MOOSE POPULATION CHARACTERISTICS IN THE FRANCES LAKE AND NORTH CANOL AREAS 1991

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**MOOSE POPULATION CHARACTERISTICS
IN THE FRANCES LAKE AND NORTH CANOL AREAS**

1991

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ABSTRACT
Aerial surveys were conducted in the North Canol (NC) and Frances Lake (FL) areas of the south-east Yukon in November 1991. Moose density, distribution, and composition in 1991 are compared to a previous survey conducted in these same areas in 1987. Moose densities increased (P <0.01) in both the NC (85%) and the FL (93%) areas over the four years between surveys for a finite rate of change of 1.16 and 1.18 per year in each of these areas, respectively. These are the highest growth rates documented in the Yukon to date. Both populations are expected to continue to increase at a rate of between 1.11 (NC) and 1.12 (FL) in 1992. This increase will occur with harvest rates equal to the mean of the past 3 years. Moose densities in the NC and FL areas were among the highest recorded in the Yukon, at 339 and 381 moose/1,000 km^2, respectively.

Recruitment rates declined from 24% to 17% (NC) and from 29% to 21% (FL) between 1987 and 1991. Calf and yearling ratios (per 100 cows) also dropped in both areas (NC - 64 to 52 calves, 54 to 38 yearlings; FL - 69 to 44 calves, 65 to 41 yearlings). The decrease in recruitment coincides with increasing wolf numbers. Moose distribution has not changed between 1987 and 1991, with approximately two thirds of the population in one quarter of the area. Local concentration areas are described.

Between 1987 and 1991, moose in the NC and FL areas respectively, were harvested primarily by resident non-natives (65-67%), followed by natives (23-26%) and outfitters (12-7%). Resident harvest has remained fairly stable over the past 12 years, although there is a trend from higher harvest levels in the early 1980's to a low in the mid-1980's, back to higher levels in the late 1980's. The number of days hunted/kill has decreased in the NC area in recent years suggesting it is becoming easier to find moose. This is consistent with the increase in moose density. Current harvest levels are within sustainable limits overall; however, the harvest within a few Game Management Subzones (GMS) appears high. If harvest levels increase in these areas or if densities or recruitment decline, local overharvest may occur. Allowable harvest levels, i.e., harvest while allowing the population to grow at 5% year are described for each GMS.

Increases in moose numbers between 1987 and 1991 are speculated to be the result of a wolf reduction program (81-85% reduction of wolves in the area) conducted in this area between 1982 and 1989.

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INTRODUCTION

Regional moose surveys have been conducted in important moose areas throughout the Yukon since 1980 (Appendix I). The selection of high priority areas was based on Game Management Subzones (GMS) that had high moose harvests. The purpose of these surveys was to obtain a Yukon-wide inventory of moose abundance, distribution, sex/age composition, and population trends. The information collected from the surveys has been used to set sustainable harvest levels (SHL), to measure calf and yearling mortality, to identify early-winter moose habitats, and to aid land use planning decisions.

In this paper, we present the results from the November 1991 surveys in the North Canol and Frances Lake areas of the south-east Yukon (Figure 1). These results are compared with the 1987 surveys conducted in the same areas (Jingfors, 1988). Changes in population density, composition, and distribution are assessed. The current population trend (stable, increasing, or declining), as well as allowable harvest levels, are evaluated. The effects of a 7-year wolf control programme on moose density, and management recommendations, are discussed.

STUDY AREA

North Canol

The 3,050 km^2 NC survey area consists of 2,954 km^2 of habitable moose range. The survey area includes portions of 7 GMS (Figure 2). Habitable range is defined as the area below which moose browse occurs, excluding large water bodies. In this area, habitable range is below 1,676m (5,500 feet) above sea level (ASL). The vegetation and physiography has been previously described by Oswald and Senyk (1977) and Jingfors (1988).

Caribou are the only other abundant ungulate species, with about 6,000 estimated in the Finlayson Moose Management Area (FMMA) in 1990 (Figure 2; Farnell and Hayes, in prep.). Based on the annual home range of the Finlayson caribou herd (26,000 km^2), the caribou density within the FMMA is 230 caribou/1,000 km^2.

Sheep are uncommon in the survey area (Barichello et. al. 1989). Large predators include wolf, black bear, and grizzly bear. Wolf densities in the FMMA were significantly reduced (50-85%) through a government management program (see discussion) between 1982 and 1989 (Farnell and Hayes, in prep.). Wolf densities have increased since 1989 and are currently at 9 wolves/1,000 km^2, the same as pre-reduction levels. Moose were previously surveyed in November 1981 and March 1982, using a stratification type aerial survey technique to determine relative distribution of moose in early and late winter (Markel and Larsen 1986). The area covered roughly between the Robert Campbell Highway and the Northwest Territory border, and between Frances Lake and the North Canol Road (Figure 2). A moose census was also conducted in November 1987 (Jingfors 1988) in the NC survey area, using the same technique described here.

Frances Lake

The 4,936 km^2 FL survey area includes all or portions of 9 GMSs of which 3,870 km^2 is habitable moose range (Figure 2). Habitable moose range in this area is defined as habitat below 1,545m (5,000 feet), excluding large water bodies.

As in the NC survey area, caribou are the second most numerous ungulate after moose. Sheep are uncommon and goats range east of Frances Lake at densities of 25-100 goats/1,000 km^2 (Barichello et. al., 1989; Barichello and Carey, 1988). Wolf numbers were reduced between 1982-1989, with current densities at 9 wolves/1,000 km^2 (Farnell and Hayes, in prep.). Both grizzly and black bears occur in the survey area. A moose population census was conducted in 1987 (Jingfors 1988). The 1981 and 1982 surveys of the North Canol area did not extend into the FL area (Markel and Larsen, 1986).

METHODS

Survey Techniques

The aerial survey technique described by Gasaway et. al. (1986) was used to estimate moose abundance, composition, and distribution. This technique was modified by replacing fixed-wing aircraft with helicopters for the census portion (Larsen 1982). Briefly, the technique involves three phases: 1) the stratification survey in which sample units (SU's) are classified into high, medium, and low density strata based on relative moose abundance observed during fixed wing reconnaissance flights; 2) the census survey in which an attempt is made to count all moose within selected SU's. A sample of SU's is randomly selected within each stratum and searched within several days of stratification; and 3) the sightability correction factor (SCF) for moose not observed on the census survey. A SCF was estimated by resurveying portions of some of the SU's at a higher search intensity (4-minutes per km^2). 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. It should be noted that a small proportion of moose are missed even at the high search intensity used during the development of the SCF. Gasaway et al. (1986) developed a more accurate sightability correction factor (SCF_c) using radio collared moose. The use of a SCF_c would result in a higher population estimate and associated confidence intervals (C.I.) than reported in this report. A SCF was not estimated during surveys conducted in previous years; therefore, between year comparisons of population estimates were made using uncorrected 1991 data.

Moose Classification o

Bulls were classified as yearlings and adults based on the size and shape of their antlers (Dubois et al 1981). Cows were differentiated from bulls by the presence of a vulva patch (Mitchell 1970) and lack of antlers. Yearling cows (18 months) could not be reliably identified in the field, but were assumed to occur in the population in equal proportions to yearling bulls. This assumption may underestimate yearling cows because yearling bulls are likely harvested from the population at a higher rate than yearling cows. Resident non-native hunters are restricted to bulls only while native hunters can harvest both cows and bulls. Fall twinning rates were calculated as the number of cows with twins ÷ the total number of cows with calves in November. November twinning rates are influenced by neonatal mortality between birth and November. Density categories, used in Figures 3 and 4 are based on census rather than stratification data.

The 1991 NC survey area was slightly larger (210 km^2) than the same survey area in 1987 because the survey boundary was extended to a higher elevation (5,000 to 5,500 feet). This modification was made because a substantial number of moose were seen at these higher elevations during the census. We do not know whether these higher elevations were also searched in 1987. However, we assume that they would have been searched if they were occupied by moose. The FL survey area remained the same between years.

Changes in Population Size

The change in population size since the 1987 survey was tested using a one-tailed student's t-test (Gasaway et. al. 1986). An alpha level of 0.05 was used to determine significance unless otherwise indicated. The finite rate of population change (net change after recruitment and mortality) was calculated as follows (see Appendix 2 for examples):

Between the 1987 and 1991 surveys: $\lambda = e^r$, (following Gasaway et. al., 1986).

where e = constant 2.7183

r = exponential rate of change,

Between 1991 and 1992 (current status): $\lambda = (1-M) \div (1-R)$ (following Gasaway et. al., 1992).

where M = adult mortality rate

R (recruitment) = yearlings ÷ yearlings and adults (in 1991)

We estimated M as $1-[\hat{\lambda}(1-R)]$; where R = the average recruitment in 1987 and 1991, and $\hat{\lambda}$ = finite rate of change between 1987 and 1991. Estimates of mortality include both hunting and natural causes.

Change in relative abundance of moose between surveys was measured by the number of moose seen/minute of search time in stratification and census flights.

Allowable Harvest

Maximum Allowable Harvest (MAH) rates for each survey area are estimated using the following two techniques:

a) Subtracting the 1991 estimated adult population from the projected 1992 adult population:

[(1991 adults + yearlings) x (adult and yearling annual survival rate) - (1991 adults)] + 1988 to 1991 average annual harvest.

Where survival rate = 1-M not including hunting, and;

b) (finite rate of change in 1991 x adult and yearling in the population) + the 1988 - 1991 average annual harvest.

The mean of the above two calculations is used to estimate the MAH for the NC and FL areas.

Harvesting at the MAH rate would stop population growth. We set a modest population growth target at 5% per year as an objective, and calculated the Adjusted Allowable Harvest (AAH) as: (MAH) - (0.05 x adults and yearlings).

The AAH for the entire FMMA was calculated by first determining the AAH density (AAH/1,000 km^2 of total area) in the survey areas, then extrapolating to the remaining GMSs within the FMMA. We assigned survey area AAH densities to adjacent, un-surveyed GMSs (Appendix 3). This extrapolation is defended on the basis of a more or less homogenous moose distribution documented during the 1981 stratification survey of most of the FMMA (Markel and Larsen 1986), and from field observations of moose distribution throughout the FMMA (R. Farnell and R. Hayes, Yukon Fish and Wildlife Branch, pers. comm.).

Harvest information for both the FL and NC areas is available for resident non-natives and commercial outfitters between 1979-1991, and for native hunters between 1987-1991. Harvest estimates are based on questionnaire responses from resident hunters (Kale 1982), compulsory submissions from outfitters of non-resident hunters (YTG internal files) and personal interviews with First Nation hunters (Quock and Jingfors 1988). The 1991 resident and native harvest in the NC survey area was also determined from a check station which operated on the North Canol Road between August 1-October 14, 1991 (Florkiewicz and Anderson 1991), and records from local air charter companies. The check station data is an accurate account of resident harvest; however, the native harvest is likely underestimated as some natives hunt year round. Similar check station harvest information for the FL survey area in 1991 was not available.

