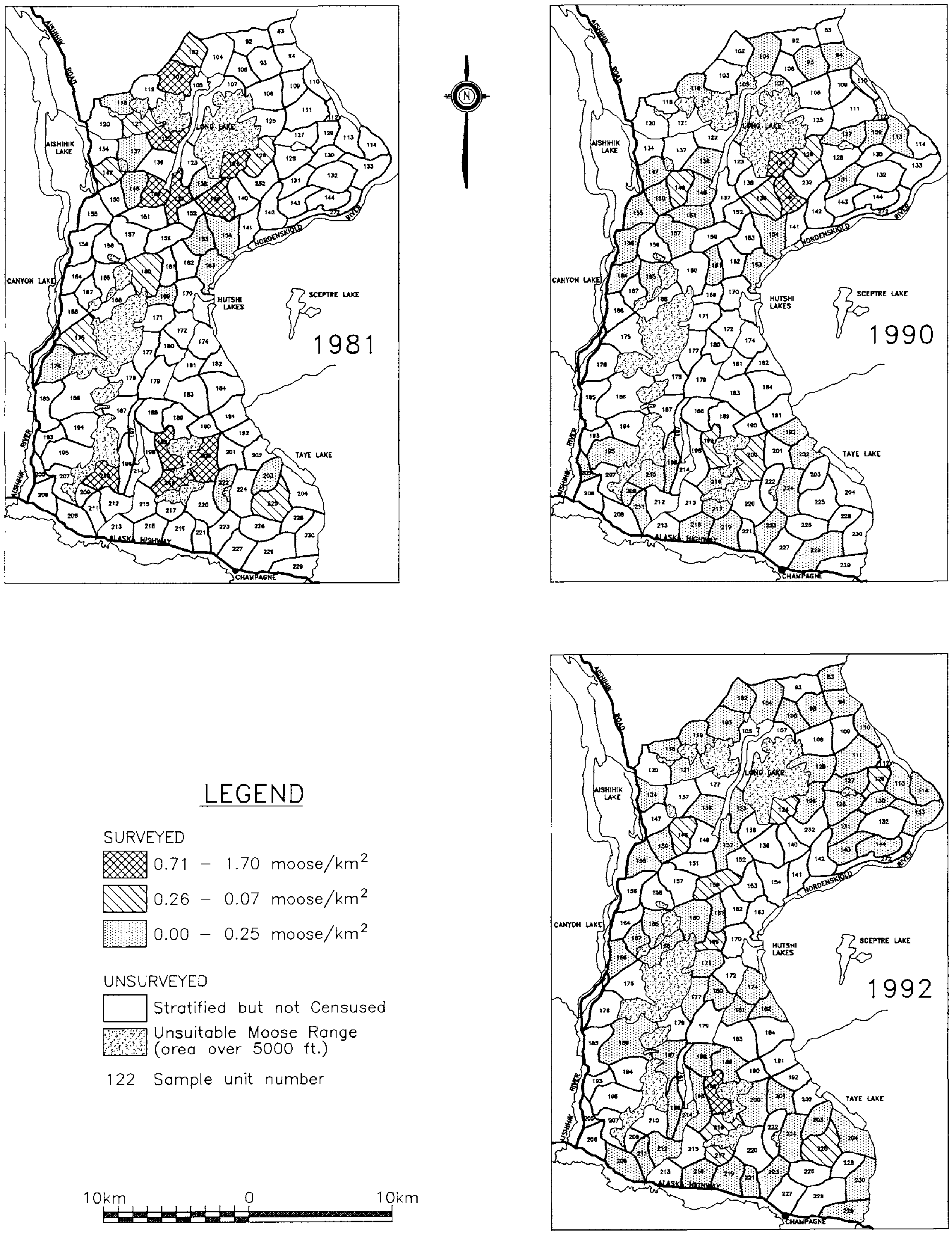


Figure 3. DISTRIBUTION OF MOOSE IN THE AISHIHIK SOUTH SURVEY AREA, 1981, 1990 & 1992.

Figure 4. Reported moose harvest in GMS5-45, 5-46 & 5-47, 1979 to 1992. (Harvest data for Champagne- Aishihik First Nation not available prior to 1988 or for 1990).

