Fort Providence Moose Census

November/December 1997

Mark Bradley

and

Faye Johnson

Department of Resources, Wildlife & Economic Development

Government of the Northwest Territories

Fort Smith, NWT

1998

Manuscript Report 135

Abstract

We conducted an aerial census of moose near Fort Providence, NT, in response to local concerns regarding the possible effects of prescribed burning of local habitats, the increasing bison population and the possibility of an increasing wolf population. We estimated a population of 116 moose (density of 0.03 moose/km^2) with a 90% confidence interval of 40 moose (35 % of the population estimate). The population has declined significantly ($t = 4.29$, $df = 46$, $p < 0.01$) since 1994, when the population was estimated to be 255 moose, or 0.07 moose/km^2. The calf:100 cow ratio was 16, also a significant decline since 1994 when calf:100 cow ratio was 31.5 ($t = 2.25$, $p < 0.05$). This census is the second in a row to document a significant decline in the moose population of the Fort Providence area; the 1991 census yielded a population density of 0.17 moose/km^2 and a calf:100 cow ratio of 55.

Table of Contents

Abstract ii
Table of Contents iii
List of Figures iv
List of Tables iv
Introduction 1
Methods 1
Study Area 2
Reconnaissance 2
Stratification 2
Census 2
Data Analysis 3
Results 4
Reconnaissance 4
Population Estimate 5
Population Estimates: 1994 vs. 1997 6
Sex and Age Ratios: 1994 vs. 1997 7
Weather: 1994 vs. 1997 8
Habitat 9
Search Effort: 1994 vs. 1997 10
Discussion 11
Population Density 11
Possible Sources of Bias 12
Population Characteristics 12
Conclusions and Recommendations 13
Literature Cited 14
Personal Communications 15

List of Figures

Figure 1. Comparison of our study area (1997 and 1994) with Shank's (1991) study areas......................2

Figure 2. Location of moose and tracks seen on reconnaissance flights. 4

Figure 3. Strata as delineated by reconnaissance flights. 4

Figure 4. Location of moose sightings during the 1997 Fort Providence census. 5

Figure 5. Temperature, wind speed and cloud cover experienced during SU searches.............................8

Figure 6. Habitat type within 10m of moose sightings. 9

Figure 7. Habitat type within 250m of moose sightings. 9

Figure 8. Search time per km² for the helicopters during the 1994 and 1997 Fort Providence moose censuses. 10

Figure 9. Search time per km² for the fixed wing aircraft during the 1994 and 1997 Fort Providence moose censuses. 10

List of Tables

Table 1. Moose population size and density for the Fort Providence study area 1997. 5

Table 2. Comparison of Fort Providence moose census results: 1994 vs. 1997. 6

Table 3. Moose population characteristics for the Fort Providence study area 1997. 7

Table 4. Population characteristics reported for N.W.T. moose populations. 11

Introduction

Despite the importance of moose as food, census work in the Northwest Territories has occurred sporadically, with censuses usually being conducted in response to a perceived crisis (e.g. pipeline through Fort Liard in the late 1970's, Donaldson and Fleck 1980) or to requests from user groups (e.g. Graf and Case 1992). Few studies involve re-censusing of set study areas (but see Bradley et al. 1996, Bradley et al. 1998 (unpubl. data), Latour 1992, Veitch et al. 1997, Case unpubl. data). Data on population status is fundamental for good management, therefore having a time series of population estimates is essential. To begin monitoring moose population trends near Fort Providence, we decided to re-census a study area established in 1991 by Shank (1991) and re-censuses in 1994 by Bradley et al. (unpubl. data).

There are two reasons for choosing Fort Providence as a study area. First is the presence of a re-introduced bison herd. Larter et al. (1994) hypothesized that the presence of bison in the area supports a higher density of wolves than would otherwise be found. Since moose are the preferred prey, the increase in wolves could suppress the density of moose in the area (predator pit theory). Shank (1991) censused 3 study areas near Fort Providence, representing high, medium, and low bison density, but could find no statistical difference in moose density among the three study areas. His work therefore did not support Larter et al's (1994) hypothesis regarding moose and bison densities, but it did provide us with baseline data for an investigation of trends in moose density. In 1994 Bradley et al. (unpubl. data) found that density had been halved since 1991.

The second reason for choosing Fort Providence as a study area is that the area is undergoing habitat management in the form of prescribed burning. The burning is being done primarily to increase the amount of grasses and sedges that are bison forage. The burning is also intended to increase deciduous shrubs on the periphery of the prairies, so it may also be beneficial for moose. If shrubs decrease however, then the burning could be deleterious for moose. Either way, monitoring of the moose population is required to test a habitat effect.

Our main objective therefore is to estimate moose density in the Fort Providence study area and then compare our data with Shank's (1991) and Bradley et al.'s (1994) data.

Methods

We followed Gasaway's (1986) stratified block sampling method for aerial moose censuses. These methods entail a reconnaissance flight, followed by division of the survey area into strata of similar moose densities. Randomly chosen survey units (SU's) are then searched thoroughly for moose. Estimates of population size are calculated for each stratum and combined to give an estimate of total population size. Sampling precision is also calculated for each stratum, then combined to give precision for the total population estimate.