Harvest information is summarized for each survey area, and for the FMMA. In all cases, harvest is estimated on a GMS basis. FMMA boundaries were drawn to correspond to GMS boundaries (Figure 2). The moose survey area boundaries do not always correspond to GMS boundaries (Figure 2). The entire harvest of the GMS is considered to have occurred within the survey area even though the GMS could extend beyond the survey area. Boundary discrepancies occurred mainly within the NC survey area, where most of the hunting occurs from the North Canol Road, or lakes accessible from the road. This is supported by aircraft charter records in 1992 (Florkiewicz and Anderson 1991), which shows no moose transported from remote portions of GMSs making up the NC survey area

Moose Distribution

Changes in moose distribution between years was assessed by comparing: 1) proportion of SU's with $\geq$10 moose in 1987 and in 1991; based on moose seen on stratification flights (contingency table analysis); 2) the cumulative percentage of moose observed on census flights vs cumulative percentage of area surveyed between years; and 3) the location of high and medium density SU's between years.

Breakdown of the cost of the survey is presented in Appendix 4.

RESULTS

Search and Sampling Intensity

Search intensity was similar on stratification, census, and sightability correction flights between the NC and FL survey areas (Table 1). The proportion of SU's censused in both areas was the same in both areas (38%)(Table 2). Mean ($\pm$SE) SU size was 17.1 km^2 ($\pm$0.19) in NC, and 17.8 km^2 ($\pm$0.16) in FL.

Population Characteristics and Distribution

North Canol

The estimated moose population in November 1991, corrected for sightability bias (SCF = 1.054), was 1,001 $\pm$ 18% (90% CI) for a mean density of 339 moose/1,000 km^2 of habitable range (Table 3)(328 moose/1,000 km^2 of total area, Appendix 3). The estimated rate of change in 1991 (1991 to 1992) was 1.11, indicating that the population is continuing to increase (11% per year) with existing harvest levels.

Estimated ratios were 52 calves and 38 yearlings/100 adult cows (Table 3). The fall twinning rate was 9% and recruitment was 17%. The adult bull/adult cow ratio is 89/100.

Moose were unevenly distributed throughout the survey area, with 61% of the observed moose in 25% of the surveyed area (Figure 5). Eight percent of SU's had $\geq$10 moose seen during stratification. SU's with the highest moose densities ($\geq$0.76 moose/km^2) were located in the mountain complex between Orchie, Tay, and Dragon Lakes, and near Jackfish and Otter Lakes (Figure 3).

Harvest has been at a mean minimum rate of 45 moose/year ($\pm$3.0, $\pm$SE) since the previous survey in 1987 (Figure 6). Most of the reported kills were made by residents (65%), followed by natives (23%), and commercial outfitters (12%). Most of the moose harvested (96%) were bulls. Residents and outfitters are restricted to only bulls, and native harvest is mainly bulls (80%) (Quock and Jingfors 1988).

Long term harvest rates of resident hunters have averaged 23 moose/year between 1979 and 1991, and has been stable since 1985 (Figure 6). Hunter effort (number of days hunted) has also remained relatively constant (Figure 6), but the effort needed to kill a moose (days effort/kill) has declined (Figure 7). The mean effort/kill went from 26 days/kill between 1979-1984 to 18 days/kill between 1985-1991 (T-test: $P<0.05$). The decrease in effort to kill a moose is related to the doubling in moose density over this same period (see discussion). Outfitter and native harvest have remained relatively constant over the periods for which records are available (Figure 6).

Harvest was unevenly distributed within the NC survey area, with 30% (13 moose) of the 1987 to 1991 mean harvest (resident, outfitter, and native) occurring in one of the seven GMS's in this area, and the remaining harvest distributed over the remaining area (Appendix 3).

The MAH for the NC survey area, based on the 1991 survey results, is 125 moose (Appendix 5). The 1991 AAH of 84 moose/year allows for annual population growth of 5%. The AAH is approximately double to the estimated 1987-1991 mean harvest of 45 moose.

The AAH and the mean (1987-1991) harvest represent 8.4% and 4% of the 1991 total mean population estimate respectively and 10.3% and 5.5% of the adult and yearling population estimates. The MAH represents 12.5% of the total population and 15.3% of the non-calf population.

Frances Lake

The estimated moose population, corrected for sightabilty bias (SCF = 1.032) was 1,475 $\pm$21% (90% CI). Density was 381 moose/1,000 km^2 of habitable range (Table 3)(299 moose/1,000 km^2 of total range, Appendix 3). The finite rate of change in 1991 was 1.12 (12% annual growth) with existing harvest levels.

Estimated ratios were 44 calves and 41 yearlings/100 adult cows. The bull/cow ratio was 57 bulls/100 adult cows. The twinning rate was 4% and recruitment was 21% (Table 3).

Similar to NC, moose were unevenly distributed throughout FL where 69% of the observed moose were in 25% of the surveyed area (Figure 8). Eleven percent of SU's had $\geq$10 moose during the stratification. SU's with the highest moose densities ($\geq$0.76 moose/km^2) were located in the mountain complex west of North Lakes, between McEvoy Lake an the west arm of Frances Lake, around Tillei Lake, and the east arm of Frances Lake (Figure 4).

Harvest has been at a mean minimum rate of 42 ($\pm$3.3, $\pm$SE) moose per year since the 1987 survey (Figure 9). Most of the kills were made by residents (67%), followed by natives (26%) and outfitters (7%). Harvest rates and effort by resident hunters have remained relatively constant at a mean of 30 moose/year between 1979 and 1991, although there was a trend to declining harvest in the early 1980's (Figure 9). Days hunted/kill has not changed significantly ($P<0.05$) from a mean of 31 days/kill between 1979 and 1984, to 23 days/kill between 1985 and 1991. Outfitter and native harvest have remained constant over the study period (Figure 9).

The moose harvest (resident, outfitter, and native) was concentrated in the Finlayson and Frances Lake areas (Appendix 3). One GMS accounted for 26% (11 moose) of the mean known annual harvest from the FL survey area between 1987 and 1991. The remaining harvest (31 moose) was relatively evenly distributed throughout the rest of the FL area.

The MAH for the FL survey area was determined to be 168 moose/year (Appendix 5). In order to meet the objective of a 5% annual growth rate, the AAH could be as high as 108 moose/year. This is more than twice the 1987-1991 mean harvest of 42 moose.

The mean (1987-1991) harvest represents 2.8% of the total population and 3.4% of the non-calf population. The MAH represents 11.4% of the total and 13.9% of the non-calf populations.

Discussion

Comparison of Moose Demography between 1987 and 1991

North Canol

The moose population has increased significantly ($P<0.01$) from 515 ($\pm$17%) in 1987 to 950 ($\pm$13%) in 1991 (Appendix 6). This is an 85% increase over 4 years. These estimates are uncorrected for sightability bias (see methods). The mean annual finite rate of change between 1987-1991, assuming a constant rate of change, was 1.164 or 16.4% per year. Moose density in NC is among the highest in the Yukon, surpassed only by FL, Teslin Burn, and Carcross prior to 1983 (Appendix 1). The rate of population growth is the second highest, next to FL (Appendix 1).

Our observation rates of moose increased on both the stratification and census flights between 1987 and 1991 (Appendix 6). These data support the observations of local residents and Renewable Resources personnel (R. Hayes, A. Baer, R. Farnell, pers. comm.), that moose have increased substantially in recent years.

Although the moose population has increased dramatically (85%) over the past 4 years, recruitment rates were significantly lower in 1991 (17%) than in 1987 (24%). Assuming this decline in recruitment rate reflects a trend and mortality rates have remained constant, current population growth rates should be lower than in recent years. Information on recruitment rates and finite rate of change from Yukon and Alaska populations (YTG files) suggest that at the lower recruitment rate of 17%, this population should still be increasing (Figure 10).

The ratios of calves and yearlings/100 cows have also declined between surveys (Appendix 6). Both calf and yearling/100 cow ratios were lower in 1991 than 1987 (calves = 52 vs 64; yearlings = 38 vs 54). Although showing a trend, the ratio between year comparisons are not significantly different (x^2: P>0.05).

Moose distribution has remained similar between surveys. The proportion of SU's with ≥10 moose has increased significantly (P<0.01) from 2% to 8% between survey years; however, the cumulative percentage of moose seen vs cumulative percentage of surveyed area has remained unchanged (Figure 5). The location of higher density areas was consistent between surveys (see Figure 3 this report and Figure 2 in Jingfors 1988). These estimates are uncorrected for sightability bias (see methods).

Frances Lake

As in the NC area, the moose population has increased significantly (P<0.01) from 741 (±16%) in 1987 to 1,428 (±13%) in 1991 (Appendix 7). These estimates are uncorrected for sightability bias (see methods). This is a 93% increase over 4 years or a finite rate of change between surveys of 1.18 or 18% per year, one of the highest rates of change documented in the Yukon (Appendix 1). The density of 370/1,000 km^2 is also one of the highest observed in the Yukon. The observation rate of moose increased on both the stratification and census flights between 1987 and 1991 (Appendix 7).

Similar to NC, the moose population growth rate appears to be slowing down. Given the recruitment rate of 21% and an adult and yearling mortality rate of 12% (see methods section for explanation of calculation), the population should be increasing (finite rate = 1.12). However, recruitment rates have declined between 1987 and 1991. Both calf and yearling/cow ratios were lower in 1991 than in 1987 (calves = 44 vs 69; yearlings = 41 vs 65) (Appendix 7).

FL distribution trends followed those in NC. The proportion of SU's with ≥10 moose increased (P<0.01) from 2% to 11% between 1987 and 1991. However, cumulative percentages of moose seen vs cumulative percentage of area surveyed has remained unchanged (Figure 8). Suggesting a consistent pattern of post-rut aggregation of moose. The location of higher density areas has remained similar between years (see Figure 4 this report and Figure 3 in Jingfors 1988).

Effects of Wolf Control on Moose Numbers

The large increases in moose numbers between 1987 and 1991 in both NC and FL coincided with large reductions in wolf numbers (Figure 11). Wolf densities were annually reduced by 50-85% of the pre-reduction population between 1983 (9 wolves/1,000 km^2) and 1990 (3 wolves/1,000 km^2) throughout the FMMA (Figure 2, Farnell et al. unpubl. ms.). Neither moose data from inside the experimental area before wolf population reduction, nor control moose data from outside the experimental area are available. We cannot show an unequivocal cause and effect relationship between increased moose numbers and decreased wolf numbers. We can, however, infer that elevated moose densities were likely the result of wolf reduction because caribou numbers also increased in the same area over the same period. Unlike moose, caribou information was collected throughout the wolf control period (Farnell et al. unpubl. ms.). Strong correlations were documented between adult caribou mortality rates, recruitment, and population size with wolf numbers in the FMMA. Caribou increased significantly ($P<0.001$) at the same rate as moose. The finite rate of change for caribou was 1.17 between 1986 and 1990, and 1.18 for moose between 1987 and 1991.

The lower recruitment rate observed in the moose population in 1991 was also observed in the caribou population in 1990 (Farnell and Hayes). This coincides with an increase in wolf numbers. Wolves may be responsible for the drop in recruitment rates on moose as moose calves represent a large proportion of moose killed by wolves in late winter (R. Hayes, pers. comm.). If lower recruitment rates are the result of increased wolf numbers, it is likely due to a functional response rather than a numerical response on the part of the wolves. The moose/wolf ratio in 1987 was 53 moose/wolf, when recruitment rate (mean of NC and FL survey areas) for moose was 27%. In 1991, the ratio doubled to 108 moose/wolf but recruitment did not increase similarly. Rather, recruitment dropped to 19%. The decrease in recruitment may be partially explained by a higher predation rate due to a higher proportion of small wolf packs killing more moose (Hayes et. al. 1991).