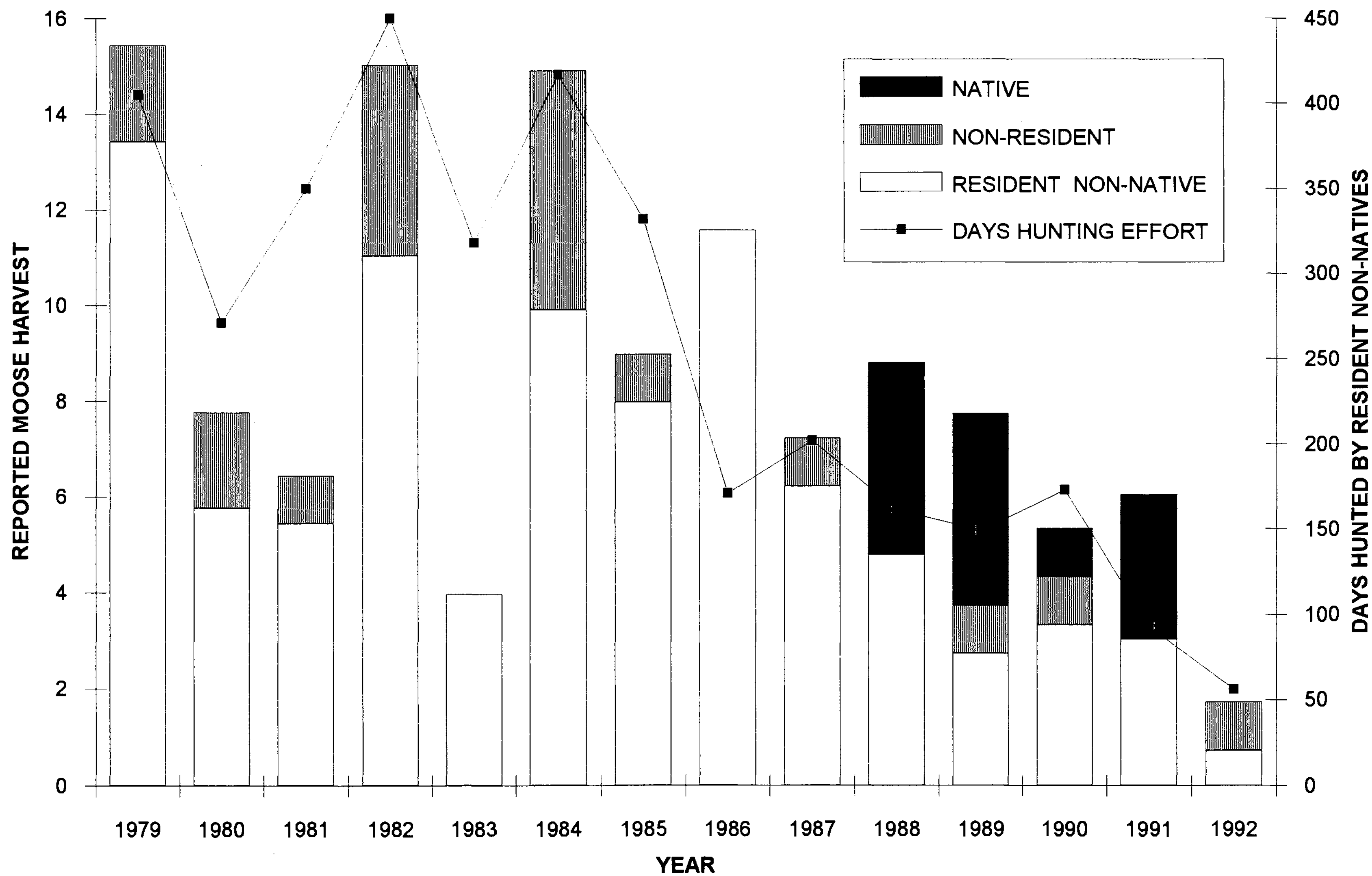