We departed from Gasaway's (1986) methods by not estimating a sightability correction factor (Scf). Gasaway (1986) asserts that estimating sightability is futile when moose densities are less than 0.4 moose/km^2, as they invariably are in the N.W.T. (summary in Graf 1992). The main purpose of our study is to compare our census with Bradley's (1994) census of the same area. We can do this without Scf's if we assume no change in sightability exists between the three censuses.

Study Area

Our study area was 3 749 km^2, and was essentially flat. Habitat ranged from open deciduous bogs to almost closed canopy jackpine and spruce forest. Study area size, shape and SU boundaries are identical to the 1994 study area which was originally designed to include two of Shank's three (1991) study areas (Figure 1). The two study areas were amalgamated to increase sample size and therefore the precision of our estimate. Shank (1991) designed his study areas to represent medium and low bison density. It would have been too expensive to choose a study area encompassing all three of Shank's study areas.

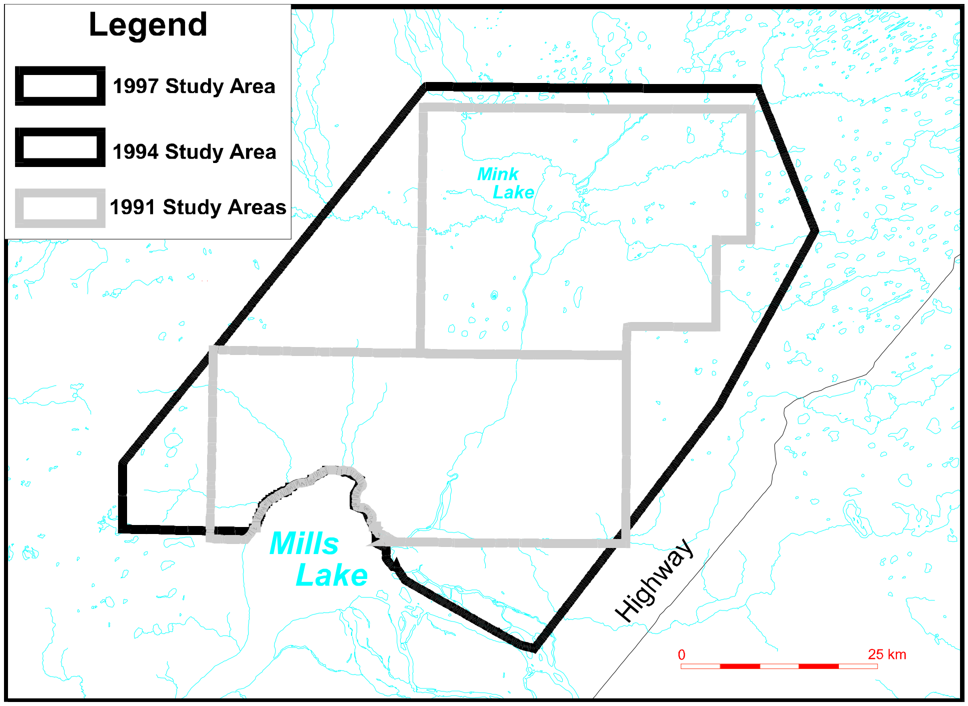

Figure 1. Comparison of our study area (1997 and 1994) with Shank's (1991) study areas.

Reconnaissance

A Cessna 185 was used for the reconnaissance flights on November 25 and 26. Parallel east-west transects were flown at 4 km intervals with a strip width of 1 km, giving us 25% coverage. The survey was flown at 160 km/hr and at an altitude of 125 m above ground level. A data recorder sat in the co-pilot's seat, and was responsible for recording numbers and locations of moose, as well as habitat type at each moose location. Notes were made on habitat within each SU. Locations were recorded on a GPS unit, downloaded to a computer, and displayed on screen.

Stratification

Each SU was classified as either high or low moose density based on several criteria: moose and track locations from the reconnaissance flight, moose locations from Bradley (1994), and location of 'good' moose habitat (generally deciduous shrubs) as seen on reconnaissance or from the Landsat data. Moose and track locations from the current reconnaissance survey outweighed the other factors, and we also tried to avoid having single SUs of one stratum surrounded by SUs of the other stratum.

Census

Each SU was searched in random order until precision for the census was acceptable (confidence interval less than 20% of the mean, calculated after each day's flying). Census searches took place from 27 November to 3 December.

We used two aircraft to search SUs: a Bell 206-B helicopter and a Cessna 185 airplane. There were 2 observers and a data recorder in both the helicopter and the airplane.

All moose recorded were classed by age (adults, yearlings, calves) and sex.

Temperature, wind speed, and percent cloud cover were recorded at the beginning of each SU search. Temperature and wind speed were obtained from the Fort Smith airport or the aircraft's instruments and cloud cover was visually estimated. Habitat type was recorded at two scales: within 10m, and within 250m of each moose sighting.

Data Analysis

We followed Gasaway's (1986) techniques for analysing moose census data. Weather, habitat, and search effort were compared using either parametric (t-tests, anova) or non-parametric (Mann-Whitney U tests, Kruskal Wallis tests) tests depending on the distribution of the data.

Results

Reconnaissance

We saw 63 moose on transect during the reconnaissance flights, representing a moose density of 0.03 moose/km^2 (Figure 2). We used the reconnaissance data to place 28 SUs into the high density stratum and 46 SUs into the low density stratum (Figure 3).