Several models have been proposed to explain the relationship between moose and their predators. The single, low density dynamic equilibrium model (SLDDE) (Gasaway et. al. 1992) suggests that predation by wolves and bears will maintain moose populations at low densities. Moose densities may fluctuate over time, but will always be lower than habitat carrying capacity. Predation limits moose density by both density-dependent processes (wolf predation; Messier, in press.) and density-independent processes (bear predation; Schwartz and Franzmann, 1991; Boutin, 1992). The numbers of wolves will be governed by the availability of prey; however, bear density is not strongly influenced by prey density (Franzmann and Schwartz 1986; Boertje et. al. 1988; Larsen et. al. 1989). In areas where the SLDDE model may apply, moose are the primary prey species, and moose, wolves, and bears are all lightly exploited (Gasaway et. al. 1992). Under the SLDDE model, moose densities could be elevated through reduction of either wolves or bears. These elevated moose densities would subsequently decline after wolf or bear populations recovered.

Haber (1977) has proposed an alternate multiple-density equilibrium (MDE) model. In this model, moose can exist for extended periods at different densities. This model suggests that if predation is reduced on a low density, predator limited moose population, moose densities will increase to habitat carrying capacity and will remain high after predator populations recover.

While these models remain untested, they have profoundly different implications for the effectiveness of wolf control to elevate ungulate populations. If the SLDDE model is appropriate, wolf numbers would have to be dramatically reduced periodically or maintained at some level below natural densities. The frequency of periodic reductions would depend on the lag time between cessation of predator population reduction and subsequent decline in moose numbers, as well as the desired level of human use of the resource. If the MDE model is appropriate, a single dramatic reduction in predators will result in high numbers of prey indefinitely.

Our survey data to-date do not provide strong support for either the SLDDE or the MDE model. Future monitoring of moose, caribou, and wolf numbers will determine which model is appropriate in the FMMA.

Harvest

We believe recent harvest levels (1987-1991) to be within sustainable limits in all GMSs throughout the FMMA (Appendix 3). At current harvest levels, the overall moose population in the FMMA will continue to grow at a minimum annual rate of 5%, assuming recruitment and natural mortality rates remain relatively unchanged. Our assessment of harvest levels assumes: 1) our current harvest information is accurate and 2) the harvest is dispersed through the FMMA in proportion to moose abundance.

We consider the harvest data to be reasonably accurate. The 1990 check station resident harvest (39 moose) was similar to the questionnaire estimated kill (44 moose) from the same GMSs (Florkiewicz and Anderson 1992). We assume that the resident questionnaire harvest from other years is also accurate. Our assessment of native harvest is based on a comparison of the number of moose kills observed along the Campbell Highway in late winter by departmental personnel (B. Hayes, pers. comm.) and the native harvest survey results (Quock, in prep.). A minimum of 8 moose kills were observed in 1990 and 18 in 1992. The reported native harvest for the same area was similar in both 1990 (3 moose) and 1991 (17 moose). In addition, 11 moose were reported killed by natives at the North Canol check station in the fall of 1991 (Florkiewicz and Anderson, 1991). Over the entire year, 16 were documented from the native harvest survey.

Distribution of the harvest throughout each GMS - AAH is calculated on an area (km^2) basis; therefore, the allowable harvest levels in Appendix 3 and Figure 2 are for the entire GMS. If the harvest for the entire GMS is concentrated in only a portion of the GMS, local overharvest could occur. For example, we have calculated an allowable harvest of 84 moose within the NC survey area (Appendix 5) which includes portions of 7 GMSs (Figure 2). The allowable harvest for the whole of these 7 GMSs is 221 moose (Appendix 3). If 221 moose were taken from within the survey area (i.e., along the NC Road), a local overharvest would occur. Currently, the mean (1987-1991) harvest (45 moose) is below the AAH for the survey area, and less than half the AAH for the larger area.

Distribution of the harvest throughout the management area in proportion to local moose abundance would minimize the effects of harvest on the moose population and would improve hunting opportunities. Hunting effort should be directed into GMSs which are substantially below the AAH, and away from areas where the mean harvest approaches the AAH. This would mean directing any additional harvest away from the North Canol and Robert Campbell highways and into the more remote portions of the management area.

A late-winter harvest could also provide additional hunting opportunities without negatively impacting the moose population. In late winter, moose from remote (unharvested) areas move into areas near Ross River and along the Campbell Highway. This shift in distribution was documented between the fall of 1981 and late-winter 1982 (Markel and Larsen 1986), and is likely in response to snow accumulations along the flanks of the Logan Mountains. A late-winter hunting strategy should be approached with caution, because: 1) moose which are concentrated on wintering areas are vulnerable to overhunting and disturbance, 2) it would be impossible to distinguish between local resident moose and migratory moose when both occur in the same area, potentially leading to overharvesting of local populations.

The challenge is to develop a harvest strategy that maintains harvest within sustainable limits, in a system where the AAH is dynamic. The suggested trend to lower recruitment values since 1991 should be monitored if possible. If the adult and yearling survivorship was 5% lower (in appendix 5 calculations) the MAH would be 66 vs 125 and the AAH would be 25 rather than 84. Harvest along the North Canol and Campbell Roads should not exceed the current level unless the harvest is spread over a large area, recruitment increases, or desired growth rates are reduced.

RECOMMENDATIONS

Population Monitoring Strategies

The moose population status should be closely monitored to determine which theoretical predator-prey model applies, and to fine-tune sustainable harvest levels. Changes in moose population size should be assessed with another census in 3-5 years, depending upon changes in wolf densities and results of trend surveys. At least one trend survey should be flown annually to obtain an index to changes in density.

Local knowledge of changes in moose numbers can be used to supplement scientific data. A technique should be developed to collect and qualify this information. Local knowledge and survey information should be compared as soon as adequate data is available to determine if local knowledge is a reliable index to population trend.

Harvest Strategy

1. Accurate harvest information should be obtained from all user groups for the FMMA. This would require a compulsory reporting system for all groups. We are presently unable to legislate native harvest reporting, however, we recommend that compulsory reporting of resident harvest be enforced as soon as possible. Outfitter harvest is already obtained through compulsory reporting.

2. The North Canol check station should continue to operate until compulsory reporting is implemented. This will allow us to continue testing the accuracy of the harvest questionnaire and native harvest information.

3. The harvest along the North Canol Road and Campbell Highways should not exceed the 1987-1991 mean harvest levels. Incentives should be offered to encourage hunting effort and harvest away from these two roads. Longer season lengths in inaccessible GMSs is one possible method to attract hunting away from road corridors.

If moose recruitment and numbers decline as wolf numbers increase (SLDDE model), we must be prepared to adjust harvest rates so as not to hasten a decline. Adjustment in harvest strategies may be required on short notice. To this end, we recommend continued development and implementation of more accurate and responsive harvest management systems. The permit hunt and the registration hunt system, both used elsewhere in the Yukon, are examples of the types of harvest management systems that could be implemented in this area.

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Table 1. Search intensity (min./km²) during November moose surveys in the North Canol and Frances Lake areas, 1991.

SURVEY/AIRCRAFT	SURVEY AREA		
	N. CANOL	FRANCES	COMBINED
Stratification (fixed wing)			
Area (km^2)	2,954	3,870	6,824
Time (minutes)	1,131	1,607	2,738
Search Intensity (min./km^2)	0.38	0.42	0.40
Survey (helicopter)			
Area (km^2)	1,129	1,490	2,619
Time (minutes)	2,523	2,834	5,357
Search Intensity (min./km^2)	2.24	1.90	2.05
Sightability Correction Factor (helicopter)			
Area (km^2)	21	17	38
Time (minutes)	126	100	226
Search Intensity (min./km^2)	6.00	5.88	5.95

Table 2. Sampling intensity of habitable moose range by survey and stratum area during early-winter census in the North Canol and Frances Lake areas, 1991.

SURVEY AREA	STRATUM				
	LOW	MEDIUM	HIGH	EXTREMELY HIGH	TOTAL
North Canol					
# of SU* in area (% of total)	137(79)	22(13)	14(8)	NA	173(100)
# of SU* censused (% of total)	40(29)	11(50)	14(100)	NA	65(38)
Frances					
# of SU* in area (% of total)	167(77)	30(14)	15(7)	5(2)	217(100)
# of SU* censused (% of total)	56(34)	13(43)	9(60)	5(100)	83(38)

*Sample Unit

Table 3. Estimated moose abundance and composition (adjusted for sightability) in the North Canol and Frances Lake survey areas, November 1991.

NORTH CANOL

	STRATUM				
	HIGH	**MEDIUM**	**LOW**	**TOTAL (90% CI)**	**% OF TOTAL**
Estimated Abundance					
Total moose[a]	322	248	431	1001±18%	-
Density (moose/1,000 km^2)	1,113	620	190	339	-
Estimated Composition[a]					
Adult bulls (≥30 mo.)	105	67	149	321±25%	32
Adult cows (≥30 mo.)	112	83	164	359±23%	36
Yearlings (≥18 mo.)[b]	61	45	30	136±29%	14
Calves	44	53	89	186±24%	19
Estimated Ratios					
Adult bulls/100 adult cows	93	80	91	90±21%	-
Yearlings/100 adult cows	54	54	18	38±21%	-
Calves/100 adult cows	39	63	55	52±12%	-
Twinning Rate[c]				9%	

Table 3. continued

FRANCES LAKE

	STRATUM					
	EXTRA HIGH	**HIGH**	**MEDIUM**	**LOW**	**TOTAL (90% CI)**	**% OF TOTAL**
Estimated Abundance						
Total moose[d]	166	353	328	627	1,475±21%	-
Density (moose/1,000 km^2)	1,506	1,254	589	215	381	-
Estimated Composition[a]						
Adult bulls (≥30 mo.)	45	90	84	128	348±27%	24
Adult cows (≥30 mo.)	71	129	124	284	609±21%	41
Yearlings (≥18 mo.)[b]	21	74	81	81	252±35%	17
Calves	29	60	43	134	267±24%	18
Estimated Ratios						
Adult bulls/100 adult cows	64	70	67	45	57±16%	-
Yearlings/100 adult cows	29	57	62	29	41±23%	-
Calves/100 adult cows	41	47	35	47	44±13%	-
Twinning Rate[c]					4%	

a. Adjusted for sightability bias (number observed *1.054).
b. Total yearlings were calculated by doubling the observed number of yearling males
c. Twinning rate = number of cows with twins divided by total number of cows with calves in November.
d. Adjusted for sightability bias (number observed *1.032).

Appendix 1. Summary of November Yukon moose survey results (revised 1992). Estimates are not corrected of sightability bias.