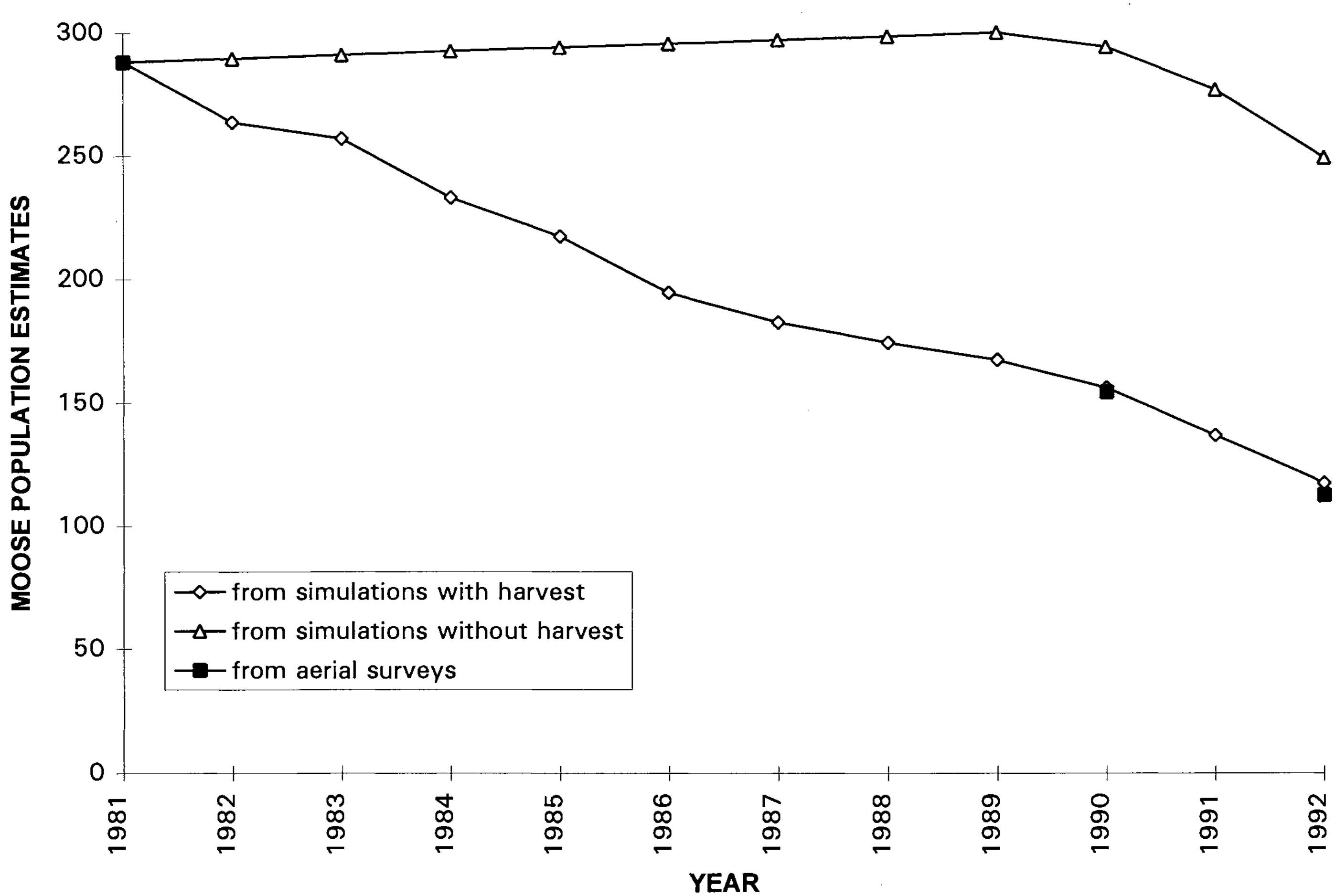


