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Fort Providence Moose Census
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Abstract

We conducted an aerial census of moose near Fort Providence. The work was done 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 255 moose (density of 0.07 moose/km^2) with a 90% confidence interval of 38 moose (15% of the population estimate). We recalculated a subset of the data to compare with a 1991 census, and estimated that density had dropped from 0.17 moose/km^2 (390 moose in total) to 0.08 moose/km^2 (190 moose in total), a statistically significant decrease ($t = 3.507$, $df = 23$, $p < 0.01$). We also estimated a calf/100 cow ratio of 32, a significant drop from the ratio of 55 estimated in 1991 ($t = 3.004$, $df = 33$, $p < 0.01$). The drop in density, combined with the lower calf crop is consistent with the theory that predation rate is increasing in the area, but is not conclusive.

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Introduction

Moose are the most important meat animal south of the treeline in the NWT. Despite this importance, census work has occurred in a sporadic fashion, 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). Very few studies involve re-censusing of set study areas (but see Latour 1992), making monitoring of population trends impossible. To begin monitoring moose population trends near Fort Providence, we decided to re-census a study area established in 1991 by Shank (1991).

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. Because moose are the preferred prey, the increase in wolves could suppress the density of moose in the area. 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 trend in moose density.

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 are eliminated however, then the burning could be deleterious for moose. Either way, monitoring of the moose population is required.

Our main objective therefore was to estimate moose density in the Fort Providence study area and compare our data with Shank's (1991) data.

Methods

We followed Gasaway et al.'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 (SUs) 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 et al.'s (1986) methods by not estimating a sightability correction factor (Scf). Gasaway et al. (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 Shank's (1991) census of the same area. We can do this without Scfs if we assume no change in sightability between the two censuses.

Study Area

Our study area was 3,749 km^2, and we designed it to include two of Shank's (1991) study areas (Figure 1). We did not have enough money to include all three of Shank's study areas, but we wanted to amalgamate Shank's two adjacent study areas so we could increase sample size and therefore the precision of our estimate. Shank (1991) designed his study areas to represent medium and low bison density.

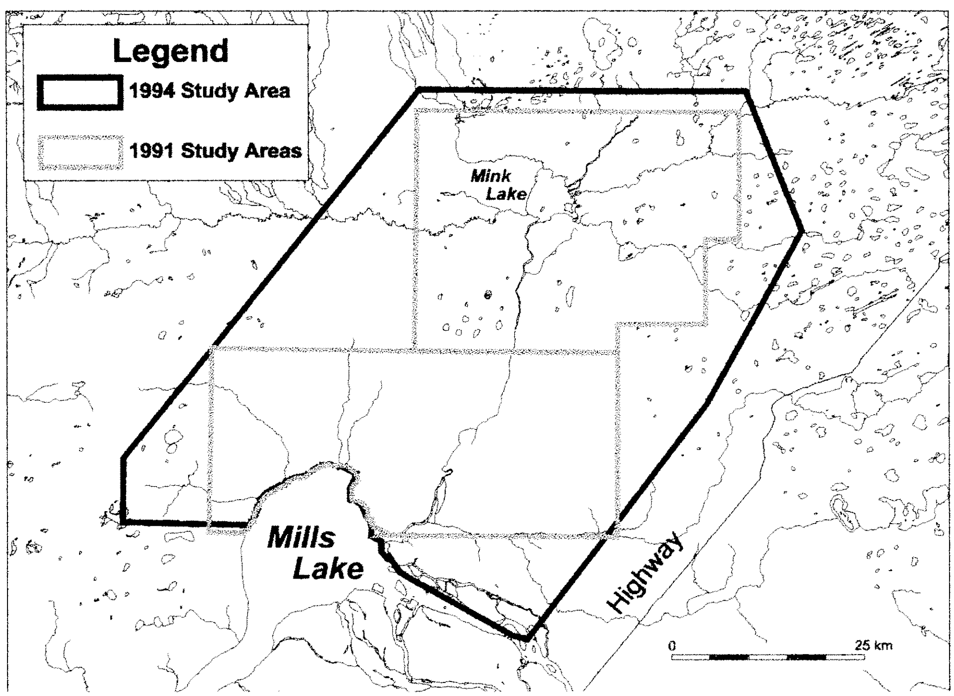

Figure 1. Comparison of our study area (1994) with Shank's (1991) study areas.