SURVEY BLOCK	SURVEY AREA (KM^2)	YEAR	ESTIMATED TOTAL 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	ESTIMATED POPULATION STATUS OBSERVED PREDICTED	AVERAGE % HARVEST[1]
1. Kluane	3755	1981	120	54	27	17	.15		stable	5
2. Aishihik	3626	1981	107	66	31	23	.16	-3%	slow	4
		1990	82	62	21	53	.12		decline (between 1981-1990)	.
3. Whitehorse North	3108	1982	170	45	1	6	.04		rapid decline	2
4. Haines Junction	2332	1981	244	34	19	40	.13			3
		1982	151	37	3	11	.02	-17%	rapid decline	
		1983	145	32	1	7	.01		(between 1981-1984)	
		1984	141	42	1	20	.01	+7%	slow increase	
		1990	223	50	31	41	.17		(between 1984-1990)	
5. Whitehorse South	2613	1981	232	33	27	20	.17			6
		1982	223	31	2	26	.02	+3%		
		1983	249	42	4	30	.03		(between 1981-1986)	
		1986	274	27	18	31	.13		slow increase	

SURVEY BLOCK	SURVEY AREA (KM^2)	YEAR	ESTIMATED TOTAL 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	ESTIMATED POPULATION STATUS OBSERVED PREDICTED	AVERAGE % HARVEST[1]
6. Carcross	916	1980	443	51	41	37	.21			2
		1982	328	76	76	9	.01	-25%	rapid decline (between 1980-1983)	
		1983	187	51	51	4	.03			
7. Teslin Burn	2515	1982	550	39	12	19	.08			4
		1983	431	30	1	30	.01	-13%	rapid decline (between 1982-1984)	
		1984	417	66	13	39	.07			
8. Nisutlin	4248	1986	130	89	36	49	.16		stable to slow increase	4
9. Liard West	7236	1983	116	75	18	18	.09		decline	4
10.Liard East	2227	1986	140	79	37	51	.17		stable to slow increase	6
11.North Canol	2744	1987	190	66	54	64	.24	16%	rapid increase (between 1987-1991)	6
	2954	1991	321	90	38	52	.17			
12.Frances Lake	3894	1987	190	55	65	69	.29	+18%	rapid increase (between 1987-1991)	4
	3870	1991	370	57	41	44	.21			
13.Dromedary	3700	1982	65	37	1	15	.01		rapid decline	7

SURVEY BLOCK	SURVEY AREA (KM^2)	YEAR	ESTIMATED TOTAL 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	ESTIMATED POPULATION STATUS — OBSERVED PREDICTED	AVERAGE % HARVEST[1]
14. Casino Trail	3055	1987	40	--[2]	--[2]	--[2]	unknown		stable to decline	3
15. Mayo North	2235	1988	128	49	42	68	.22		rapid increase	2
16. Mayo South	2616	1988	148	76	11	56	.06		decline	2
17. Dawson East	2611	1989	269	65	41	76	.20		rapid increase	1
18. Dawson West	1870	1989	168	105	25	45	.11		stable to slow decline	2
Yukon Wide Average	51,601[3]	--	218	58	22	33	.11			4

1. Mean (1987 to 1990) harvest (resident, non-resident, native) expressed as a percentage of estimated adult and yearling population.
2. Sample size too small to accurately determine sex and age ratios.
3. Total area surveyed = approximately 20% of Yukon.

Appendix 2. Examples of calculations of finite rates of change.

a) Between the 1987 and 1991 North Canol surveys.

exponential rate of change (r) =

$$\frac{\log_e \text{population estimate time}_2 - \text{loge population estimate at time}_1}{\text{Number of years between surveys}}$$

$$= \frac{\log_e 950 - \log_e 516}{4}$$

$$= \frac{6.86 - 6.25}{4}$$

$= 0.15$

finite rate (λ) $= e^r$

$= 2.7183^{0.15}$

$= 1.164$

% change $= (\quad -1)\ 100$

$= 16.4\%$

b) Between 1991 and 1992 in the North Canol survey area

finite rate = (1-M) ÷ (1-R) ; where R = estimated recruitment in 1991

of $M = 1-[\hat{\lambda}\ (1-R)]$ where R = mean recruitment in 1987 (0.24) and 1991 (0.17)

$M = 1-[1.164\ (1-0.21)]$

$M = 0.080$ or 8.0%

finite rate of change $= (1 - 0.08) \div (1 - 0.17)$

$= 1.11$

a) Between the 1987 and 1991 Frances Lake surveys.

$$= \frac{\log_e 1428 - \log_e 741}{4}$$

$$= \frac{7.26 - 6.608}{4}$$

$$= \frac{.656}{4}$$

$$= .164$$

finite rate ($\hat{\lambda}$) $= e^r$

$= 2.7183^{0.164}$

$= 1.178$ (1.18)

% change $= (\hat{\lambda} - 1)\ 100$

$= 17.8\%$

b) Between 1991 and 1992 in the Frances Lake survey area

finite rate = (1-M) ÷ (1-R), where R = estimated recruitment in 1991.

of M = 1-[$\hat{\lambda}$ (1-R)] where R = mean recruitment in 1987 (0.29) and 1991 (0.21)

M = 1-[1.178 (1-0.25)]

M = 0.117 or 11.7%

finite rate of change = (1 - .117) ÷ (1 - .21)

= 1.12

Appendix 3. Summary of moose numbers, mean harvest (1987-1991), maximum allowable harvest[2] and adjusted allowable harvest [3] by Game Management Subzone in the Finlayson moose management area.

GMS	AREA KM^2	MOOSE/1,000 KM^2 TOTAL AREA[1]	TOTAL MOOSE	MEAN HARVEST 1987-1991				1992[2] MAH	1992[3] AAH
				RESIDENT	NON-RESIDENT	INDIAN	TOTAL		
GMS all or partially censused during the North Canol survey									
4-39	1,085	328	356	5	0	1	6	44	30
4-40	1,900	328	623	7	5	2	14	78	52
4-49	947	328	310	2	0	5	7	39	26
11-02	1,438	328	471	8	0	0	8	59	40
11-05	763	328	250	1	0	1	2	31	21
11-06	671	328	220	1	0	1	2	28	18
11-07	1,239	328	406	5	0	1	6	51	34
Subtotal	8,046		2,636	28	5	10	45	327	221
GMS all or partially censused during the Frances Lake Survey									
10-07	1,880	299	562	8	2	1	11	64	41
11-15	1,222	299	365	4	0	1	5	41	27
11-16	1,088	299	325	2	0	3	5	37	24
11-17	427	299	128	3	0	1	4	14	9
11-18	958	299	286	1	1	0	2	32	21
11-20	1,030	299	308	3	0	0	3	35	22
11-21	285	299	85	3	0	0	3	10	6
11-22	483	299	144	2	0	4	6	16	11
11-23	1,321	299	395	2	0	1	3	45	29
Subtotal	8,699		2,598	28	3	11	42	294	190

GMS	AREA KM²	MOOSE/1,000 KM² TOTAL AREA[1]	TOTAL MOOSE	MEAN HARVEST 1987-1991				1992[2] MAH	1992[3] AAH
				RESIDENT	NON-RESIDENT	INDIAN	TOTAL		
Unsurveyed GMS within the Finlayson Moose Management Area									
4-50	462	328	151	1	0	3	4	19	13
10-05	1,236	328	405	2	0	2	4	51	34
10-06	1,463	328	480	1	2	1	4	60	40
10-08	1,640	299	492	3	1	3	7	55	36
10-09	816	299	244	0	2	0	2	28	18
10-19	550	299	165	2	0	4	6	19	12
11-03	251	299	75	1	0	0	1	8	5
11-04	871	299	261	0	0	0	0	29	19
11-08	917	328	300	1	0	2	3	38	25
11-09	2,813	328	922	3	0	5	8	115	77
11-10	861	328	282	2	0	0	2	35	24
11-11	672	299	201	1	0	0	1	23	15
11-12	1,012	299	304	0	0	0	0	34	22
11-13	659	299	197	0	0	0	0	22	14
11-14	916	299	275	4	0	0	4	31	20
Subtotal	15,145		4,761	21	5	20	46	567	374
TOTAL	31,890		10,009	77	13	41	131	1188	785

1. Extrapolated densities based on moose/total area within the NC and FL survey areas, includes area considered to be non-moose range.
2. MAH for areas with 328 moose/1,000 km² is 12.5% of total moose and 11.3% for areas with 300 moose/1,000 km². An example of how these percentages were calculated follows: MAH in NC (328 moose/1,000 km² total area) is 125 moose over 3,050 km² total area or 41 moose/1,000 km². This represents 12.5% of the total population density (41/328).
3. AAH for areas with 328 moose/1,000 km² is 8.4% of total moose and 7.3% for areas with 300 moose/1,000 km².

Appendix 4. Summary of cost (x 1,000) associated with aerial moose surveys in 1991.

Aircraft[a]	Fixed wing	22.0 (including fuel)
	Helicopter	62.3 (including fuel)
Food and Lodging		11.6
Miscellaneous		3.1
Personnel[b]		8.5
TOTAL		107.5

a. Aircraft costs (dry) were $200/hour f.w.; $500/hour helicopter.

b. Personnel costs (except for the two authors) are included - total of 148 person days between 13 people (excluding preparation and write-up) were needed to conduct the survey.

Appendix 5. Calculations of allowable moose harvest in the North Canol and Frances Lake survey areas, 1991.

Maximum Allowable Harvest

Methods:

A. (((ad + yrlg) x ad and yrlg survival rate) - ad) + 1987-1991 mean harvest

1. North Canol Survey Area

(((815) x 0.92) - 680) + 45 = 115 moose

2. Frances Lake Survey Area

(((1,208) x 0.88) - 956) + 42 = 149 moose

B. (finite rate of change in 1991 x ad and yrlg) + 1987-1991 mean harvest

1. North Canol Survey Area

(0.11 x 815) + 45 = 135 moose

2. Frances Lake Survey Area

(0.12 x 1,208) + 42 = 187 moose

C. Mean of A and B

1. (115 + 135) ÷ 2 = 125 moose

2. (149 + 187) ÷ 2 = 168 moose

Adjusted Allowable Harvest

A. (Maximum allowable harvest) - (0.05 x ad an yrlg)

1. North Canol Survey Area

125 - (0.05 x 815) = 84 moose

2. Frances Lake Survey Area

168 - (0.05 x 1,208) = 108 moose

Appendix 6. Summary of moose survey results from the North Canol survey area, November 1987 and 1991 (estimated values have NOT been adjusted for sightability bias).

Population Characteristics	**1987**	**1991**
Estimated abundance with 90% CI		
Total moose[1]	516±17%	950±13%
Density (moose/1,000 km^2)	188	321
Estimated composition with 90% CI [% of total population]		
Adult bulls (≥30 mo.)	121±23% [23]	304±20% [32]
Adult cows (≥30 mo.)	183±22% [36]	341±17% [36]
Yearlings (≥18 mo.)	96±27% [19]	129±24% [14]
Calves	116±24% [23]	176±19% [19]
Observed composition		
Adult bulls	66	169
Adult cows	65	188
Yearlings	50	86
Calves	50	90
TOTAL	231	533
Estimated ratios with 90% CI		
Adult bulls/100 adult cows	66±27%	89±21%
Yearlings/100 adult cows	54±31%	38±32%
Calves/100 adult cows	64±14%	52±12%
Observed ratios		
Adult bulls/100 adult cows	101	90
Yearlings/100 adult cows	77	46
Calves/100 adult cows	77	48
Twinning rate	10%	9%
Survey Characteristics		
Stratification		
Area (km^2)	2,744	2,954
Time (minutes)	1,207	1,131
Search intensity (min./km^2)	0.439	0.383
Moose seen	238	408
Moose seen/min.	0.197	0.361
Dates	Nov. 6-9	Nov. 5-8

Census

	1987	1991
Area (km^2)	971	1,129
Percentage of survey area searched	35%	38%
Time (minutes)	1,679	2,523
Search intensity (min./km^2)	1.729	2.235
Moose seen	231	533
Moose seen/min.	0.138	0.212
Dates	Nov. 12-16	Nov. 8-14

1. Population estimates are significantly different between 1987 and 1991 ($P < 0.01$), one-tailed student t-test.

Appendix 7. Summary of moose survey results from the Frances Lake survey area, November 1987 and 1991 (estimated values have NOT been adjusted for sightability bias).