Figure 5. Moose population simulations for Aishihik south area with and without human harvest



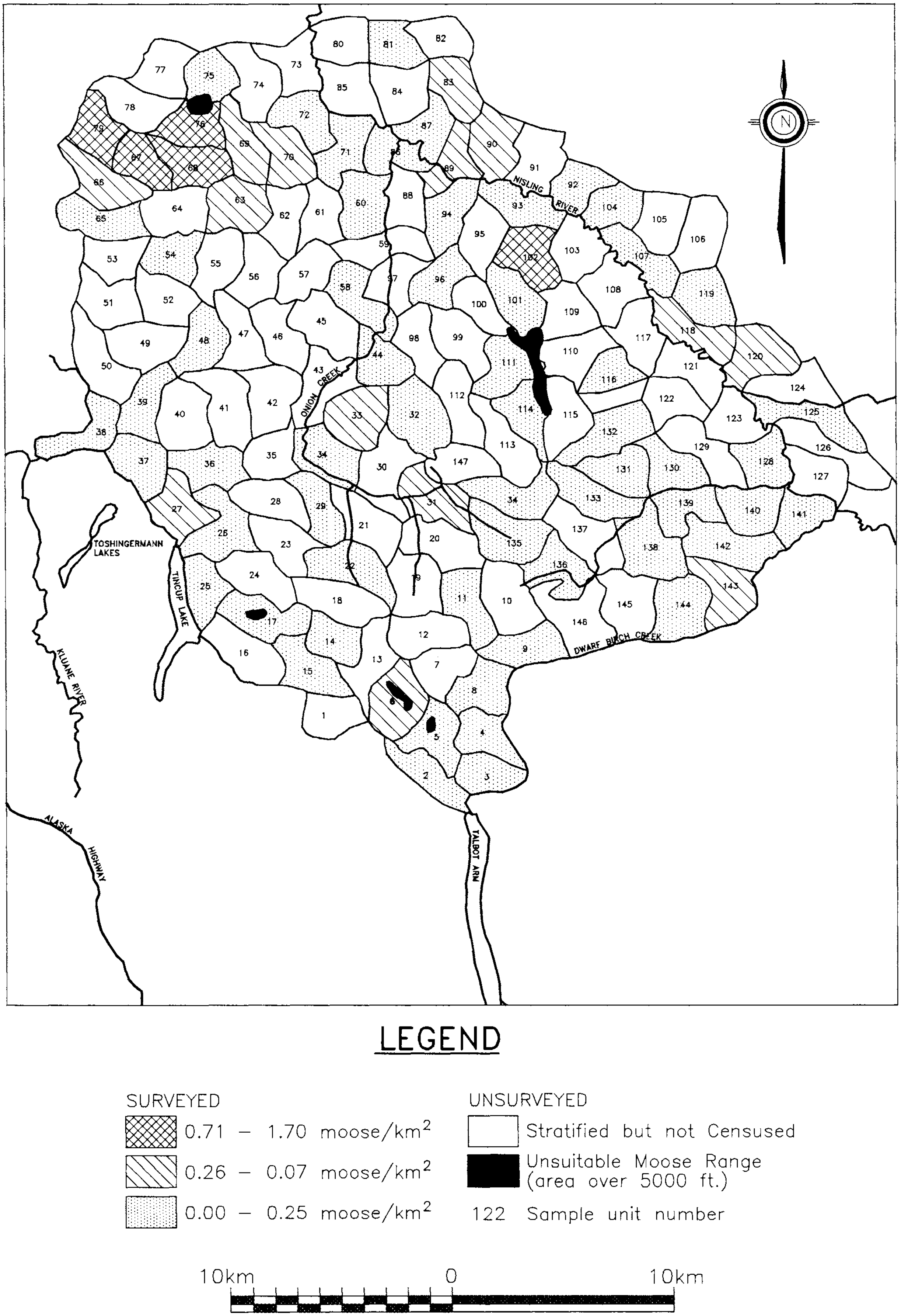


Figure 6. DISTRIBUTION OF MOOSE IN THE ONION LAKE SURVEY AREA 1992.

Table 1. Summary of Survey Area Information

Survey Area	Total Area (Km^2)	Moose Habitat (Km^2)	Eco-regions①	GMS's	Survey Type	Caribou②	Sheep②	Wolves③	Grizzly Bears③
Aishihik South	2,500	1,969	8&10	5-45 to 5-47	Strat. Random Block	few	270	9	10
Onion Creek	3,505	3,397	8&10	5-12 to 5-14, 5-19, 5-25, 5-27	Strat. Random Block	640④	few	9.6	10-20
Kluane East	2,371	1,876	8	5-39 to 5-41	Strat.	590④	210	14	20
Talbot Creek	2,005	1,876	8&10	5-29	Strat.	590④	<50	5	20
Aishihik-Onion Crk	20,000	not calc.	8&10	5-12 to 5-14, 5-19, 5-25, 5-27 to 5-42, 5-45 to 5-47	Winter Comp. Count	640	1800	SEE ABOVE	SEE ABOVE
Big Salmon	4,000	not calc.	4&5	8-03, 8-05 to 8-11,	Winter Comp. Count	unknown	0	10	15
Mayo	5,000	not calc.	10	2-58, 4-01 4-04	Winter Comp. Count	200④	0	10	17
Dawson	2,005	1,870	10&11	3-04	Winter Comp. Count	few	0	8	12

