SIZE, COMPOSITION, AND HARVEST OF THE NORMAN WELLS AREA MOOSE POPULATION, NOVEMBER 1995

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ABSTRACT

A stratified random block survey of moose (*Alces alces*) was flown over a 2910 km^2 area west of Norman Wells, NWT during 15-25 November, 1995. Moose density within the study area was estimated to be 0.17 moose/km^2 and the estimated population size was 497 $\pm$ 490 (90% C.I.). The coefficient of variation for the survey was 132%. There were 56 calves per 100 $\geq$ 1-year-old females and 96 $\geq$ 1-year-old males per 100 $\geq$ 1-year-old females. The percentage of cows with calves that were accompanied by twins was 10%. More moose (30.7%) were seen in areas that had burned in the previous 25 years than in any of five other habitat types, although this habitat covers only 7% of the study area. The Norman Wells area moose population appears to be stable in numbers and composition with continued high productivity, as was noted earlier for this population by other researchers. In 1993-94 and 1994-95 the minimum estimated harvest of moose by resident and general hunting licence holders from this population was 27 and 30 moose, respectively. These harvest rates represent at least 6% of the estimated population and appear to be within sustainable limits. Lack of large tracts of forest in early successional stages may limit future growth potential of the population and a re-evaluation of forest fire management policy within the study area to enhance the moose population is necessary.

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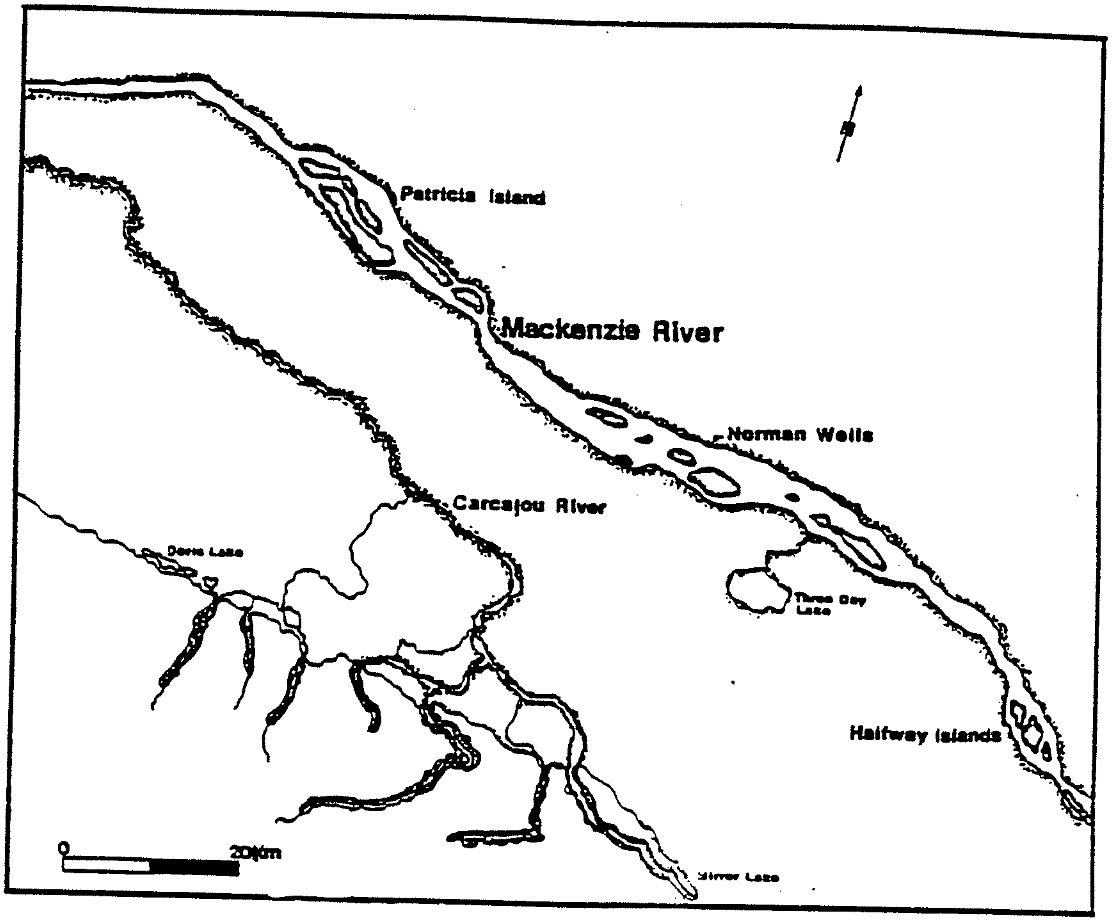

Figure 1. The study area west of Norman Wells.