Population Characteristics	**1987**	**1991**
Estimated abundance with 90% CI		
Total moose[1]	741±16%	1,428±13%
Density (moose/1,000 km^2)	190	370
Estimated composition with 90% CI [% of total population]		
Adult bulls (≥30 mo.)	143±25% [19]	337±18% [24]
Adult cows (≥30 mo.)	255±18% [34]	589±14% [41]
Yearlings (≥18 mo.)	166±35% [24]	258±16% [18]
Calves	177±21% [24]	258±16% [18]
Observed composition		
Adult bulls	64	174
Adult cows	97	289
Yearlings	64	124
Calves	70	125
TOTAL	295	712
Estimated ratios with 90% CI		
Adult bulls/100 adult cows	55±37%	57±16%
Yearlings/100 adult cows	65±41%	42±23%
Calves/100 adult cows	69±11%	44±13%
Observed ratios		
Adult bulls/100 adult cows	66	60
Yearlings/100 adult cows	66	43
Calves/100 adult cows	72	43
Twinning rate	5%	4%
Survey Characteristics		
Stratification		
Area (km^2)	3,894	3,870
Time (minutes)	1,200	1,607
Search intensity (min./km^2)	0.308	0.415
Moose seen	341	804
Moose seen/min.	0.284	0.500
Dates	Nov. 18-20	Nov. 16-19

Census

	1987	1991
Area (km^2)	862	1,490
Percentage of survey area searched	22%	39%
Time (minutes)	1,306	2,834
Search intensity (min./km^2)	1.515	1.902
Moose seen	295	712
Moose seen/min.	0.226	0.251
Dates	Nov. 21-23	Nov. 19-26

1. Population estimates are significantly different between 1987 and 1991 ($P < 0.01$), one-tailed student t-test.

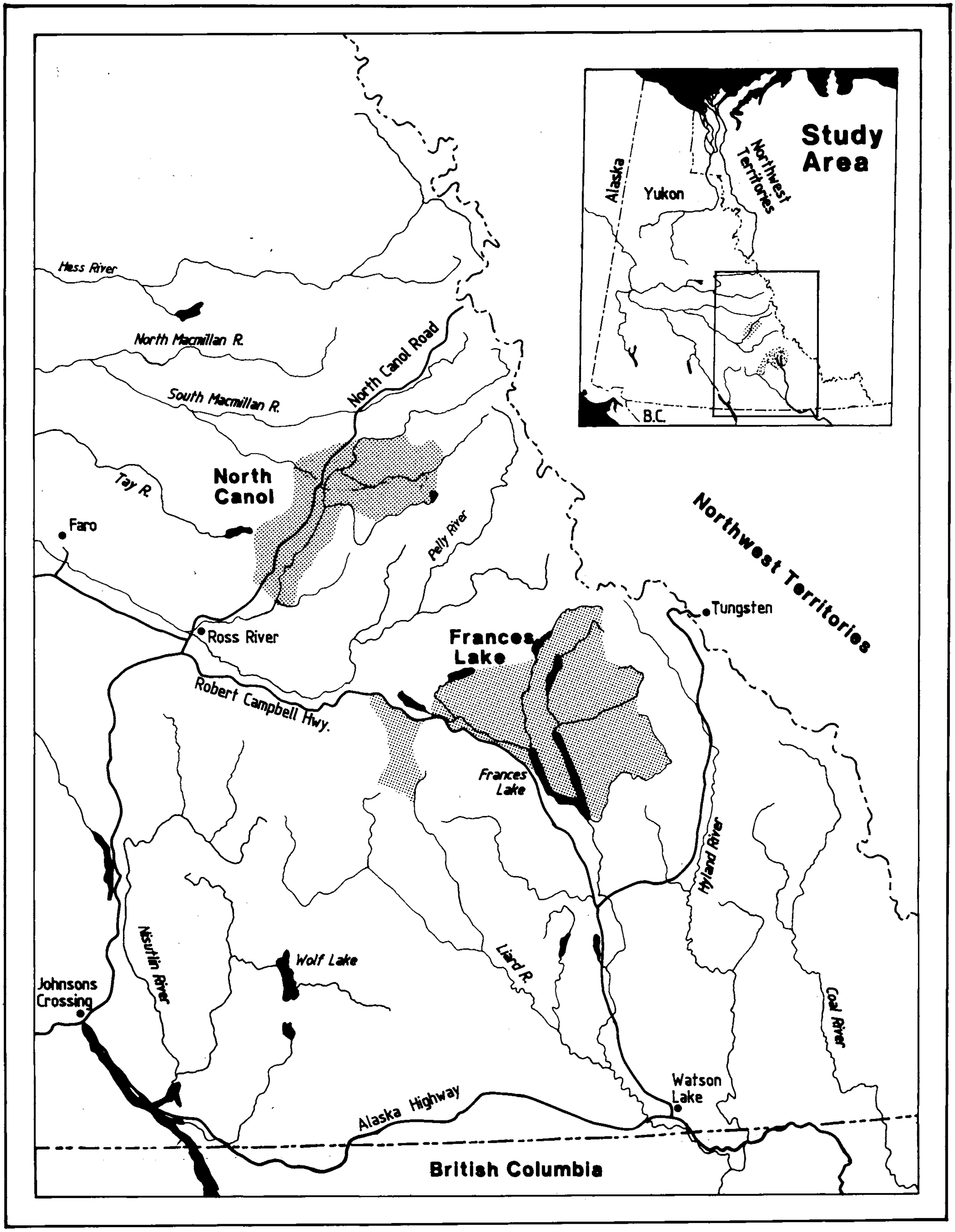

Figure 1. Moose survey areas, 1991.

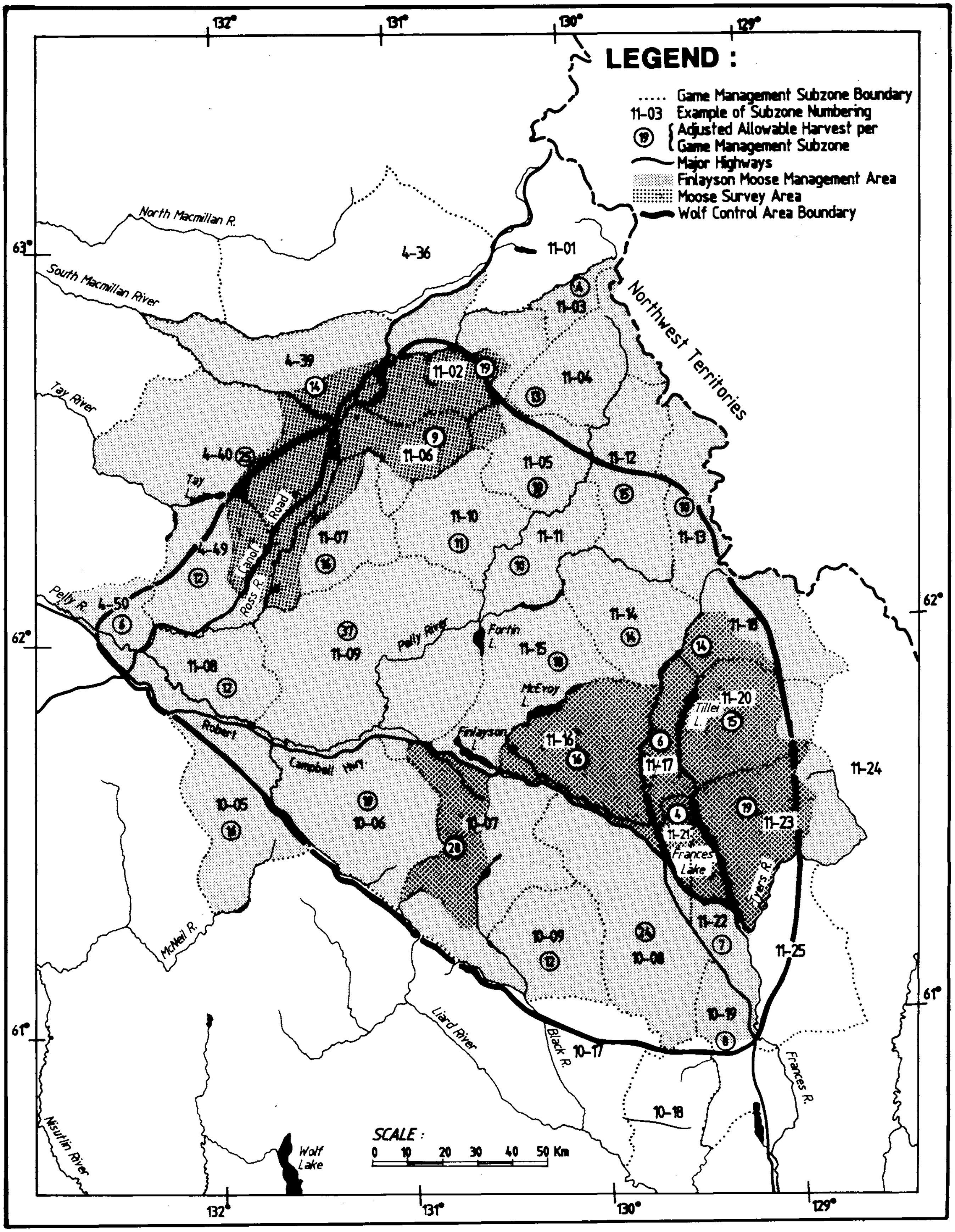

Figure 2. Spatial relationship among 1991 moose survey areas, wolf reduction area, game management subzones, Finlayson moose management area, and allowable harvest.