We designed our SUs according to Gasaway et al.'s (1986) method: SUs should be consistent in size to reduce variance, should not have narrow protrusions to minimize any edge effect, should contain uniform habitat, and should have uniform moose distribution. We used Shank's (1991) census data, Landsat satellite habitat data, digitized fire maps (Resources, Wildlife, & Economic Development Territorial Fire Centre), and local knowledge of the area to draw SU boundaries.

We differed from Gasaway et al.'s (1986) method by increasing average SU size from 33 km^2 to 50 km^2. We did this for three reasons. One, an increase in SU size increases the precision of your estimate by decreasing variation in moose density among SUs. Two, moose densities in the N.W.T. are lower than in Alaska, therefore a larger SU than Gasaway's is needed so that at least one moose is found in each SU. Three, the advent of GPS (Global Positioning System) technology has made aerial navigation much easier, making it easier to accurately search larger blocks.

Reconnaissance

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

Stratification

Given the low moose densities found during the reconnaissance and the inability of Shank (1991) to adequately delineate three survey strata, we delineated only two strata. We classed each SU as either high or low moose density based on several criteria: moose and track locations from the reconnaissance flight, moose locations from Shank (1991), and location of 'good' moose habitat (generally deciduous shrubs) as seen on reconnaissance or from the Landsat data. Moose and track locations from our own reconnaissance outweighed the other factors, and we also tried to avoid having single SUs of one stratum surrounded by SUs of the other stratum.

Census

We numbered each SU, then randomly picked numbers until we had a search order for all SUs. We searched the first 12 SUs in the most efficient order, then searched each SU in the search 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 2 December.

We used two aircraft to search SUs: a Bell 206 helicopter and a Cessna 150 air plane. There were 2 observers and a data recorder in the helicopter while there was only one observer (who also functioned as data recorder) in the air plane.

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

Weather

We recorded temperature, wind speed, and percent cloud cover at the beginning of each SU search. We obtained temperature and wind speed from the aircraft's instruments and we estimated cloud cover visually.

Habitat

We recorded habitat type in the immediate vicinity of each moose sighting. We also classed each SU by predominant habitat type. Classifying an entire SU as one habitat or another was very subjective, as each SU often contained several habitat types. Due to the difference in scale, habitat classes were not identical between the moose sighting data and the SU data.

Data Analysis

We followed Gasaway et al.'s (1986) techniques for analysing moose census data.

Results

Reconnaissance

We saw 38 moose on transect during the reconnaissance flights, representing a moose density of 0.04 moose/km^2 (Figure 2). We used the reconnaissance data to place 27 SUs into the high density stratum and 47 SUs into the low density stratum (Figure 3).