INTRODUCTION

Moose (*Alces alces andersonii*) have been vital to the nutrition, economy, and culture of residents of the Mackenzie Valley for generations, and are the most accessible big-game species for hunters from Norman Wells year-round. Residents of Norman Wells hunt for moose along rivers and inland, depending on the season. Popular moose hunting areas include the west bank of the Mackenzie River on the opposite side of the river from the town in the relatively flat, boreal forest region between the river and the foothills of the Mackenzie Mountains; the main areas hunted are Heart Lake, Hoosier Ridge, Three Day Lake, Mirror Lake, Carcajou River, and on islands in the Mackenzie River (Fig. 1). All these areas are relatively easily accessed by snowmobile from Norman Wells or by a short flight in chartered aircraft.

General Hunting Licence (GHL) holders can harvest any number of moose year-round for subsistence, and without restriction on where harvest occurs outside municipal boundaries. Persons living in the N.W.T. for a minimum of 24 continuous months prior to application are eligible for a resident hunting licence (RHL) for big game species. Resident hunting for moose is restricted to the period from 01 Sep to 31 Jan and the bag limit is one moose of either sex per year. Moose hunting by RHL holders is also not allowed on islands in the Mackenzie River from 01 Dec to 31 Jan.

The population of Norman Wells has increased rapidly in the past five years because of a change in the work schedule at the community's primary employer, Imperial Oil Resources Ltd. (IORL). More IORL employees now live permanently in the community rather than on a scheduled in and out basis from southern Canada, which has resulted in an increased potential pool of moose hunters who meet the 24-month residency requirement. Therefore, there is still validity to the concern that Brackett et al. (1985) and Jingfors et al. (1987) first raised over potential increases in the moose harvest during the expansion of IORL's activities in Norman Wells in the mid-1980's. There are projections that the town's population could increase to 950-1000 by 2000, almost double the 1989 population estimate of 525 (Liz Danielsen, Development Officer, Town of Norman Wells, pers. comm.). However, despite the increase in population the number of RHL moose hunters in 1994-95 (N = 41) has not changed substantially from the 36 RHL holders that purchased moose tags in 1989-90 (Latour 1992). There are proportionally fewer GHL holders (N = 35) in Norman Wells (1995 pop. estimate 850; Anonymous 1995) than in the other four communities in the Sahtu Region; GHL holders from Norman Wells generally harvest less than 20 moose per year.

The Norman Wells area moose population was first systematically surveyed by Brackett et al. (1985) in 1980 and they recorded a moose density of 0.11 per km^2 for a 683 km^2 area in the vicinity of the Mountain and Carcajou rivers, and of 0.05 per km^2 for a 506 km^2 area along the Mackenzie River between Fort Norman and the San Sault rapids ca. 110 km downriver from Norman Wells. Jingfors et al. (1987) used a technique developed by Gasaway et al. (1987) in Alaska to aerial survey moose in a 3100 km^2 study area across the Mackenzie River from Norman Wells in November 1984 and obtained a population estimate of 465 $\pm$ 90 (90% C.I.). In November 1989, Latour (1992) slightly reduced the study area to 2910 km^2 by eliminating the islands of the Mackenzie River and an area around Mirror Lake (both high density moose areas in the 1984 survey). He used the same methods as Jingfors et al. (1987) and obtained a population estimate of 435 $\pm$ 139 (90% C.I.) moose; however, he assumed that there had been no real decrease in the population because of the smaller study area.

A three-year study of moose movements, productivity, and survival was done by Stenhouse et al. (1995) between Nov 1985 and Nov 1988 in a 2838 km^2 study area that was essentially the same as the one used for the Norman Wells population estimates in 1984 and 1989. This study of 30 radio-collared female moose ≥ 1.5-year-old found a non-migratory population with a pregnancy rate of 96% for adult (≥ 2-yr-old) females and 40% for yearling females; twinning rate was 31%. Mean annual adult female survival was estimated to be 85% and calf survival was estimated to be 44% and stable; the mean annual hunting mortality rate for radio-collared animals was estimated to be 3% (Stenhouse et al. 1995).

The present study was designed to obtain current estimates of the population size and harvest rate for the Norman Wells area moose population in the same area as Jingfors et al. (1987), Latour (1992), and Stenhouse et al. (1995). It was designed also to obtain data on productivity and population composition that could be compared to the previous surveys so that long-term population trends could be determined and appropriate management recommendations based on those analyses.

STUDY AREA

The 2910 km^2 study area limits are identical to those used in 1989 by Latour (1992); however, Latour (1992) calculated the study area to be 2993 km^2. Reanalysis of his original data shows that the smaller area is correct. The general limits of the study area were originally delineated by Jingfors et al. (1987) for their study in 1984; Latour slightly reduced their ca. 3200 km^2 study area for his survey. No reason was given in Latour (1992) for this decision and he cannot recall why it was done (Paul Latour, Canadian Wildlife Service, Yellowknife, NT, pers. comm.).

The study area is bounded by Perry Island, Virgin Creek, the Mackenzie Mountains, Mirror Lake, Halfway Island, and the Mackenzie River (Fig. 1). The area is within the northern boreal forest, has low relief (average elevation 250 m above sea level), and a subarctic climate (Stenhouse et al. 1995). Mean daily January temperature at Norman Wells (65° 17' N, 126° 50' W) is -28.9° C and in July is 16.3° C; only three months have an average temperature greater than 10° C (Walton-Rankin 1977). The mean annual snowfall is 147 cm and rainfall is 19 cm (Anonymous 1995).