① After Oswald and Senyk, 1977
② Estimated number
③ Estimated density per 1000 Km^2
④ Seasonal use

Table 2. Summary of parameter values for populations simulations for Aishihik south area

YEAR	POPULATION ESTIMATES from surveys	POPULATION ESTIMATES from simulations with harvest	POPULATION ESTIMATES from simulations without harvest	RECRUITMENT RATE	NATURAL MORTALITY RATE with harvest	NATURAL MORTALITY RATE without harvest	HUMAN HARVEST
1981	288	288	288	0.21	0.18	0.18	12
1982		263	289	0.185	0.18	0.18	26
1984		233	292	0.185	0.18	0.18	25
1985		217	294	0.185	0.18	0.18	17
1986		194	295	0.185	0.18	0.18	24
1987		182	297	0.185	0.18	0.18	13
1988		169	298	0.185	0.18	0.18	14
1989		162	300	0.185	0.18	0.18	8
1990	154	153	294	0.16	0.18	0.18	6
1991		134	276	0.12	0.2	0.18	7
1992	112	115	248	0.08	0.2	0.18	3

Table 3. Search intensity (min./km^2) on early winter moose surveys in S.W. Yukon, 1992.

SURVEY/AIRCRAFT	SURVEY AREA			
	AISHIHIK SOUTH	ONION CREEK	TALBOT CREEK	KLUANE EAST
Stratification (fixed wing)				
survey dates (November)	7-11	12-22	17-22	11-13
area (km^2)	1965	3397	727	1876
time (min.)	776	1432	246	839
search intensity (min./km^2)	0.39	0.42	0.34	0.45
Survey (helicopter)				
survey dates (November)	11-16	22-30		
area (km^2)	1157	1697	N/A	N/A
time (min.)	2098	3093	N/A	N/A
search intensity (min./km^2)	1.81	1.82	N/A	N/A
Sightability Correction Factor (helicopter)				
area (km^2)	25.8	81.5	N/A	N/A
time (min.)	96	339	N/A	N/A
search intensity (min./km^2)	3.72	4.16	N/A	N/A

Table 4. Sampling intensity of habitable moose range by stratum and survey area during the early winter census in S.W. Yukon, 1992.

	STRATUM			
SURVEY AREA	LOW	MEDIUM	HIGH	TOTAL
Aishihik South				
Number of SU* in area (% of total)	122(94)	8(6)	--	130(100)
Number of SU surveyed (% of strata)	69(57)	8(100)	--	77(59)
Area in km^2 in stratum (% of total)	1825(93)	140(7)	--	1965(100)
Onion Creek				
Number of SU in area (% of total)	128(87)	14(10)	5(3)	147(100)
Number of SU surveyed (% of strata)	55(43)	14(100)	5(100)	74(50)
Area in km^2 in stratum (% of total)	2934(86)	339(10)	124(4)	3397(100)

* Sample Unit

Table 5. Estimated moose abundance, observed and estimated composition of moose in the Aishihik South survey area, November, 1992.

	STRATUM		
	HIGH	LOW	TOTAL
Estimated Abundance (90% CI)			
Total moose[a]	61	65	126±26%
Density (moose/1,000 km^2)	435	36	64
Estimated Composition[a] (90% CI)			
Adult bulls (≥30 mo.)	18	23	41±33%
Adult cows (≥30 mo.)	33	34	68±29%
Yearlings (≥18 mo.)	2	8	10±78%
Calves	8	0	8±16%
Observed Composition			
Adult bulls (≥30 mo.)	17	12	29
Adult cows (≥30 mo.)	31	18	49
Yearlings[b] (≥18 mo.)	2	4	6
Calves	7	0	7
TOTAL	57	34	91
Estimated Population Ratios			
Adult bulls/100 adult cows	55	64	61
Yearlings/100 adult cows	6	22	15
Calves/100 adult cows	21	0	11
Adult bulls/total population	30%	35%	33%
Adult cows/total population	54%	52%	54%
Yearlings/total population	3%	12%	8%
Calves/total population	11%	0%	6%
Observed Ratios			
Adult bulls/100 adult cows	55	67	59
Yearlings/100 adult cows	6	22	12
Calves/100 adult cows	23	0	14
Adult bulls/total population	30%	35%	32%
Adult cows/total population	54%	53%	54%
Yearlings/total population	4%	12%	7%
Calves/total population	12%	0%	8%
Twinning Rate[c]			17%

a. Adjusted for sightability bias (1.068).
b. Total yearlings were calculated by doubling the observed number of yearling males.
c. Twinning rate = the number of cows with twins divided by the total number of cows with calves in November.