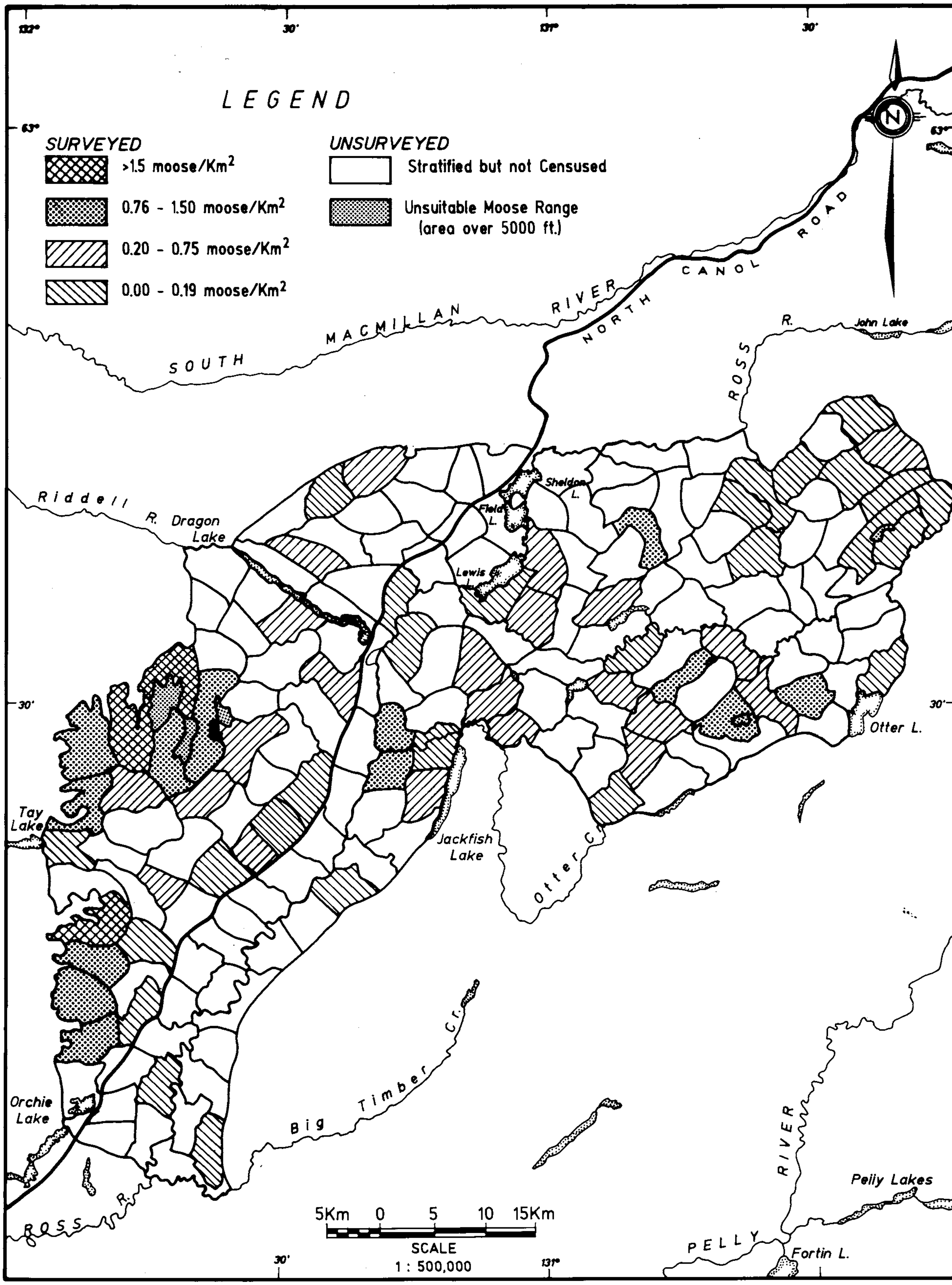

Figure 3. Distribution of moose in the North Canol survey area, 1991.

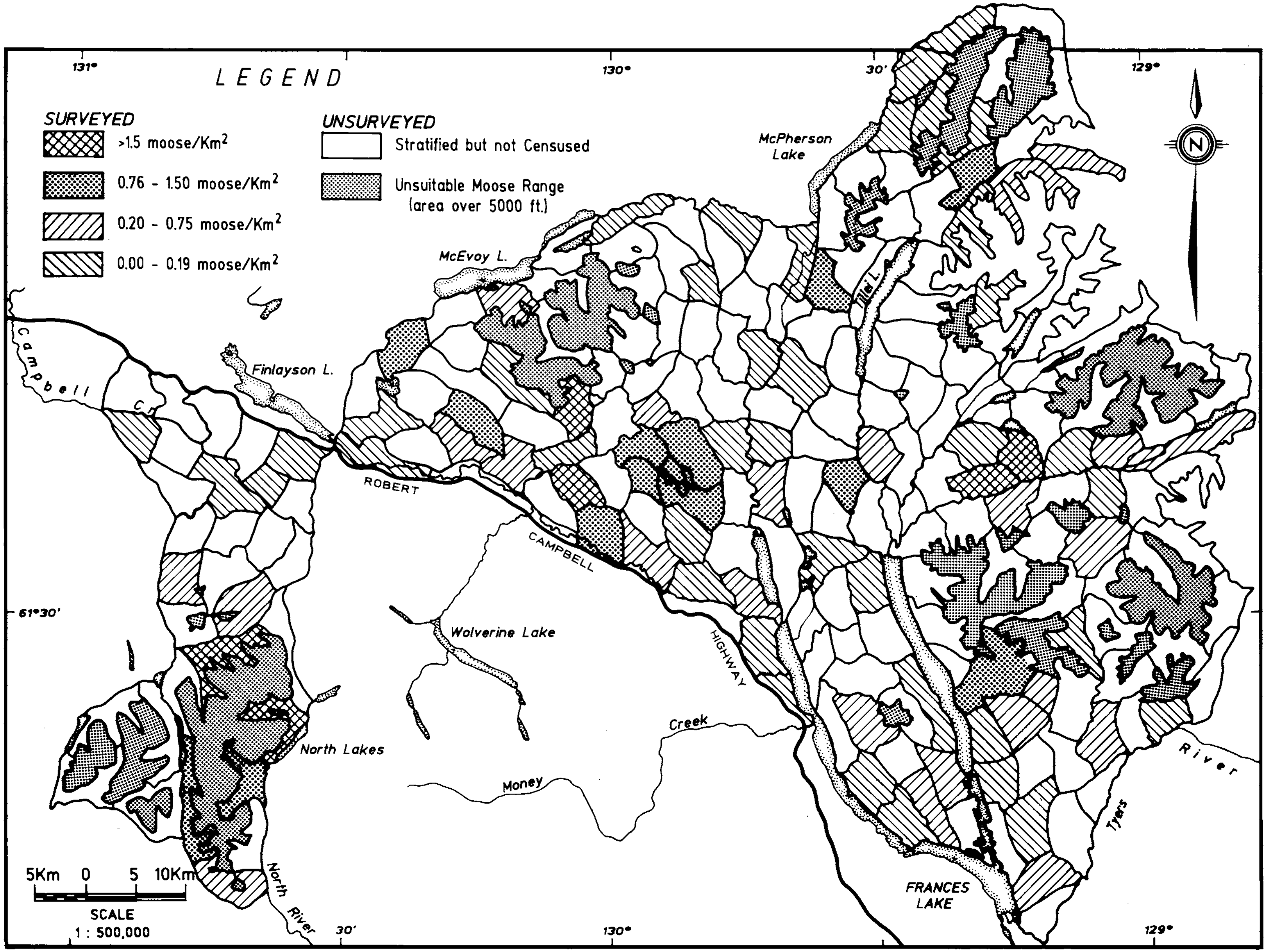

Figure 4. Distribution of moose in the Frances Lake survey area, 1991 (density categories based on census rather than stratification results).

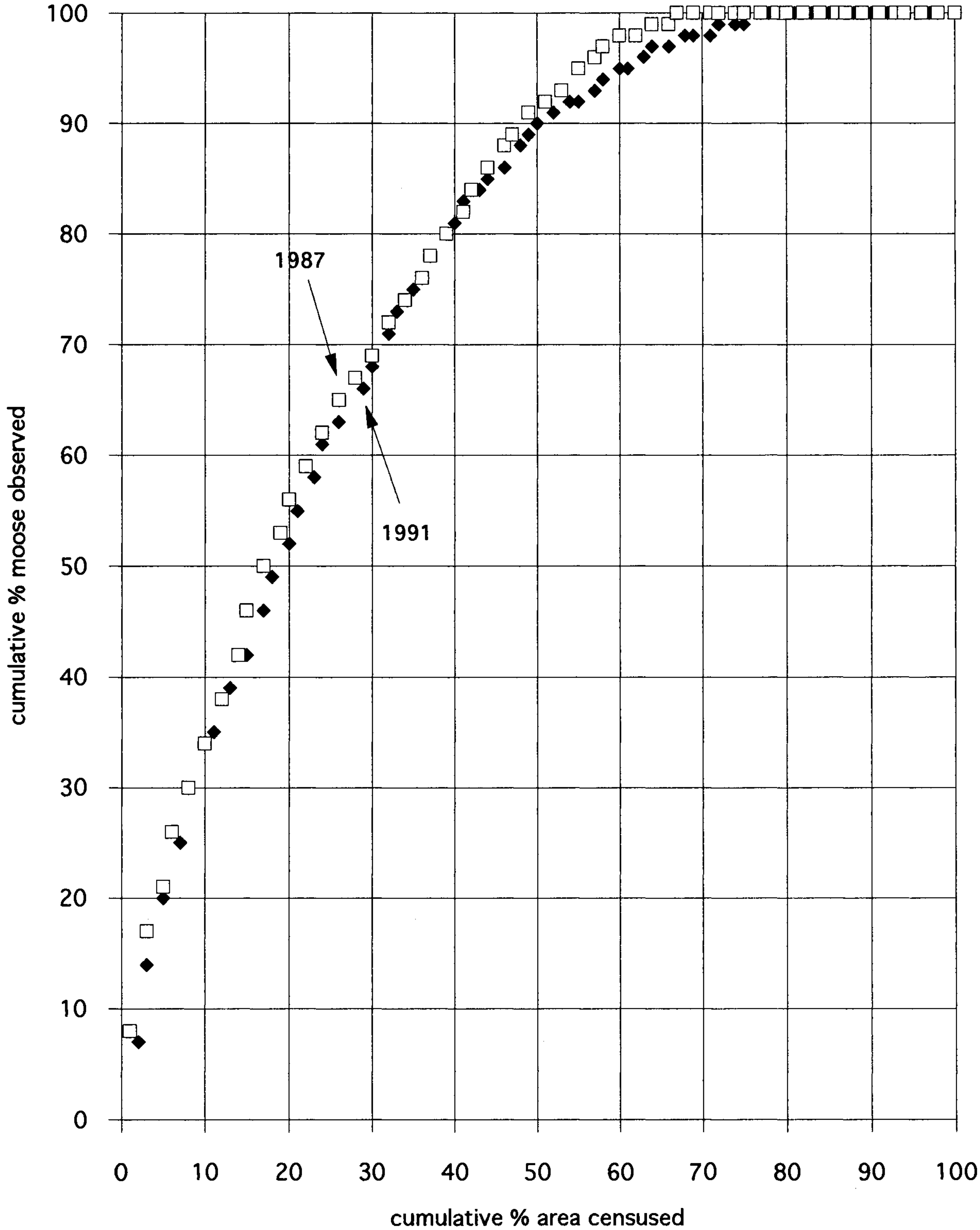

Figure 5. Comparison between cumulative percentage of moose observed and cumulative percentage of areas censused in the North Canol survey area in 1987 and 1991.