The gently rolling terrain tends to be poorly drained and dominated by black spruce (*Picea mariana*); however, more well-drained and riparian areas also have white spruce (*P. glauca*), balsam poplar (*Populus balsamifera*), white birch (*Betula papyrifera*), and trembling aspen (*P. tremuloides*). Dense stands of willow (*Salix* spp.), red-osier dogwood (*Cornus stolonifera*), and alder (*Alnus* spp.) - shrubs favoured as browse by moose - occur in sometimes dense stands along streams and rivers, at the edge of lakes, and on the islands of the Mackenzie River. Portions of the study area have been burned by forest fire, especially a 129 km^2 area in the centre near Heart Lake that burned in 1969 (Paul Rivard, Forest Fire Management Officer, Dept. of Renewable Resources, file data). Forest fire in different parts of the study area and at different times pre-1975 has resulted in a patchwork of stages of deciduous regeneration (Jingfors et al. 1987) and potential as feeding areas for moose; however, no substantial areas of forest have burned in the study area since the mid-1970's (Territorial Forest Fire Centre, Dept. of Renewable Resources, file data).

A network of abandoned exploration roads, well sites, and seismic lines from oil and gas exploration and extraction activities centred at Norman Wells covers the study area and currently provide reasonable access for all-terrain vehicles and snowmobiles. The Canol Heritage Trail, which is primarily used by hikers in summer and by snowmobilers in winter, crosses the study area between Bear Island and Dodo Canyon (Fig. 1).

Potential non-human predators of moose in the study area include wolves (*Canis lupus*), grizzly bears (*Ursus arctos*), and black bears (*U. americanus*); population densities and numbers of these species are unknown.