Table 6. Summary of moose distribution and abundance in Aishihik South survey area.

SAMPLE UNIT	YEAR AND STRATUM		
	1981	1990	1992
102	M	NC	L
103	H	NC	L
121	M	NC	L
122	H	NC	NC
124	H	H	M
126	M	M	L
129	L	L	M
137	H	NC	L
139	H	H	NC
147	M	L	NC
148	L	M	M
149	H	L	NC
151	M	L	NC
159	NC	M	M
160	M	NC	L
169	L	NC	M
175	M	NC	NC
199	M	M	H
200	H	M	L
210	H	L	NC
216	H	H	M
217	NC	L	M
225	M	NC	M

Legend

H = high stratum (= >0.71 moose/km^2)
M = moderate stratum (0.26 - 0.70 moose/km^2)
L = low stratum (0.00 - 0.25 moose/km^2)
NC = not censused

NOTE: All sample units identified as having moderate or high density during 1992 stratification flights were censused.

Table 7. Estimated moose abundance and observed and estimated composition in the Onion Creek survey area, November, 1992.

	STRATUM			
	HIGH	MEDIUM	LOW	TOTAL
Estimated Abundance (90% CI)				
Total moose[a]	125	83	207	416±18%
Density[a] (moose/1,000 km^2)	1011	245	71	122
Estimated Composition[a] (90% CI)				
Adult bulls (≥30 mo.)	39	34	39	112±20%
Adult cows (≥30 mo.)	71	43	116	229±20%
Yearlings (≥18 mo.)	4	2	21	28±50%
Calves	11	5	31	47±25%
Observed Composition				
Adult bulls (≥30 mo.)	35	30	15	80
Adult cows (≥30 mo.)	64	38	44	146
Yearlings[b] (≥18 mo.)	4	2	8	14
Calves	10	4	12	26
TOTAL	113	74	79	266
Estimated Ratios				
Adult bulls/100 adult cows	55	79	34	49
Yearlings/100 adult cows	6	5	18	12
Calves/100 adult cows	15	12	27	21
Adult bulls/total population	31%	41%	19%	27%
Adult cows/total population	57%	52%	56%	55%
Yearlings/total population	3%	2%	10%	7%
Calves/total population	9%	6%	15%	11%
Observed Ratios				
Adult bulls/100 adult cows	55	79	35	54
Yearlings/100 adult cows	6	5	17	9
Calves/100 adult cows	16	11	30	19
Adult bulls/total population	31%	41%	19%	30%
Adult cows/total population	57%	51%	56%	55%
Yearlings/total population	4%	3%	10%	5%
Calves/total population	9%	5%	16%	10%
Twinning Rate[c]				0%

a. Adjusted for a sightability correction factor or 1.109.
b. Total yearlings were calculated by doubling the observed number of yearling males.
c. Twinning rate = the number of cows with twins divided by the total number of cows with calves in November.

TABLE 8. Summary of 1993 moose composition survey data

AREA	Population Density (Moose/1000 Km^2)[1]	SURVEY TIME (min.)	ADULTS SEEN	CALVES SEEN	TOTAL MOOSE SEEN	PERCENT CALVES	MOOSE SEEN/ MINUTE
Aishihik	**64-82 (1992)**	**1510**	**95**	**11**	**106**	**10%**	**0.07**
Big Salmon	**195 (1993)**	**1192**	**90**	**10**	**100**	**10%**	**0.08**
Mayo	**122 (1993)**	**997**	**109**	**15**	**124**	**12%**	**0.12**
Dawson	**168 (1989)**	**910**	**105**	**8**	**113**	**7%**	**0.12**

1 Population density estimates from early winter aerial surveys. Survey year in brackets.

Appendix 1. Cost (x 1,000) associated with aerial moose surveys in 1992.