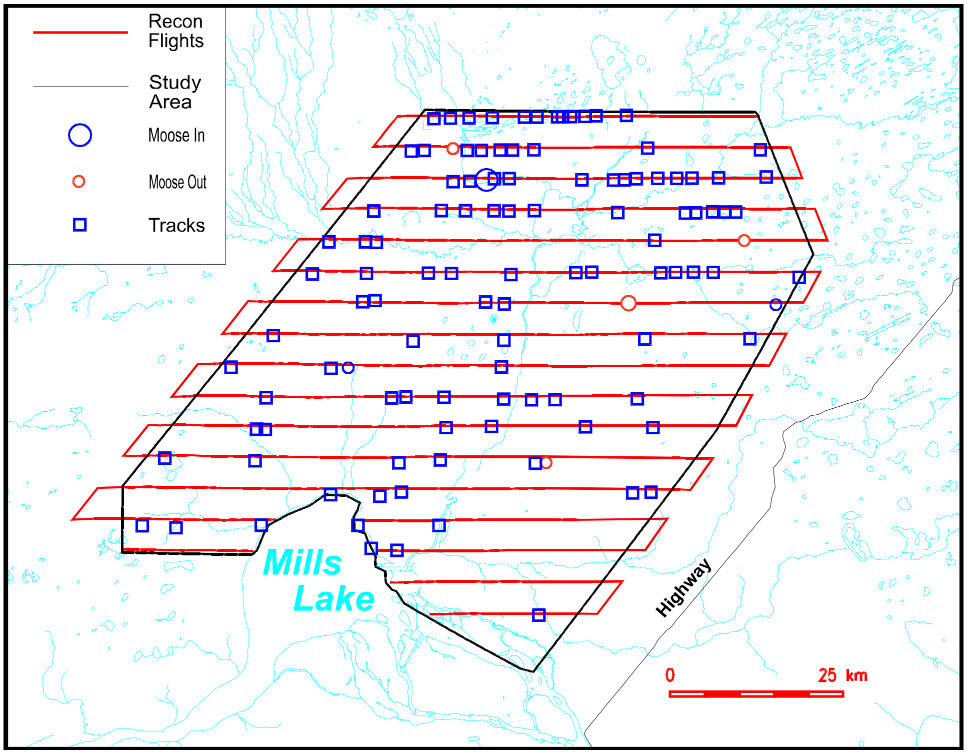

Figure 2. Location of moose and tracks seen on reconnaissance flights.

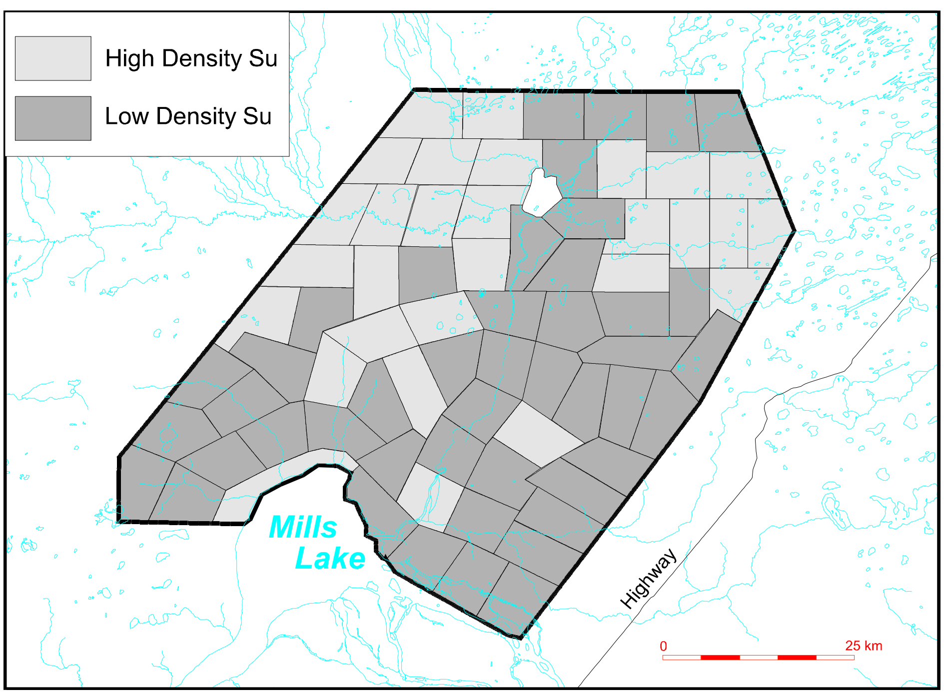

Figure 3. Strata as delineated by reconnaissance flights.

Population Estimate

Sixty three moose were counted (Figure 4), and a population estimate of 115 moose was calculated. The 90% confidence interval was 40 moose, or 35% of the estimate. The coefficient of variation was 0.20. Density was 0.03 moose/km^2 (Table 1).