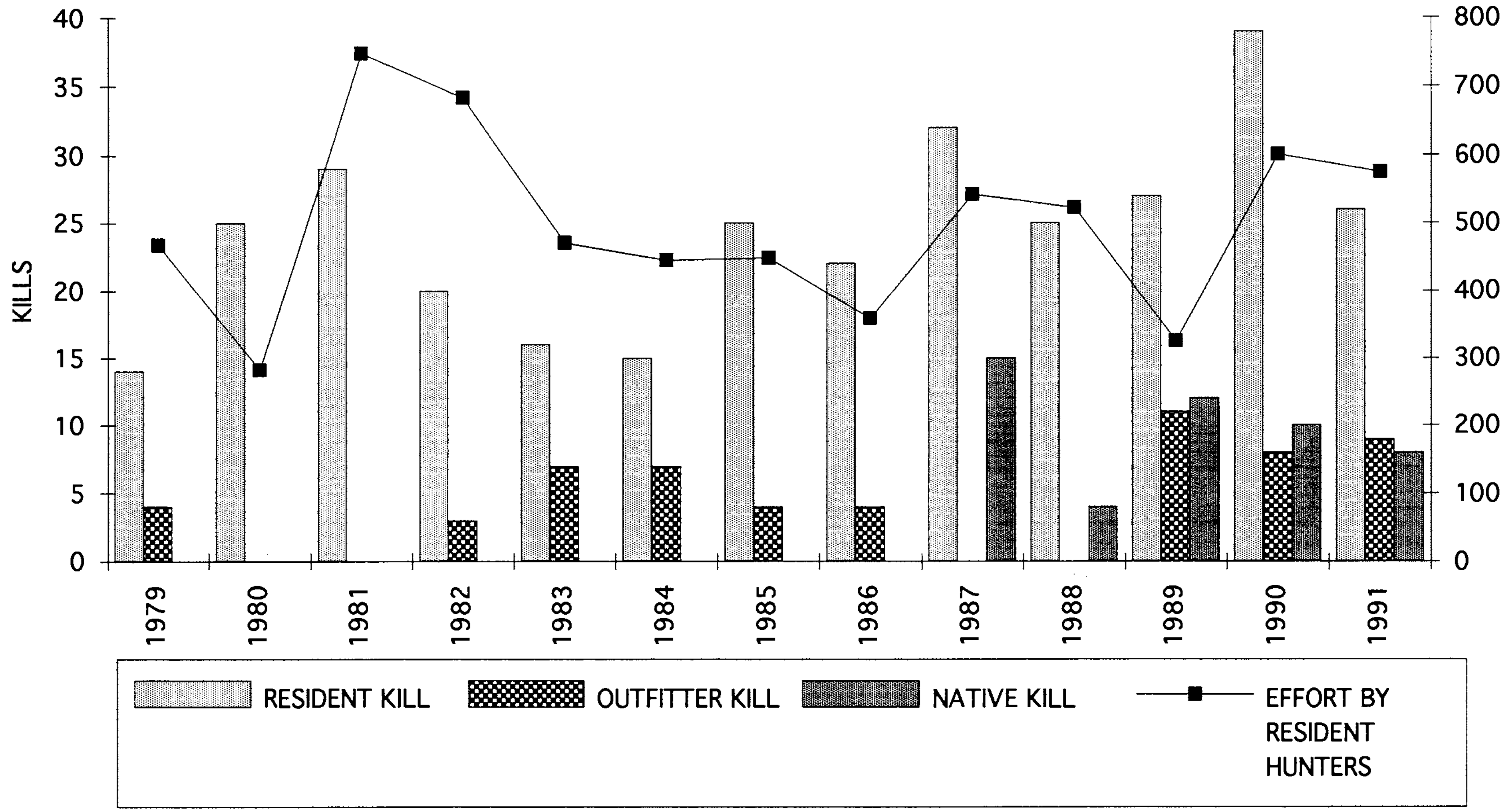

Figure 6. Reported moose harvest and days effort by resident hunters, and harvest by outfitters and First Nation hunters in the North Canol survey area, 1979-1991.

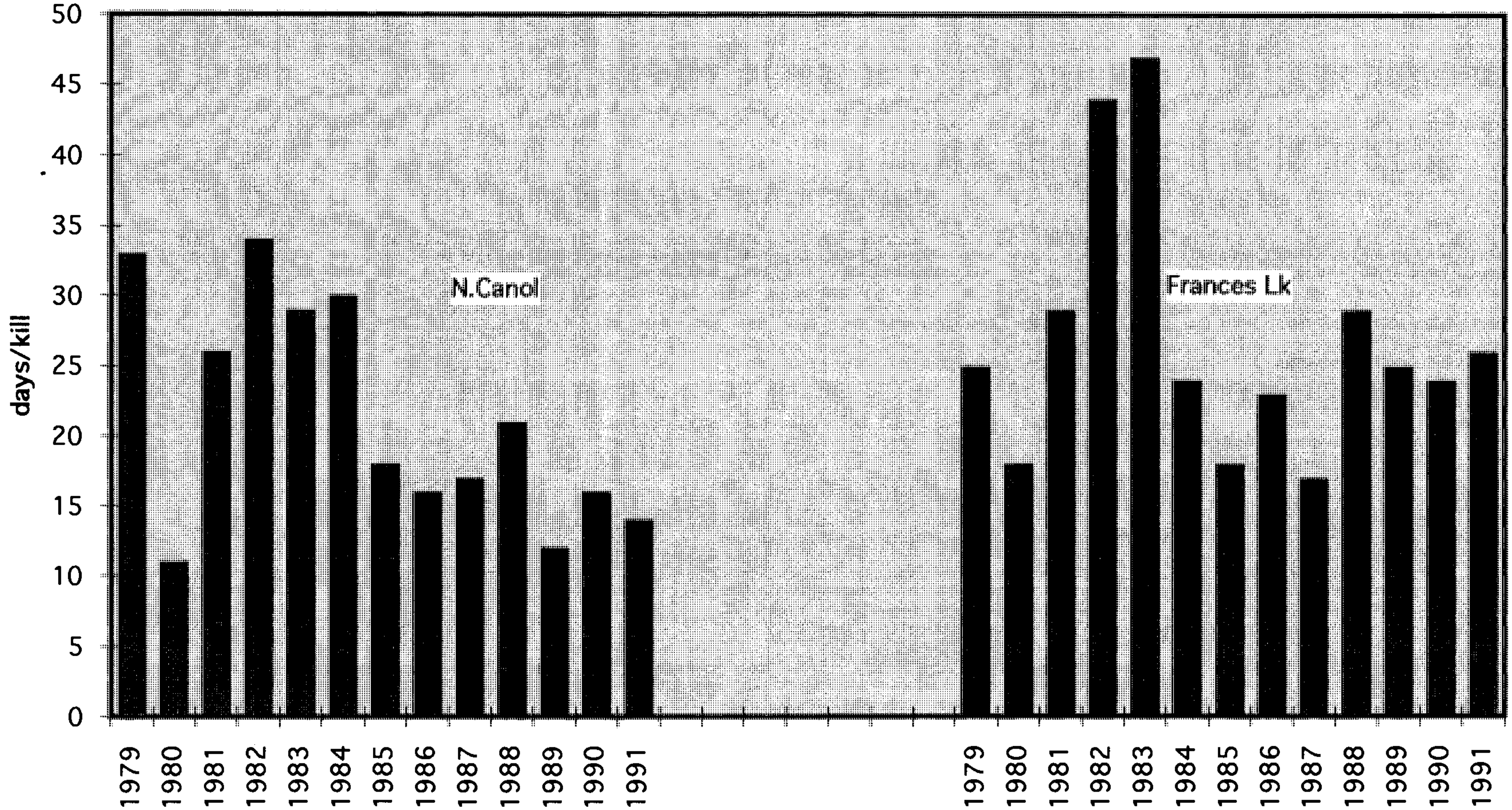

Figure 7. Resident moose hunter days effort/kill in the North Canol and Frances Lake survey areas, 1979-1991.

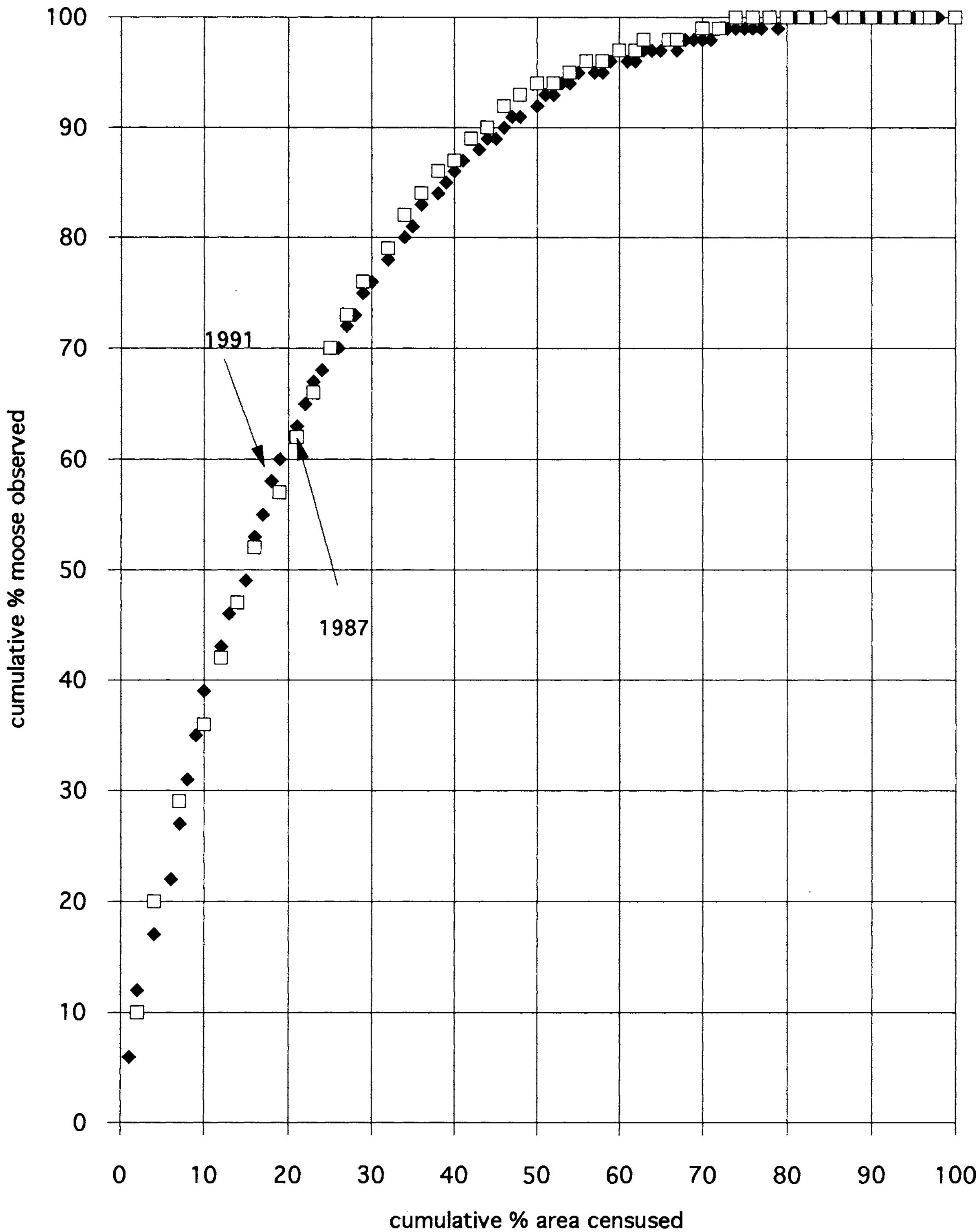

Figure 8. Comparison between cumulative percentage of observed moose and percentage of area censused in the Frances Lake survey area in 1987 and 1991.