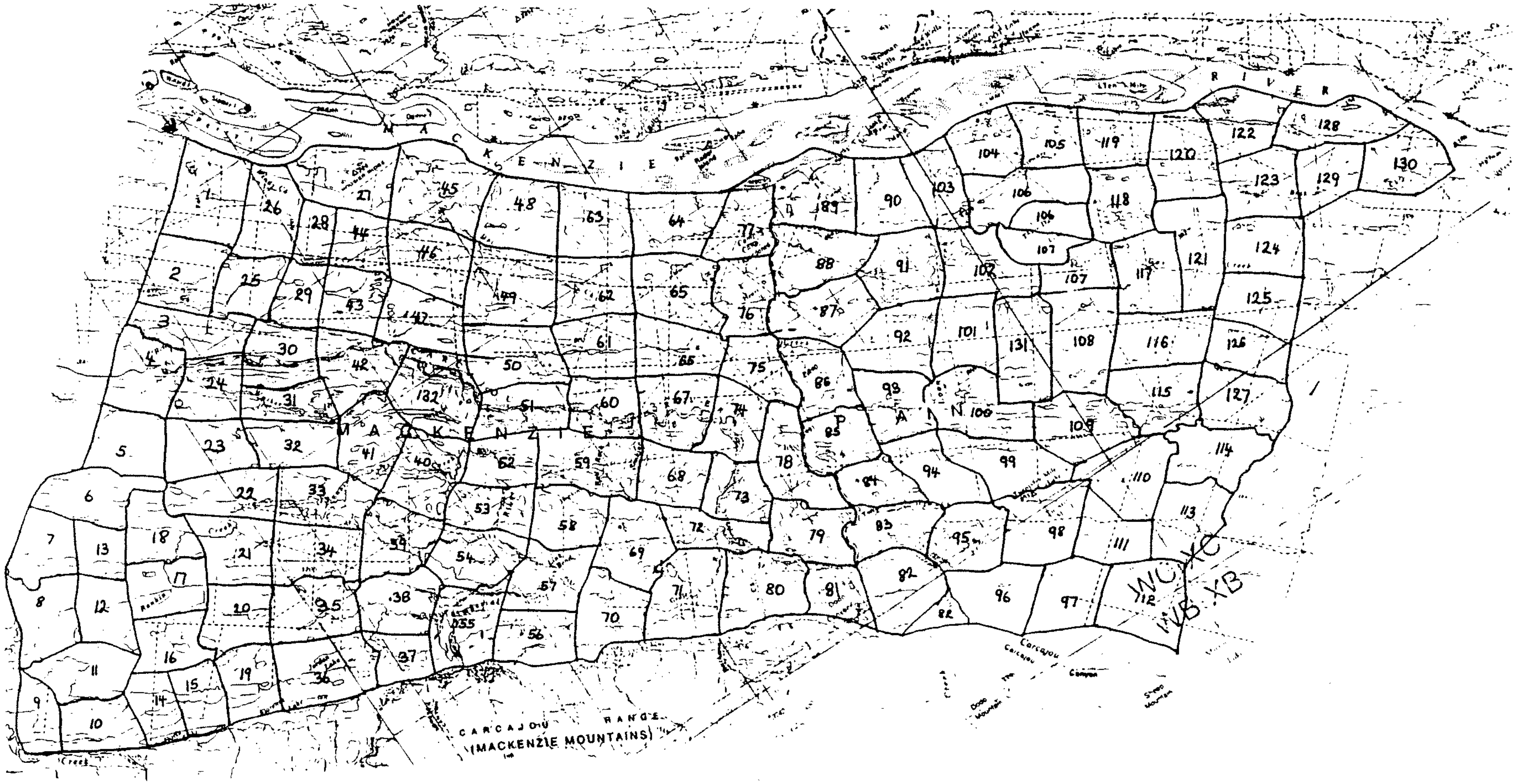

Figure 2. Location of sampling units within the Norman Wells area moose population study area (1:250,000 scale).

METHODS

This survey used the stratified random block design as designed by Gasaway et al. (1986). A total of 132 sampling units (S.U.) with an average size of 22.6 km^2 was delineated by Latour (1992); these same S.U. were used in this survey (Fig. 2). These S.U. were bounded, where feasible, using natural landscape features in order to make it easier to locate them in-flight.

An initial reconnaissance survey to stratify the study area was flown in a Cessna 207, with two observers in the rear and a navigator/data recorder in front with the pilot. This survey was flown over all S.U. at ca. 100 m above ground level (agl) and 190 km/h. Two usually parallel lines were flown through each S.U. and the locations of all moose, moose tracks, and wolf tracks were recorded on 1: 50 000 topographic maps. Following the reconnaissance, and using the same classifications as Jingfors et al. (1987) and Latour (1992), all S.U. were assigned to one of three strata based on density: high ($\geq$ 10 moose and tracks), medium (3-9 moose and tracks), and low ($\leq$ 2 moose and tracks).

Once all S.U. had been assigned to these strata a survey of randomly selected S.U. was flown in helicopter. Prior to starting this stage, we had determined that our project budget would allow 40 S.U. to be surveyed in 28 hours of helicopter time based on a predicted average of 1.5 min per km^2, an average S.U. size of 22.6 km^2, and an estimated 5.5 h of non-survey ferry time. In order to increase the precision of our population estimate, we used the procedure of optimal allocation of sample intensity based on observed variance in numbers of moose and tracks seen in the stratification survey to determine the number of S.U. that we should sample in each stratum (Siniff and Skoog 1964; Gasaway et al. 1986). The S.U. to be surveyed were drawn at random using the random number generator of Microsoft *Excel* 5.0.

After 17 S.U. had been surveyed we again used the procedure of optimal allocation to determine how many of the remaining 23 blocks should be flown in each stratum using the observed stratum variance from S.U. already surveyed (Gasaway et al. 1986).

With the exception of one flight, the same two observers (R.P. and N.M.) flew the helicopter and stratification surveys. Parallel transects, spaced at 0.5 km intervals, were flown at ca. 100 m agl and 100-120 km/h perpendicular to the long axis of each S.U. and all sightings of moose were recorded. We classified all moose observed (medium or large bull; cow; calf) by antler size, antler configuration, and body size. No attempt was made to identify yearlings due to the high likelihood of misclassification, as was experienced by Jingfors et al. (1987); therefore, yearlings were included with the adult cohort (moose $\geq$ 1-yr-old)

The vegetation type was recorded for each moose or group of moose observed. We classified vegetation to the following categories as per Latour (1992): stunted spruce forest, spruce forest, creek bottom, burn, willow/alder, and cutline.

As per Gasaway et al. (1986) and Latour (1992) we did not attempt to determine sightability (percentage of moose seen in the areas searched) because Gasaway et al. (1986) concluded that it is not economically feasible to estimate sightability where density is less than 1.7/km^2; previous density estimates for the Norman Wells area moose population were far below this threshold at 0.15/km^2 in both 1984 and 1989 (Jingfors et al. 1987; Latour 1992). The limited budget available for this survey precluded an estimate of sightability.

To obtain minimum estimates of the number of moose harvested from the Norman Wells area moose population annually in or within 5 km of the study area, we interviewed all residents of

Norman Wells who purchased moose tags with a N.W.T. RHL or who held a GHL for the 1993-94 (N = 66) and 1994-95 (N = 66) hunting years (01 Jul to 30 Jun).

RESULTS

Survey Characteristics

The reconnaissance was flown during 15-17 November 1995 and the census during 17-25 November. Snow conditions at the start of the survey were subjectively ranked as moderate in age, complete in coverage, and good overall (Gasaway et al. 1986). Light snowfall on 12 and 13 Nov prior to the start of the stratification survey provided some fresh cover; however, this snowfall was not sufficient to totally obliterate all old tracks. Temperatures ranged from -38 to -15° C; conditions were generally clear and sunny during the three days we flew the stratification. Snow, low cloud, ice crystals, and high winds delayed the helicopter survey from 18 Nov to the afternoon of 22 Nov; fresh snow during those days improved our snow age classification to fresh (Gasaway et al. 1986).