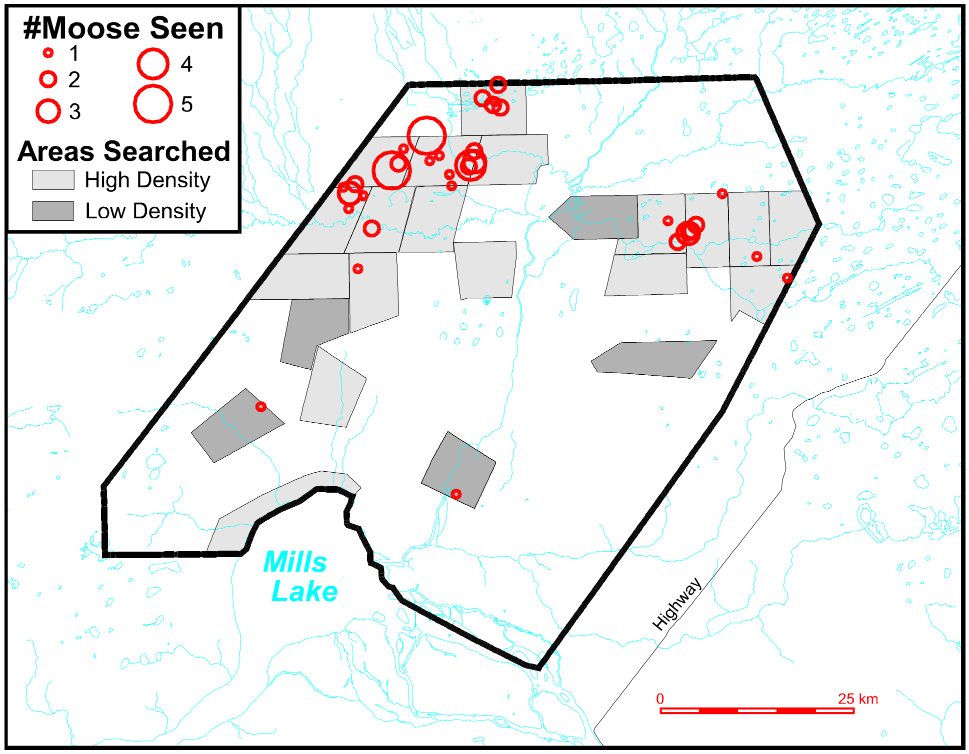

Figure 4. Location of moose sightings during the 1997 Fort Providence census.

Table 1. Moose population size and density for the Fort Providence study area 1997.

Strata	Low	High	Total
Total area (km^2)	2 345.20	1 404.00	3 749.20
Area surveyed (km^2)	249.04	882.28	1 131.32
Total SU's	46	28	74
#SU's surveyed	5	18	23
%SU's surveyed	11	63	30
Moose seen	2	61	63
Density (/km2)	0.01	0.07	0.03
Population Estimate	18.8	97.1	**115.9**
Variance	121.39	427.03	548.42
Degrees of freedom	4	17	21
Coefficient of variation			0.20
90% C.I. (% of population estimate)			34.77%

Population Estimates: 1994 vs. 1997

Population size (or density) in 1997 was less than half that found in 1994 (Table 2), a statistically significant decrease.

Table 2. Comparison of Fort Providence moose census results: 1994 vs. 1997.

	1994	This Study: 1997
Total Area (km^2)	3 749.2	3 749.2
Area Surveyed (km^2)	1 499.4	1 131.3
% of Total Area Surveyed	40	30
Total # Blocks	74	74
#Blocks Surveyed	30	23
#Moose Seen	154	63
Population Estimate	255.2	115.9
Density	0.07	0.03
Variance	508.03	548.42
Degrees of freedom	27	21
90% C.I. (% of population estimate)	15.04	34.77
		$t = 4.29$, $df = 46$, $p < 0.01$

Sex and Age Ratios: 1994 vs. 1997

The sex ratio was 176 bulls per 100 cows, calf to cow ratio was 16 calves per 100 cows, and the yearling to bull ratio was 0 yearlings per 100 bulls for the 1997 census (Table 3). The sex ratio did differ between 1997 and 1994, and there were significantly less calves and yearlings in 1997. No twins were seen in 1994 or in 1997 (Table 3).

Table 3. Moose population characteristics for the Fort Providence study area 1997.

	Number		
Sex/age class	1994	1997	
Total moose	154	115	
Total cows	59	21	
Lone cows	42	15	
Cows w/1 calf	17	5	
Cows w/2 calves	0	0	
Total calves	17	5	
Total bulls	78	37	
Yearling bulls	2	0	
	Ratio + 90%CI		t-test
	1994	1997	p
Bulls:100 cows (w/yearlings)	137 ± 31%	176 ± 55%	t = 0.66, df = 14, p > 0.40
Calves:100 cows (w/yearlings)	**31.5 ± 23%**	**16 ± 61%**	**t = 2.25, df = 22, p < 0.05**
Yearlings:100 bulls	2.15 ± 94%	0%	
Twinning Rate	0%	0%	

Weather: 1994 vs. 1997

During the 1997 census temperature ranged from -5 to -20 ^{o}C, wind ranged from 0 to 10 km/hr and cloud cover ranged from 0 to 100% (Figure 4). Visibility was good throughout our census, except for two days (30 November and 01 December) when fog prevented us from flying.

If we compare the weather recorded during the 1994 and 1997 censuses (Figure 5), we see that it was warmer in 1997 (Mann-Whitney U test: $T = 1152.0$, $p < 0.01$), but that there was no difference in wind speed ($T = 747.5$, $p = 0.58$). There was a difference in cloud cover ($T = 903.0$, $df = 25,30$, $p < 0.01$): the median cloud cover in 1997 was 100% compared to a median cloud cover of 30% in 1994.