ITEMS	COST
Aircraft[a]	
fixed wing	20.6 (excluding fuel)
helicopter	52.4 (excluding fuel)
Personnel[b] (casual and contract)	23.1
Food and Lodging	8.1
Miscellaneous	0.7
TOTAL	123.8

a. Aircraft costs (dry) were $210/hour fixed wing, $318/hour helicopter

b. A total of 173 person days (permanent, casual and contract) between 18 people (excluding preparation and write-up) were needed to conduct the survey.

APPENDIX 2. SUMMARY OF NOVEMBER YUKON MOOSE SURVEY RESULTS (revised June, 1994)

SURVEY BLOCK	YEAR	SURVEY AREA (KM^2)	POPULATION ESTIMATE	ESTIMATED TOTAL[1] MOOSE/1,000 KM^2	ESTIMATED BULLS/100 COWS	ESTIMATED YEARLINGS/100 COWS	ESTIMATED CALVES/100 COWS	ESTIMATED RECRUITMENT (YEARLINGS/ YEARLINGS AND ADULTS)	ANNUAL FINITE RATE OF CHANGE BETWEEN SURVEYS	POPULATION STATUS (P)=predicted (O)=observed
1. Kluane	1981	3755	434[2]	120	54	27	17	.15		slow decline 1981-1992 (P)
2. Aishihik	1981	3626	377[2]	107	66	31	23	.16		
	1990	3626	291[2]	79	61	21	52	.12	-3%	slow decline 1981-1990 (O)
	1990	3626	301[3]	82	62	21	53	.12	-3%	
3. Aishihik South	1981	1965	322[2]	166	67	45	24	.21		
	1990	1965	253[3]	129	42	26	56	.16	-5%	slow decline 1981-1990 (O)
	1992	1965	126[3]	64	61	15	11	.08	-24%	rapid decline 1990-1992 (O)
4. Whitehorse North	1982	3108	533[2]	170	45	1	6	.04		
	1993	3275	435[3]	130	110	18	47	.08	-2%	stable or slow decline (O)
5. Haines Junction	1981	2332	570[2]	244	34	19	40	.13		
	1982	2332	351[2]	151	37	3	11	.02		
	1983	2332	337[2]	145	32	1	7	.01		
	1984	2332	329[2]	141	42	1	20	.01	-17%	rapid decline 1981-1984 (O)
	1990	2332	513[3]	223	50	31	42	.17	+7%	increase 1984-1990 (O)
6. Whitehorse South	1981	2613	607[2]	232	33	27	20	.17		
	1982	2613	582[2]	223	31	2	26	.02		
	1983	2613	651[2]	249	42	4	30	.03		
	1986	2613	717[2]	274	27	18	31	.13	+3%	slow increase 1981-1986 (O)
7. Carcross	1980	916	406[2]	443	51	41	37	.21		
	1982	916	300[2]	328	76	1	9	.01		
	1983	916	171[2]	187	51	7	4	.03	-25%	rapid decline 1980-1983 (O)
8. Teslin Burn	1982	2512	1383[2]	550	39	12	19	.08		
	1983	1095	472[2]	431	30	1	30	.01		
	1984	2512	1051[2]	417	66	13	39	.07	-13%	rapid decline 1982-1984 (O)
9. Nisutlin	1986	4210	563[2]	134	98	36	49	.16		stable to slow increase (P)
10. Liard West	1983	7236	838[2]	116	75	18	18	.09		decline (P)
11. Liard East	1986	2210	305[2]	138	79	37	51	.17		stable to slow increase (P)
12. North Canol	1987	2744	516[2]	188	66	54	64	.24		
	1991	2954	950[2]	322	89	38	52	.17		