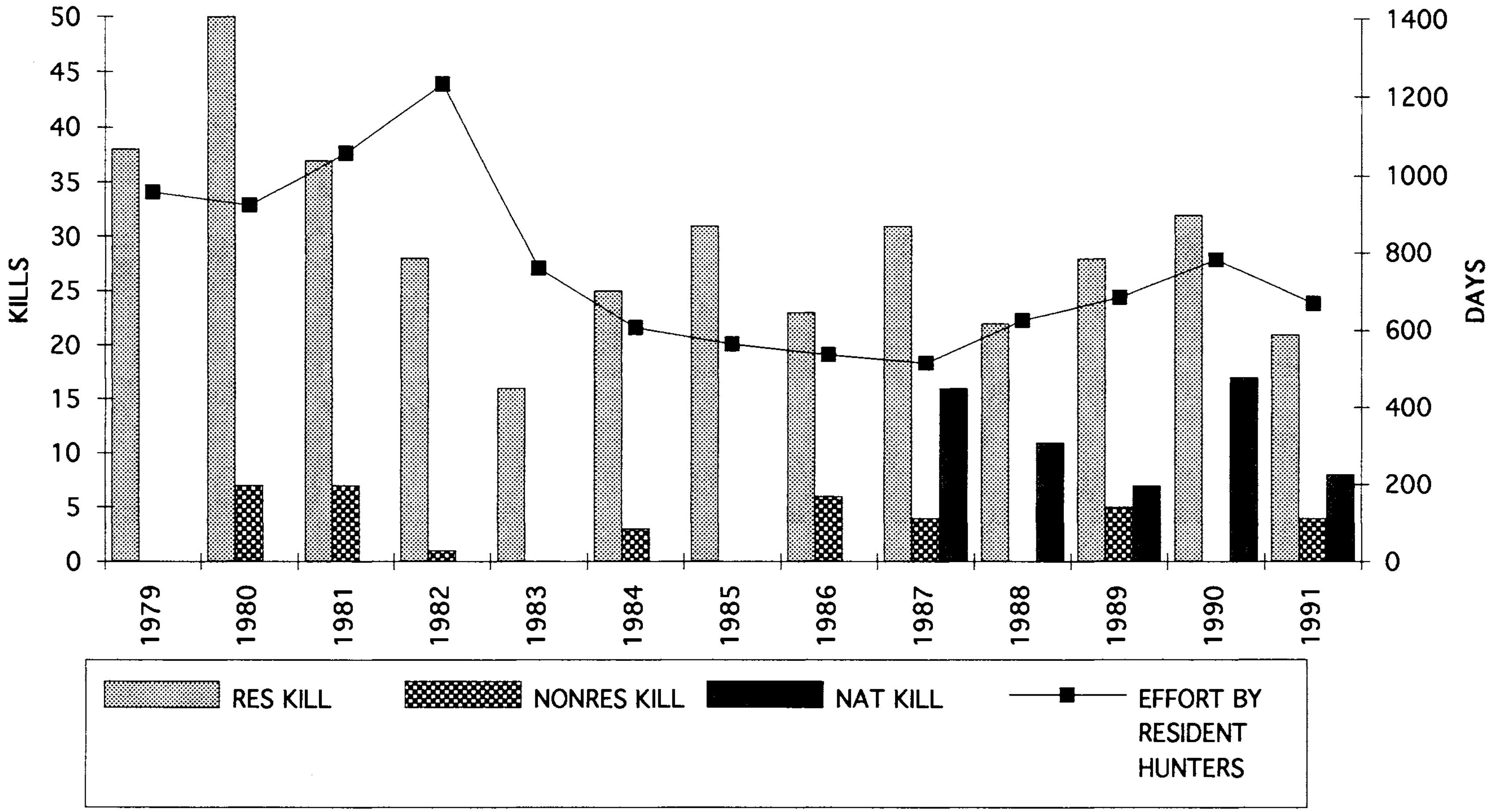

Figure 9. Moose harvest and days effort by resident hunters, and harvest by outfitters and First Nation hunters in the Frances Lake survey area, 1979-1991.

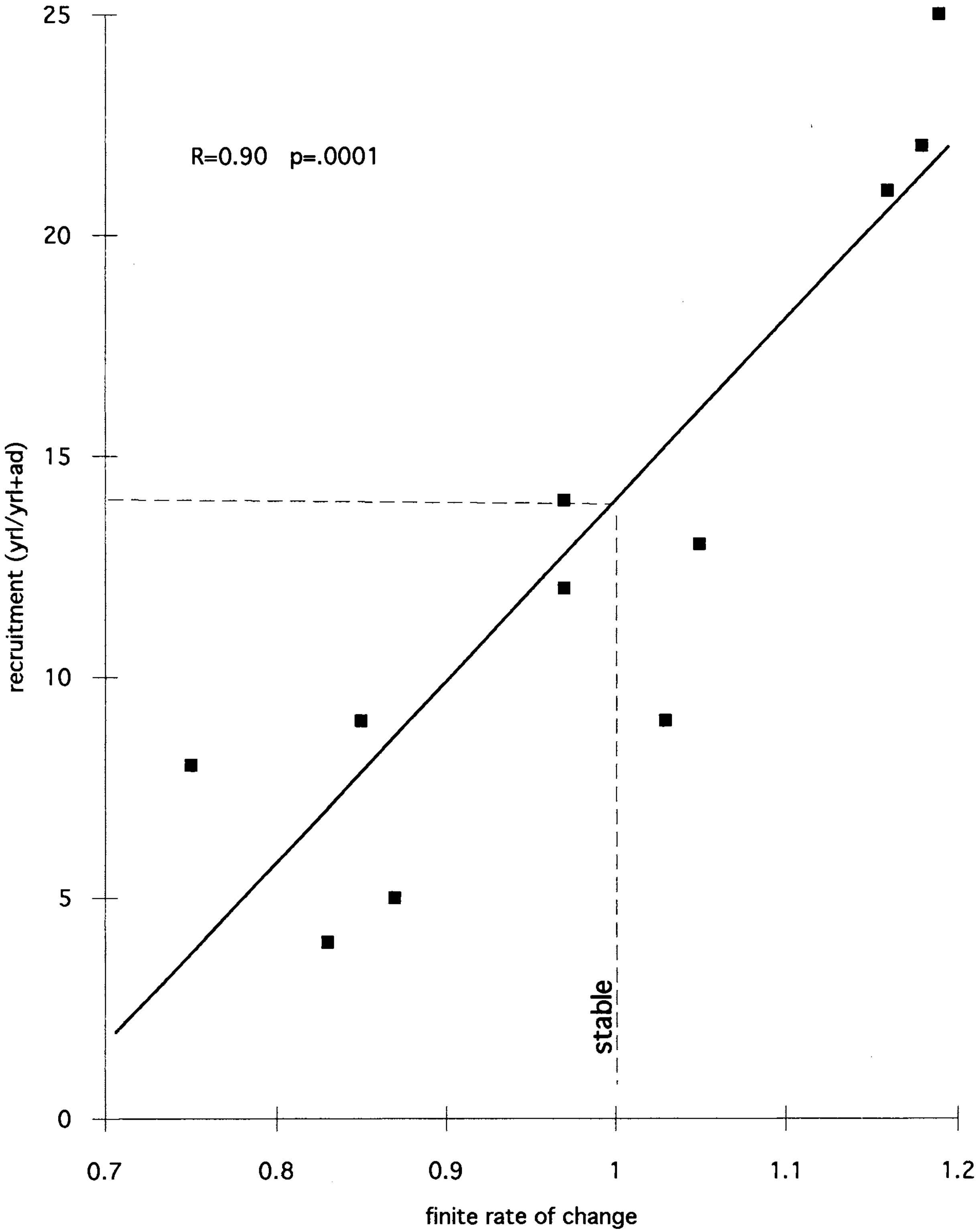

Figure 10. Comparison of recruitment (R) and finite rate of change observed in moose populations in the Yukon (n=7), and east-central Alaska (n=4). Alaska data from Gasaway et al. 1992, Yukon data from Appendix 1.

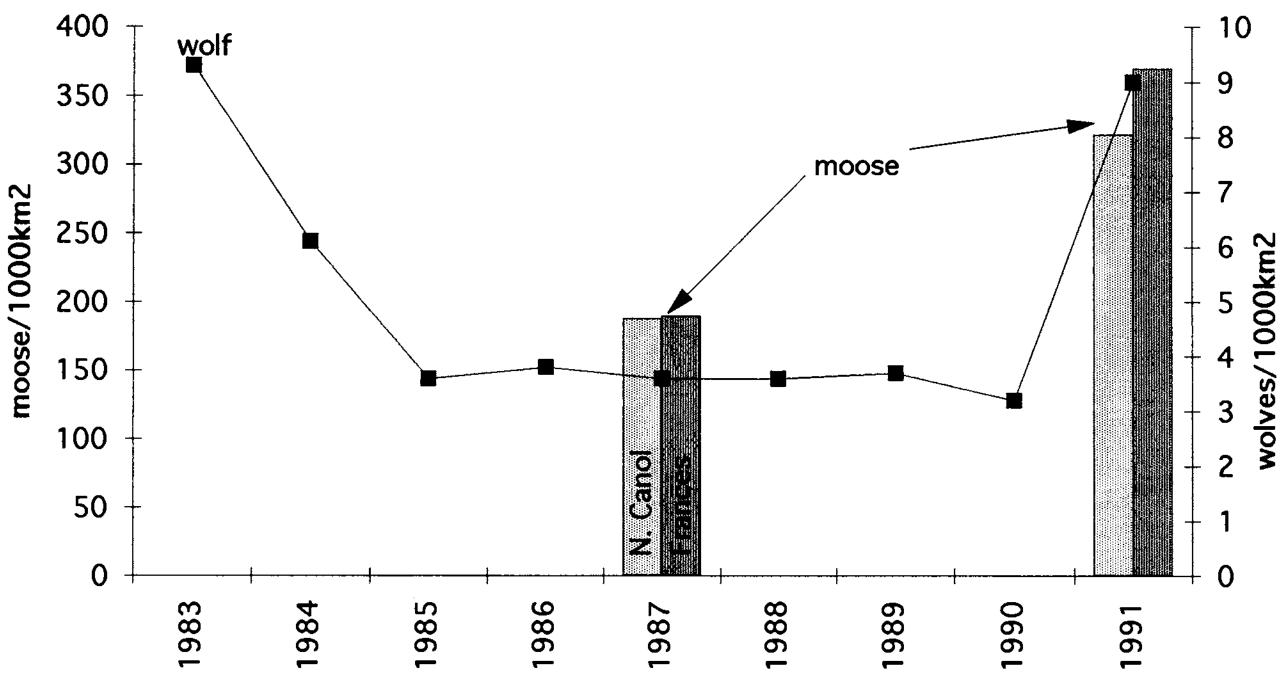

Figure 11. Comparison of moose and wolf densities in the Finlayson management area, 1983-1991.