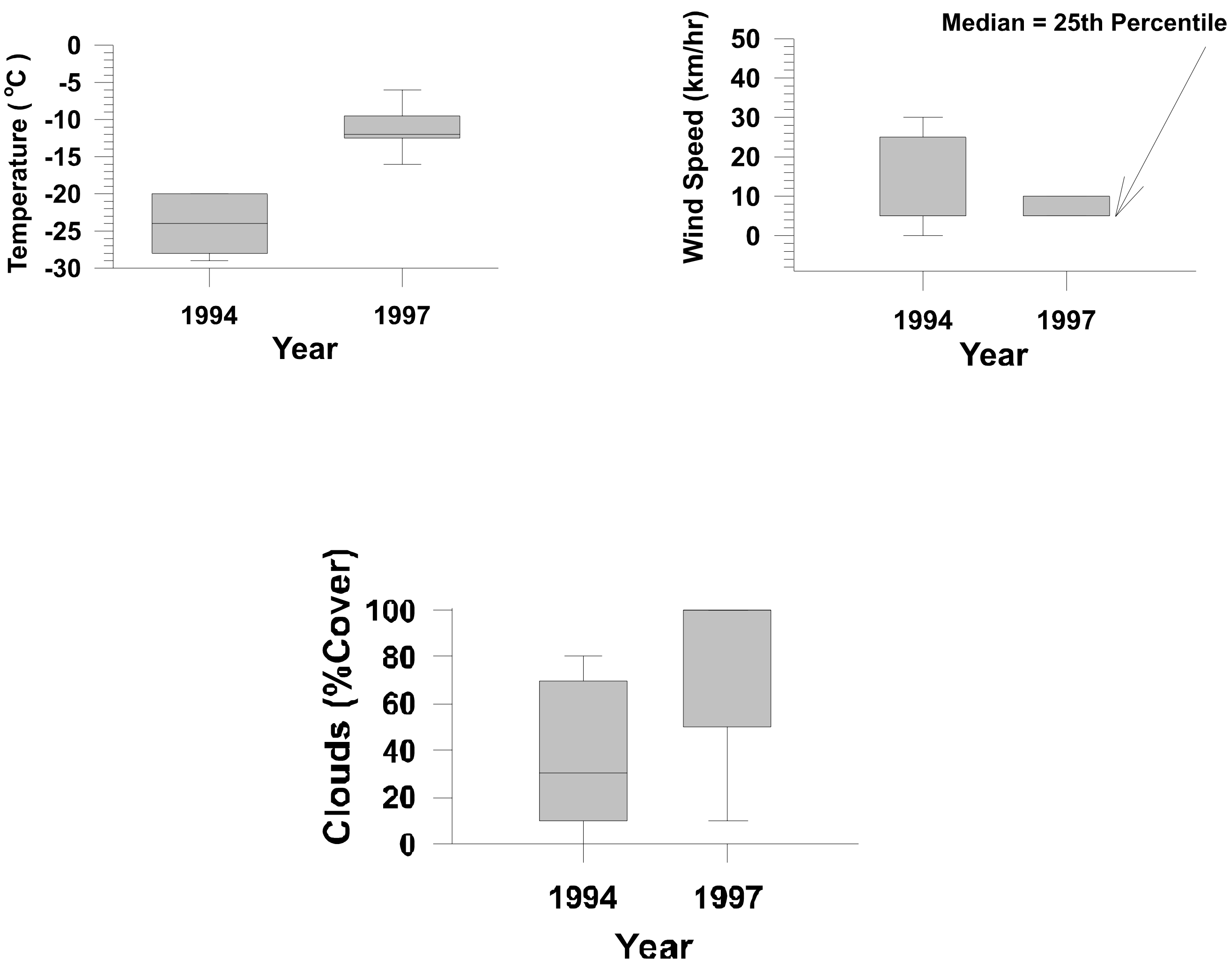

Figure 5. Temperature, wind speed and cloud cover experienced during SU searches. Lines inside boxes represent medians, boxes represent 25th and 75th percentiles, while error bars represent 10th and 90th percentiles.

Habitat

At the fine habitat scale (within 10m of each moose group) 86% of the moose sightings were in relatively ‘open’ habitats (Figure 6). At the coarse habitat scale (within 250m of each moose group) 91% of the sightings were in open habitats (Figure 7). When the two scales were considered together (i.e. immediate:general), only 3% of sightings were in ‘forested:forested’, 6% were in ‘open:forested’ and 76% were in ‘open:open’. 15% of moose were in ‘forested:open habitats.