SURVEY BLOCK	YEAR	SURVEY AREA (KM^2)	POPULATION ESTIMATE	ESTIMATED TOTAL[1] MOOSE/1,000 KM^2	ESTIMATED BULLS/100 COWS	ESTIMATED YEARLINGS/100 COWS	ESTIMATED CALVES/100 COWS	ESTIMATED RECRUITMENT (YEARLINGS/ YEARLINGS AND ADULTS)	ANNUAL FINITE RATE OF CHANGE BETWEEN SURVEYS	POPULATION STATUS (P)=predicted (O)=observed
	1991	2954	1002[3]	339	90	38	52	.17	+.16%	rapid increase 1987-1991 (O)
13. Frances Lake	1987	3894	741[2]	190	55	65	69	.29		
	1991	3894	1432[2]	370	57	42	44	.21		
	1991	3894	1479[3]	382	57	42	44	.21	+.19%	rapid increase 1987-1991 (O)
14. Dromedary	1982	3548	228[2]	64	37	1	15	.01		rapid decline (P)
15. Casino Trail	1987	3055	137[2]	45	--[4]	--[4]	--[4]	unknown		stable to decline (P)
16. Mayo North	1988	2235	286[2]	128	49	42	68	.22		rapid increase (P)
17. Mayo South	1988	2616	387[2]	148	76	11	56	.06		
18. Mayo	1993	3049	362[2]	119	82	18	51	.09	3%	stable to slow increase (O)
19. Mayo	1993	3049	373[3]	122	82	18	51	.09		
20. Dawson East	1989	2611	691[3]	269	65	41	76	.20		rapid increase (P)
21. Dawson West	1989	1870	313[3]	168	105	25	45	.11		stable to slow decline
22. Onion Creek	1992	3397	416[3]	122	49	12	12	.08		stable to slow decline (P)
23. Big Salmon	1993	2700	532[3]	197	70	17	50	.09		stable to slow decline (P)
Yukon Wide Average		61,565[5]	61,000[6]	1857 132[8]	68[9]	23[9]	38[9]	.11[10]		stable to slow decline (P)

1 Small differences between estimated population size, area surveyed and density are due to rounding error
2 Sightability correction factor not applied
3 Sightability correction factor applied
4 Sample size too small to accurately determine sex and age ratios.
5 Total area surveyed = approx. 13% of Yukon.
6 Moose population estimate for entire Yukon
7 Average density from most recent census of areas surveyed
8 Estimated mean density for entire Yukon based on density estimates for each Game Management Subzone
9 Average from most recent census of areas surveyed
10 Average from all areas censused

Appendix 3. Summary of moose survey results from the Aishihik South survey area, November 1981, 1990 and 1992. NOTE: sightability correction factor has not been incorporated.

POPULATION CHARACTERISTICS	1981	1990	1992
Estimated Abundance (90% CI)			
Total moose[1]	322 (±8%)	205 (±19%)	118 (±16%)
Density (moose/1,000 km^2)	166	104	60
Estimated Composition (90% CI)			
Adult bulls (≥30 mo.)	91 (±34%)	39 (±34%)	39 (±23%)
Adult cows (≥30 mo.)	136 (±21%)	91 (±20%)	63 (±19%)
Yearlings (≥18 mo.)	61 (±40%)	24 (±40%)	9 (±60%)
Calves	33 (±53%)	51 (±26%)	7 (±0%)
Observed Composition			
Adult bulls	67	27	29
Adult cows	112	63	49
Yearlings	38	14	6
Calves	22	36	7
TOTAL	239	140	91
Observed Ratios			
Adult bulls/100 adult cows	60	43	59
Yearlings/100 adult cows	34	22	12
Calves/100 adult cows	20	32	14
Adult bulls/total population	28%	19%	32%
Adult cows/total population	47%	45%	54%
Yearlings/total population	16%	10%	7%
Calves/total population	9%	26%	8%
Twinning Rate	16%	6%	17%
<u>Survey Characteristics</u>			
Stratification			
Area (km^2)	1965	1965	1965
Time (min.)	n/a	n/a	776
Search Intensity (min./km^2)	n/a	n/a	0.39
Moose Seen	237	98	64
Moose Seen/min.	n/a	n/a	0.09
Dates	Nov. 19-22	Nov. 5-10	Nov. 7-11
Census			
Area (km^2)	507	843	1157
Percentage of Survey Area Searched	26%	43%	59%
Time (minutes)	669	1532	2098
Search Intensity (min./km^2)	1.4	1.8	1.8
Moose Seen	228	140	91
Moose Seen/min.	0.34	0.09	0.04
Dates	Nov. 23-26	Nov. 9-16	Nov. 11-16

1 Significantly different between 1981 and 1990; 1990 and 1992 ($P<0.20$), 2 Tailed Student t-Test.