A total of 7.3 hours of flying was required for the initial reconnaissance of the area (6.4 h over study area and 0.9 h in ferry time), followed by an additional 24.6 hours for the census (18.8 h over the S.U. and 5.8 h in ferry time). The overall S.U. and areal sampling intensities for the low density stratum (17.8 and 17.2 %, respectively; Table 1) differed from those of the medium density stratum (57.1 and 55.7%, respectively; Table 1). Search intensity was the same for both strata (1.3 min/km^2; Table 1).

Light conditions varied throughout the survey (Table 2) and were different for the two strata: conditions were classified as bright for 81.3% of low density S.U. versus 37.5% of medium density, and were classified as flat for 18.7% and 62.5% of low and medium density

Table 1 Search intensity and sampling effort during the Norman Wells area moose survey, November 1995

	Stratum		
	Medium	Low	Total
Stratum area (km^2)	982.9	1927.2	2910.1
No. of sample units (s.u.)	42	90	132
No. of s.u. surveyed	24	16	40
% of s.u. surveyed	57.1	17.8	30.3
Area surveyed (km^2)	545.3	331.8	877.1
% of area surveyed	55.5	17.2	30.1
Search intensity ($min/km^2 \pm$ s.d.)	1.3 ± 0.2	1.3 ± 1.2	1.3 ± 0.2

Table 2 Light type and intensity for each S.U. surveyed during the Norman Wells area moose survey, November 1995

Light Type	Low Density			Medium Density			Total
	High Intensity	Medium Intensity	Low Intensity	High Intensity	Medium Intensity	Low Intensity	
Bright	1	11	1	2	6	1	22
Flat	0	2	1	0	10	5	18
Total	1	13	2	2	16	6	40

S.U., respectively. For both flat and bright light conditions overall intensity was primarily classified as medium rather than either low or high (Table 2).

Only one observed moose could not be sexed and aged (Table 4) - an animal that was in tall, dense spruce forest and that would not emerge even with persistent hovering; after several unsuccessful passes we left it unclassified. All males observed had at least one antler, which made misclassification of males and females unlikely and we are confident in the accuracy of our age and sex categories.

Population Characteristics and Distribution

There were an estimated 497 $\pm$ 490 (90% C.I.) moose in the study area; overall density was 0.17 moose/km^2; densities differed between the low and medium density strata at 0.13 and 0.25 moose/km^2, respectively (Table 3). There was a greater proportion of males in the low density stratum (51% versus 25% in the medium density stratum; Table 3), whereas females and calves were more prevalent in the medium density stratum. There were 56 calves and 96 males per 100 females, respectively. Of 30 females that were accompanied by calves, 3 (10%) were accompanied by twins.

Mean group size was 1.9 $\pm$ 0.8 moose; the largest group observed was 5 animals. Mean group size was highest in cutline habitat (2.2 $\pm$ 1.6 moose) and lowest in creek bottom habitat (1.6 $\pm$ 0.5 moose). Two S.U. in the Heart Lake area burn had $\geq$ 20 moose observed and had densities of 0.96 (S.U. # 65; Fig. 2) and 1.01 moose/km^2 (S.U. # 66; Fig. 2); only 5 (12.5%) had $\geq$ 10 moose, and 4 of these S.U. were within the Heart Lake area burn.

Table 3 Moose population density and composition west of Norman Wells, November 1995

	Stratum		
	Medium	Low	Total
Density (moose/km^2)	0.25	0.13	0.17
Estimated No. Bulls	62 (25%)	128 (51%)	190 (38%)
Estimated No. Cows	119 (49%)	78 (31%)	197 (40%)
Estimated No. Calves	65 (26%)	45 (18%)	110 (22%)
Estimated Total No. Moose	246	251	497
Coefficient of Variation	82.5%	116.0%	132.5%

Table 4 Moose distribution by habitat type west of Norman Wells, November 1995.

Habitat Type	No. Groups	Mean Group Size ± s.d.	No. Bulls	No. Cows	No. Calves	No. Unknown	Total Moose
Willow/ Alder	22	2.0 ± 0.7	10	20	14	0	44
Stunted Spruce	22	1.8 ± 1.0	15	17	8	0	40
Spruce Forest	9	1.6 ± 0.5	1	7	5	1	14
Cutline	5	2.2 ± 1.6	3	7	1	0	11
Creek Bottom	8	1.6 ± 0.5	9	3	1	0	13
≤ 30-yr-old Burn	29	1.9 ± 0.7	16	24	14	0	54
Total	95	1.9 ± 0.8	54	78	42	1	176

Observations of Predators and Predation

During the stratification survey all observations of wolves and wolf tracks were recorded. A total of 84 (63.6%) S.U. had wolf tracks observed in them, while 67% had moose or moose tracks. The Pearson's correlation coefficient (r = 0.28) between the numbers of wolf tracks and moose/moose tracks seen during the stratification flights suggests a weak positive relationship; however, the Pearson's correlation coefficient between wolf tracks and moose observed in the stratification survey (r = 0.68) suggests more strongly that wolves were following moose.