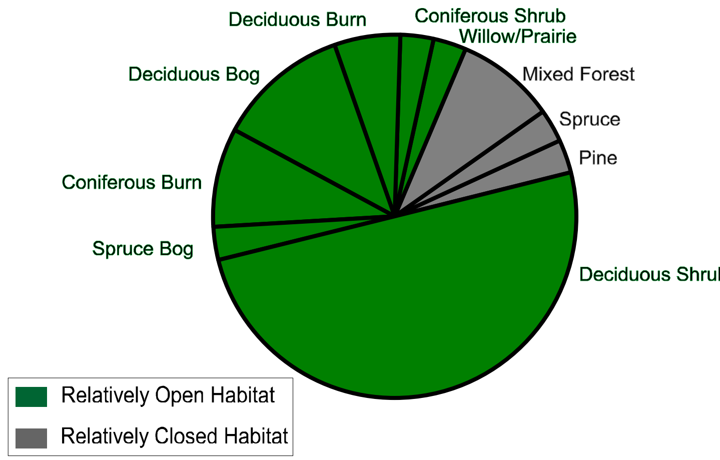

Figure 6. Habitat type within 10m of moose sightings.

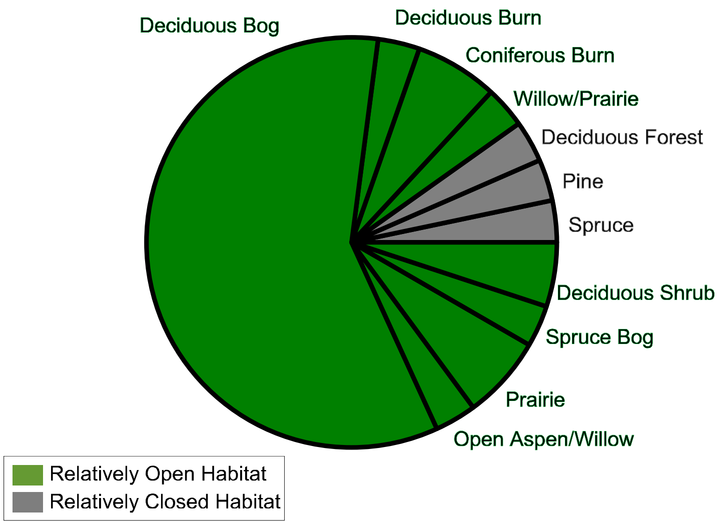

Figure 7. Habitat type within 250m of moose sightings.

Search Effort: 1994 vs. 1997

The helicopter group spent more time searching per unit area in 1997 compared to 1994 (Figure 8). The 1997 helicopter group's search time was about 135% of the 1994's group's time (Mann-Whitney U test: T = 207.0, n(small) = 18, n(big) = 18, $P < 0.01$). The 1997 fixed wing group's search time was only about 83% of the 1994 group's search time (t test: T = -2.17 with 22 degrees of freedom, $P = 0.04$). No relationship could be found between search effort and number of moose seen per SU for the helicopter or the fixed wing crew in 1997, suggesting that our search effort was adequate.

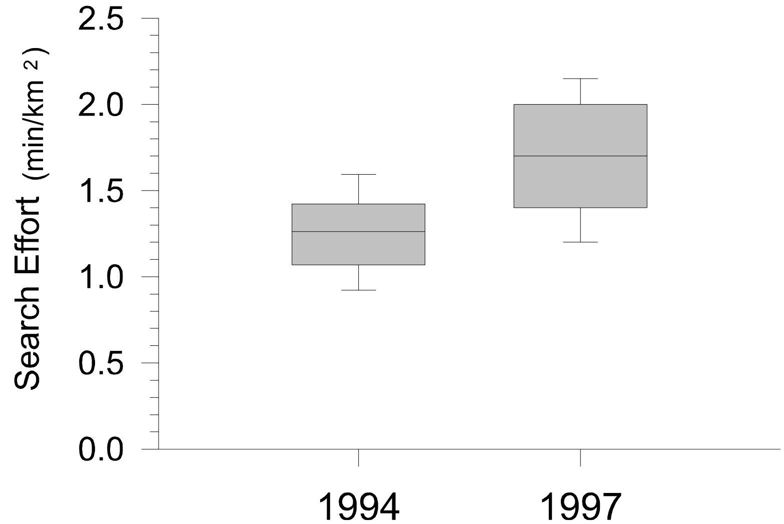

Figure 8. Search time per km² for the helicopters during the 1994 and 1997 Fort Providence moose censuses.

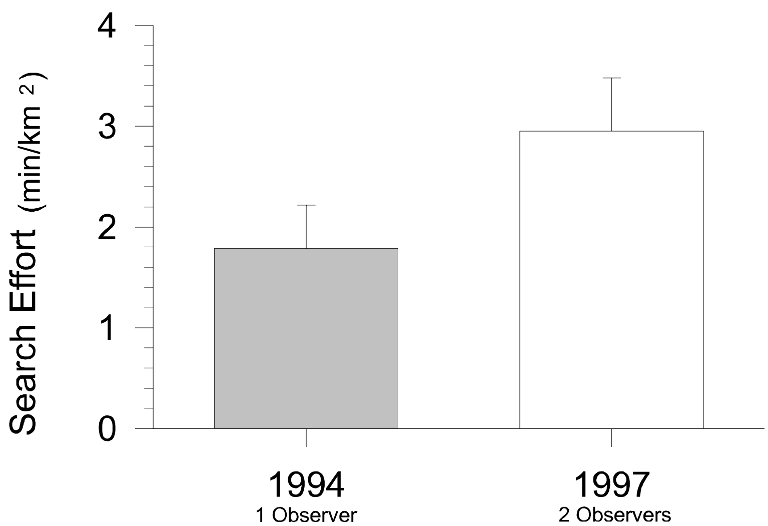

Figure 9. Search time per km² for the fixed wing aircraft during the 1994 and 1997 Fort Providence moose censuses.

Discussion

Population Density

Moose density in the N.W.T. ranges from 0.03 to 0.17 moose/km2. The moose density of 0.03 moose/km2 for our study is therefore at the bottom of this range (Table 4). Data for this table represent block censuses conducted in the N.W.T. The highest moose density yet published for the N.W.T. was in Fort Providence in 1991 (Table 4, Shank 1991), so there appears to have been a precipitous decline in moose numbers in the intervening six years. Precision of both censuses was high enough to allow us to demonstrate the statistical significance of the decline, but it is still important to examine the circumstances of both censuses to look for possible differences in bias.

Table 4. Population characteristics reported for N.W.T. moose populations. Only block surveys are included.

Location	Year	Density	CV	Calf:100 Cow	Author
Fort Wrigley	1982	0.03	n/a	n/a	Hawley and Antoniak 1983.
Slave River Lowlands	1981	0.04	n/a	n/a	Hawley and Antoniak 1983.
Inuvik	1986	0.05	0.04	44	Stenhouse and Kutney, in Graf, R. 1992.
Slave River Lowlands	1980	0.05	n/a	n/a	Hawley and Antoniak 1983.
Slave River Lowlands	1982	0.05	n/a	n/a	Hawley and Antoniak 1983.
Liard Valley	1980	0.06	n/a	n/a	Hawley and Antoniak 1983.
Inuvik	1986	0.06	0.15	25	Jingfors and Kutney 1989.
Liard Valley	1986	0.07	0.22	100	Case unpubl. data.
Fort Providence	1994	0.07	0.08	32	Bradley et al. 1998a.
Liard Valley	1981	0.10	n/a	n/a	Hawley and Antoniak 1983.
South Slave River Lowlands	1986	0.12	0.20	63	Graf and Case 1991.
South Slave River Lowlands	1996	0.11	0.10	37	Bradley and Kearey 1998?
Liard Valley	1985	0.12	0.17	81	Case unpubl. data.
Fort Good Hope	1984	0.13	0.1	61	Jingfors et al. 1987.
Liard Valley	1979	0.13	n/a	31	Donaldson and Fleck 1980.
Norman Wells	1984	0.15	0.11	44	Jingfors et al. 1987.
Norman Wells	1992	0.15	0.19	57	Latour 1992.
Liard Valley	1994	0.16	n/a	32	Bradley et al. unpubl. data.
North Slave River Lowlands	1988	0.16	0.10	69	Graf and Case 1992.
North Slave River Lowlands	1995	0.15	0.12	33	Bradley et al. 1998b.
Norman Wells	1995	0.17	n/a	56	Veitch et al. 1997.
Fort Providence	1991	0.17	0.14	55	Shank 1991 unpubl. data.

Possible Sources of Bias

There are at least 4 potential sources of bias when comparing two censuses: differences in technique, differences in effort, differences in weather during the census, and differences in observer experience.

One difference in technique between the 1994 and 1997 censuses was the changing of fixed wing aircraft type. A Cessna 150 was used in 1994 because of the low hourly rate. However, it was discovered that since the observer could only reliably see moose out of one side of the plane, twice as many transects had to be flown, thus the potential monetary savings were lost. The use of a Cessna 185 in 1997 proved to be cheaper, and probably more reliable, as observers could concentrate solely on looking for moose, leaving the data recording to the person in the front. Since we think that the 1997 technique was, if anything, better than in 1994, the discovery of a decline is not in question.

The use of fixed wing aircraft in a moose census is somewhat unusual. Although the techniques of Gasaway et al (1986) were designed for fixed wing aircraft, it has become standard to use only helicopters for SU searches. We felt that the blending of aircraft type was justified for three reasons. First, in an SU search you are attempting to find all moose. Therefore, if the observer thinks that sightability is low, he can simply spend more time searching. Also, the aircraft we used (a Cessna 185) has a slow stall speed (70 kph) and in practise, the fixed wing's normal air speed was approximately the same as in the helicopter (100 kph). Because of lower maneuverability, only sparsely forested, high visibility SUs were allocated to the fixed wing crew.

Search effort was probably not a factor in the observed decline because search effort for the helicopter crew was greater in 1997 compared to 1994. The 1997 fixed wing crew's search effort was about 83% of the 1994 crew's. In 1994, however, observations could be made out of only one side of the Cessna 150, therefore search time would have to be doubled to achieve search effort equal to the Cessna 185 (used in 1997). Since search times in 1994 were less than twice 1997's, we believe that search effort was, if anything, better in 1997.

No relationship between search time and number of moose could be found, suggesting that search effort was adequate for the 1997 census.

The weather was slightly less windy, and warmer in 1997 compared to 1994 (Figure 4). Visibility was considered good for both the 1994 and 1997 censuses. Since severe weather conditions were not encountered during either census, weather probably did not introduce a bias in our comparison of moose densities.

Moose were observed almost exclusively in open habitats, (Figures 6 and 7), so moose were selecting open habitats. This data is presented to show that the moose had not yet moved into the forests for cover, as they often do in late winter (Gasaway et al. 1986). We wanted to conduct our census before late winter in order to maximize sightability of moose. Had we seen many moose in the forests, we would have suspected that we had timed our survey incorrectly.