Only one wolf was observed during the stratification survey - on the SE side of Three Day Lake (S.U.# 107; Fig. 2). During the helicopter survey two wolves were observed feeding on a recently killed moose calf on 17 Nov just north of Rete Lake (S.U. #3; Fig. 2); this S.U. also had a lone cow observed within 2 km of the kill site. An apparently wolf-killed moose of unknown sex and age was found on the edge of a small lake near the centre of the study area (S.U. #58; Fig. 2); the carcass had been completely consumed and only a large piece of hide remained.

Harvest

There were at least 27 moose harvested in 1993-94, of which 11 (41%) were taken by RHL holders and 16 (59%) by GHL holders, and 30 harvested in 1994-95, of which 9 (30%) were taken by RHL holders and 21 (70%) by GHL holders. The number of successful moose

Table 5 Age and sex of moose harvested by resident hunting licence (RHL) and general hunting licence (GHL) holders from Norman Wells for the 1993-94 (93-94) and 1994-95 (94-95) hunting years.

	Calf (< 1-yr)		Cow (≥ 1-yr)		Bull (≥ 1-yr)		Total Harvest	
	93-94	94-95	93-94	94-95	93-94	94-95	93-94	94-95
RHL	2	1	0	2	9	6	11	9
GHL	0	5	5	9	11	7	16	21
Total	2	6	5	11	20	13	27	30

hunters for 1993-94 and 1994-95 were 19 (1.4 moose/successful hunter) and 18 (1.7 moose/successful hunter), respectively. The majority of successful hunters took one moose per year; the most taken by a hunter in a single year was 9 by a GHL holder in 1994-95.

The combined harvest for 1993-94 and 1994-95 was primarily of adult (≥ 1-yr-old) male moose - 58% (33 of 57) were of this age and sex class (Table 5), 28% (16 of 57) were adult females and 14% (8 of 57) were calves (< 1-yr-old). Most moose (95%) were harvested in the fall (01 Sep to 30 Oct) and winter (01 Nov to 31 Mar) hunting seasons (Table 6). The greatest number of moose harvested in a single area was in the Heart Lake area burn (30% of harvest); three locations provided 72% of the total harvest from this population: Heart Lake, Three Day Lake, and the islands of the Mackenzie River (Table 7).

Table 6 Seasonal harvest of moose by Norman Wells moose hunters for the 1993-94 (93-94) and 1994-95 (94-95) hunting years. Spring = 01 Apr-31 May ; summer = 01 Jun-31 Aug ; fall = 01 Sep-31 Oct ; winter = 01 Nov-31 Mar .

Season of Successful Hunt	1993-94	1994-95	Total
Spring	0	0	0
Summer	1	1	2
Fall	14	13	27
Winter	11	16	27
Unknown	1	0	1
Total	27	30	57

Table 7 Harvest location of the Norman Wells area moose population for the 1993-94 and 1994-95 hunting years.

Location	1993-94	1994-95	Total
Three Day Lake	4	5	9
Heart Lake	6	11	17
Mackenzie River banks	2	1	3
Mirror Lake	3	0	3
Hoosier Ridge	1	0	1
Mackenzie River islands	7	8	15
Canyon Creek	1	0	1
Norman Wells	2	0	2
Carcajou River	0	5	5
Unknown	1	0	1
Total	27	30	57

DISCUSSION

Observability and Classification

The search intensity of this survey (ca. 1.3 min/km^2) compares favourably with similar moose surveys in the Mackenzie Valley (Jingfors et al. 1987; Latour 1992; MacLean 1994). The total snow cover and recent snowfalls prior to both the stratification and helicopter portions of the survey aided in our ability to observe moose. Light conditions were generally favourable, especially for the low density stratum where most of the S.U. were surveyed during bright light conditions. No turbulence was recorded during any of the S.U. searches, so the combination of mostly clear and calm conditions enhanced observer sightability of moose.

However, our estimate of population size is a minimum because of the under-counting that invariably occurs during aerial searches of moose and other large mammals in forested and partially forested habitat (Caughley 1974; LeResche and Rausch 1974). Sightability estimates for moose during aerial surveys from a number of jurisdictions across North America have ranged from 34% to 98% (Bisset and Rempel 1991). Bisset and Rempel (1991) reviewed aerial inventories of moose in Ontario from 1975-1990 (average density of 0.39 moose/km^2) and used a linear correction model to estimate an average sightability of 79%. They found that the significant factors in determining sightability of moose included snow depth and crust, time-on-plot, aircraft type, and cloud cover. Other researchers have also documented the influence of snow conditions (LeResche and Rausch 1974), observer experience (LeResche and Rausch 1974), airspeed and altitude (Caughley 1974), and habitat cover type (LeResche and Rausch 1974). In our survey we noticed increased difficulty in spotting moose in habitats with greater cover (e.g., spruce forest) compared to more open areas where moose were relatively easy to see, and we recognize this as a bias that underestimated true population size.

Population Characteristics

The estimated number of moose in the Norman Wells area population (497 ± 490) has remained essentially unchanged since the last surveys in 1989 (435 ± 139; Latour 1992) and 1984 (465 ± 90; Jingfors et al. 1987); however, the study area of Jingfors was slightly larger at 3200 km^2 and included the islands of the Mackenzie River and the area around Mirror Lake, both well-known moose hunting areas for residents of Norman Wells (Table 7). The wide 90% confidence interval for our estimate most likely resulted from error in stratification and the delay of three days between stratification and the S.U. survey. Only 9 (37.5%) of the S.U. in the medium density stratum contained 3-9 moose and only 10 (62.5%) of the low density contained 0-2 moose. The stratification flight resulted in no high S.U. classified as high density; however, during the helicopter survey we found ≥ 9 in 6 (15%) of the S.U. Five S.U. classified as medium density contained > 9 moose, and 10 had ≤ 2 moose. The thin snow cover allowed moose to move freely throughout the study area - it took 11 days to complete the survey (including the stratification flight) and there was ample opportunity for moose distribution to change between the time of stratification and the helicopter survey of a particular S.U. These circumstances also account for the high coefficient of variation for the survey of 132.5%; the standard for moose surveys in the N.W.T. is 10-15%.

Moose in the study area are maintaining the good first six-month calf survival observed in 1984 by Jingfors et al. (1987) and in 1989 by Latour (1992). The current estimate of 56 calves per 100 females in Nov is a slight increase from the 48:100 ratio of 1989 and the 44:100 ratio in 1984. Stenhouse et al. (1995) recorded a pregnancy rate for female moose in the study area for 1986 and 1987 of 96% and 40% for adult (≥ 2-yr-old) and yearling moose, respectively. The 3-yr (1986-1988) mean calf:female ratio immediately after birth of 1.3:1 reported by Stenhouse et al. (1995) and our observed calf:female ratio of 0.6:1 gives an estimate of calf survival (unadjusted for adult female mortality from Jun to Nov) for the first six months of 46.2%. Stenhouse et al. (1995) estimated calf survival to six months to be 63% and for the following six months to be 67%; their estimate of annual calf survival was 44 ± 0.06%. Therefore, it appears that calf survival for the population may be decreasing; however, the possible factors that might contribute to this decrease are unknown. In many areas it has been found that predation by both black and brown (grizzly) bears may be a significant predator on moose ≤ 1-yr-old (Ballard 1992) and that predation may limit moose populations at low densities (Gasaway et al. 1992). In interior Alaska and on the Kenai Peninsula black bears accounted for 40% and 35%, respectively, of all calf mortalities (Franzmann et al. 1980; Osborne et al. 1991); in southcentral and eastcentral Alaska grizzly bears took 43% and 52%, respectively, of radio-collared moose calves (Ballard et al. 1981; Boertje et al. 1987 *in* Osborne et al. 1991; Ballard et al. 1991). Wolves are also a major predator of both adult and calf moose and a low density of moose is the rule in systems where wolves, black bears, and brown/grizzly bears co-exist with a light to moderate human harvest (Gasaway et al. 1992).

Stenhouse et al. (1995) estimated the annual survival rate for adult radio-collared moose between 1985 and 1988 to be 85%, including hunting mortality. Therefore, it is necessary that the population maintain its current high productivity in order to ensure that recruitment continues to replace or exceed this adult mortality in order to prevent a decline in the herd. With predicted losses of high quality habitat in the study area as the Heart Lake burn progresses in age (see below), this is, unfortunately, an unlikely scenario.

Distribution

The highest density of moose occurred in the central part of the study area, and most were within the Heart Lake burn of 1969. Burned areas of $\leq$ 30-yr-old only cover ca. 7% of the study area (Latour 1992) but 30.7% of all moose sighted in the survey were in those burns, which is likely attributable to higher quality and abundance of browse available. The greater density of moose in northern post-fire habitats has been well documented by Schwartz and Franzmann (1991) in Alaska's Kenai Peninsula where the density of moose in a 12,500 km^2 burn peaked 24 years post-fire at 3.6 moose/km^2, declined to 1.3 moose/km^2 at 35 years post-fire, and further declined to 0.3 moose/km^2 40 years after the fire. Ideal moose habitat features a mosaic of early successional stages interspersed with fairly large areas of mature and old forest (Don Thomas, Research Scientist, Canadian Wildlife Service, Edmonton, AB, pers. comm.).

We saw very few moose or moose tracks in the large tracts of closed spruce forest that dominate most of the study area and only 8% of all moose sighted from the helicopter were in spruce forest (Table 4), even though this habitat covers over 50% of the total area. However, it is also true that spruce forest is the habitat in which observers are most likely to miss moose due to the height and density of the cover and that mature and old forest are used more by moose as cover in summer when they are easily heat-stressed (Renecker and Hudson 1986). Moose also use dense mature and old forest as bedding cover in winter and for feeding during severe winter periods (Peek et al. 1976).