Population Characteristics

The calf per 100 cow ratio of 16 that we observed in 1997 is at the low end of the range reported for the N.W.T. (Table 4). The calf:cow ratio had declined from 32 in 1994 (Table 3), which itself was a decline from the calf:cow ratio of 55 in 1991 (Bradley unpubl. data)

Conclusions and Recommendations

The two major results to come out of this study are that since 1994, population density is down by about one half, and calf to100 cow ratio dropped from 32 to16. There are many possible reasons for a population decline, including predation, human harvest, and food supply.

A deterioration of food supply between censuses seems unlikely. Since we did not study the food supply we cannot rule it out, but three years is probably too short a time for successional changes in habitat to severely impact moose browse. Subjectively, moose appear to be occurring at densities well below the carrying capacity of the habitat; moose density in Sweden for instance, is more than one order of magnitude larger than ours, in an area of similar latitude (Cederlund and Sand 1994).

The Department of Resources, Wildlife and Economic Development and the Resource Management Committee of Fort Providence are currently collecting harvest information from the hunters of Fort Providence. The level of harvest appears to be well below that required to produce a halving of population density. They also do not seem to be targeting young animals (13 calves/100 cows in the harvested population, Bradley et al, in prep), which you would predict from our census data, if human hunting were causing the observed decline.

Larter et al (1994) predicted that the increasing bison population would cause a corresponding increase in the wolf population, thereby increasing predation on moose, the favoured prey species. Our data, i.e. the drop in density, accompanied by a decrease in calf to cow ratio, is consistent with their hypothesis of an increase in predation, especially if you assume that predators will target calves.

There are a few things to remember when interpreting our data however. One, census data is observational and by itself can only lend support to the predation hypothesis, not prove or disprove it. Two, there are other plausible hypotheses for the decline besides wolf predation. Black bears for example, are known to be predators of moose calves in other parts of North America (Ballard et al 1990), but we have no information on bear density. Also, there was a large forest fire on the nearby Horn Plateau in 1995 and if young browse plants have grown up it could be attracting moose away from our study area. Severe weather could also account for the decline.

Given our result of 2 consecutive declines, from the highest recorded moose density in the N.W.T. to the lowest, as well as a concurrent decline in calf:cow ratios, we suggest that more intensive research is necessary. The roles that habitat and predation play in moose population dynamics should be investigated. We will be working with the Fort Providence Integrated Resource Management Committee on more intensive research programs.

Literature Cited

Ballard, W.B., S.D. Miller, and J.S. Whitman. 1990. Brown and black bear predation on moose in southcentral Alaska. Alces. 26: 1-8.

Bradley, M., L. Keary, and T. Ellsworth.1996. Abundance and distribution of moose in the Northern Slave River Lowlands, NWT, November/December 1995. G.N.W.T. Manuscript Report 101. 14pp.

Cederlund, G., and H. Sand. 1994. Home-range size in relation to age and sex in moose. Journal of Mammalogy. 75: 1005-1015 pp.

Crete, M., L.P. Rivest, H. Jolicoeur, J.M. Brassard, and F. Messier. 1986. Predicting and correcting helicopter counts of moose with observations made from fixed-wing aircraft in southern Quebec. Journal of Applied Ecology. 23: 751-761.

Donaldson, J.L. and S. Fleck. 1980. An assessment of potential effects of the Liard Highway on moose and other wildlife populations in the Lower Liard Valley. G.N.W.T. Manuscipt Report. 36 pp.

Gasaway, W.C., S.D. DuBios, D.J. Reed, and S.J. Harbo. 1986 Estimating moose population parameters from aerial surveys. Biological Papers of the University of Alaska 22. 108 pp.

Graf, R. and R. Case. 1991. Abundance and distribution of moose in the South Slave River Lowlands, NWT, November, 1986. G.N.W.T. Manuscript Report. 40. 25 pp.

Graf, R., and R. Case. 1992. Abundance and distribution of moose in the North Slave River Lowlands, NWT, November, 1987 & 1988. G.N.W.T. Manuscript Report. 17 pp.

Hawley, V., and R. Antoniak. 1983. Fort Smith Region moose studies, 1979-1982. G.N.W.T. Draft Report. 95pp.

Jingfors, K., R. Bullion, and R. Case. 1987. Abundance and population composition of moose along the Mackenzie River, November 1984. G.N.W.T. File Report. 70. 39pp.

Larter, N.C., A.R.E. Sinclair, and C.C. Gates. 1994. The response of predators to an erupting Bison, *Bison bison athabascae*, population. Canadian Field-Naturalist 108: 318-327.

Latour, P. 1992. Population size and composition of moose west of Norman Wells. GNWT Manuscript Report 42. 17 pp.

Shank, C. 1991. Fort Providence moose survey - November 1991. G.N.W.T. Draft Manuscript Report. 51 pp.

Veitch, A.M., R.A. Popko, and N. McDonald. 1997. Size, composition, and harvest of the Norman Wells area moose population, November 1995. G.N.W.T. Manuscript Report 93:32 pp.

Personal Communications

Case, R. Manager, Technical Support, Department of Resources, Wildlife and Economic Development. Government of the Northwest Territories, 5102 50th Ave. Yellowknife, NT.