We classified the Hoosier Ridge area as low density in our stratification flights, whereas in 1984 and 1989 S.U. in this area were classified as high and medium, respectively. Hoosier Ridge in the past has been a popular area for some moose hunters from Norman Wells because of its proximity and moose availability; however, our survey of hunters found that only one moose has been taken there in the past two years. We cannot explain the apparent change in moose use of this area in recent years.

Jingfors et al. (1984) found the Mackenzie River islands to be a high density moose area; however, Latour (1989) noted that he saw few moose on the islands and in the present survey only one moose was seen on the islands during the stratification and helicopter surveys. The islands were not included as part of Latour's 1989 study area or in our survey but we flew across them regularly on our way to and from the study area.

Harvest and Management Recommendations

The minimum estimates of harvest from this population in 1993-94 and 1994-95 represents a two-fold increase from Latour's (1992) estimate of 15 moose per year in 1989; however, the stability in our estimate of population size, continued high productivity, and stability in other population parameters (e.g., adult male: adult female ratios) suggests that the current level of harvest is within sustainable limits. We must emphasize that our harvest estimates are an absolute minimum because they do not include moose taken by GHL holders not normally resident in Norman Wells, harvest by RHL from outside Norman Wells, losses to illegal harvest, and wounding loss. However, it is not likely that the number of moose taken from these sources exceeds 5 animals per year; therefore total human-related mortality should not currently exceed 7% of the population per year.

Norman Wells moose hunters tend to select adult (≥1-yr-old) males over adult females (Table 5) and 58% of all moose taken in the two hunting seasons for which we have data were of this age/sex class. It is interesting adult males as a proportion of the harvest dropped from 74% in 1993-94 to 43% in 1994-95. We have no explanation for this change and none of the hunters interviewed reported any change in their harvest strategy between years. The slight sex-selection in the harvest may contribute to the observed adult male: adult female ratio of 96:100

Although there are 73 people from Norman Wells on the most recent list of GHL holders for the Northwest Territories (Jan 1995) only 35 currently live in the community; of those only ca. 10 exercise their right to hunt moose each year (Ruby McDonald, pers. comm.). The number of RHL holders that hunt moose has not greatly increased despite a rapid increase in the population of Norman Wells in recent years from ca. 525 in 1989 to ca. 850 in 1995 (Anonymous 1995; Liz Danielsen, pers. comm.). We do not know if the numbers of RHL moose hunters will increase as a result of predicted further increases in the community's population; annual RHL and GHL harvest should be more closely monitored than in the past to detect changes in the pattern and level of harvest. Annual surveys of all moose hunters in Norman Wells provide those data and keep biologists informed of concerns and questions residents have about moose and moose management in the local area.

The current practice of aerial surveys using the stratified sampling unit technique in mid-November should be continued with a 5-year interval between surveys. Crichton (1992) reviewed the moose management practices of 17 North American jurisdictions and found that 16 flew aerial surveys, of those 15 did population surveys and classified counts; 11 jurisdictions indicated that they flew their surveys at intervals of 2-5 years.

The next survey of this population should occur no later than 2000 and should use the same study area and methods as previous surveys, except that a stratification flight prior to the helicopter survey will not be necessary as the study area can be stratified as well, or better, by using the results of the three previous surveys. This would avoid the problem created by stratifying based primarily on observations of tracks, eliminate weather-related delays between stratification and the helicopter survey, reduce the total amount of time required for the survey, be safer, and be less costly.

Finally, the results of our aerial survey and harvest study show the importance of the Heart Lake burn to moose and moose hunters and strongly indicates that it is necessary to maintain a mosaic of different aged post-burn habitats among older growth forest to provide the necessary browse to support the present, or an increased, number of moose. Extensive studies in Alaska (e.g., Schwartz and Franzmann 1991) have shown clearly how moose populations respond to forest succession post-fire and now the highest density area for the Norman Wells area moose population has passed the 24-yr post-fire peak documented in Alaska and there are no substantial tracts of burns within the study area of younger age. Thus, it is almost certain that the Norman Wells area moose population will decline over the next few years because of the loss of early-regeneration habitat as a result of human interference with the boreal forest's natural fire cycle; the annual rate of decline in the Kenai study was 9%/yr between 17 and 43 years post-fire (Loranger et al. 1991). The forest-fire management regime within the study area over the past decade has been vigorous suppression of all forest fires (P. Rivard, pers. comm.). For the Norman Wells area moose population to sustain or increase its numbers in the face of diminished high quality habitat abundance and facing a possible increase in human harvest - this approach must be re-evaluated by the Department of Renewable Resources in conjunction with the Norman Wells Renewable Resource Council and the Sahtu Renewable Resources Board, which is the principal agent for wildlife management within the Sahtu Settlement Area (Sahtu Dene and Metis Comprehensive Land Claim Agreement Volume 1 (1993): 57).

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