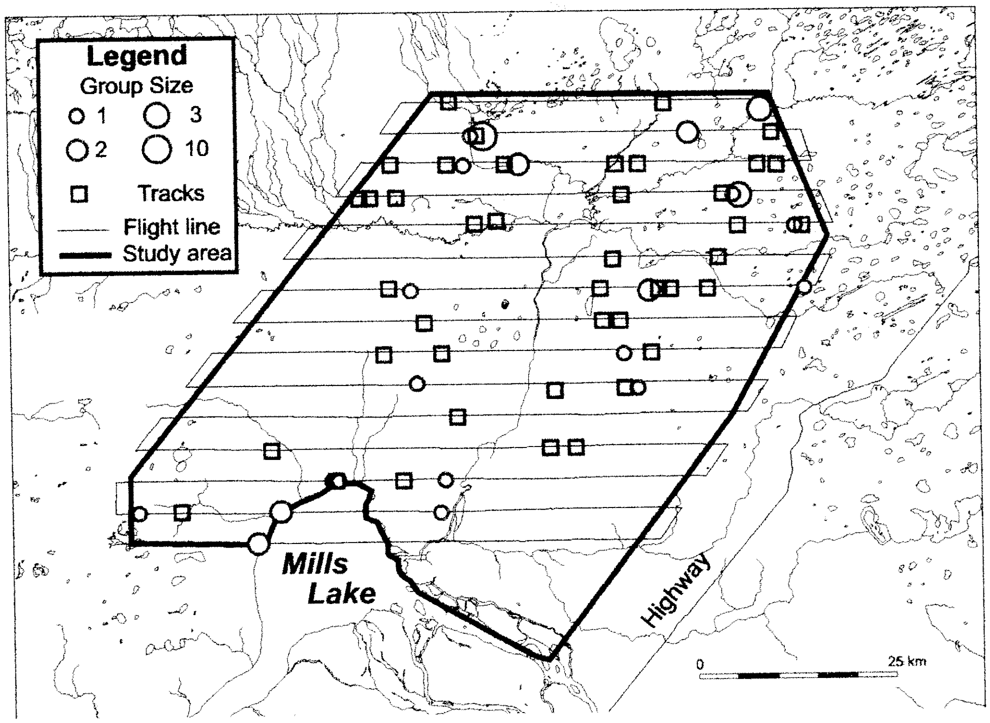

Figure 2. Location of moose and moose tracks seen on reconnaissance flights.

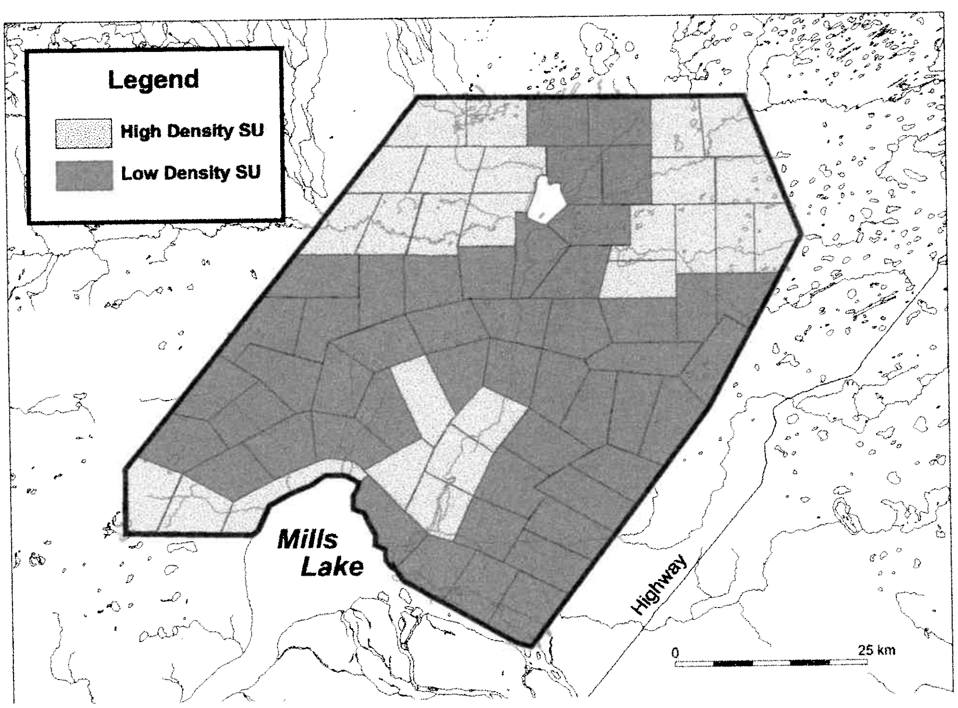

Figure 3. Strata as delineated by reconnaissance flights.

Population Estimate

We counted 154 moose (Figure 4), and calculated a population estimate of 255 moose. The 90% confidence interval for our census was 38 moose, or 15% of the estimate. The coefficient of variation was 0.09. Density was 0.07 moose/km^2 (Table 1).

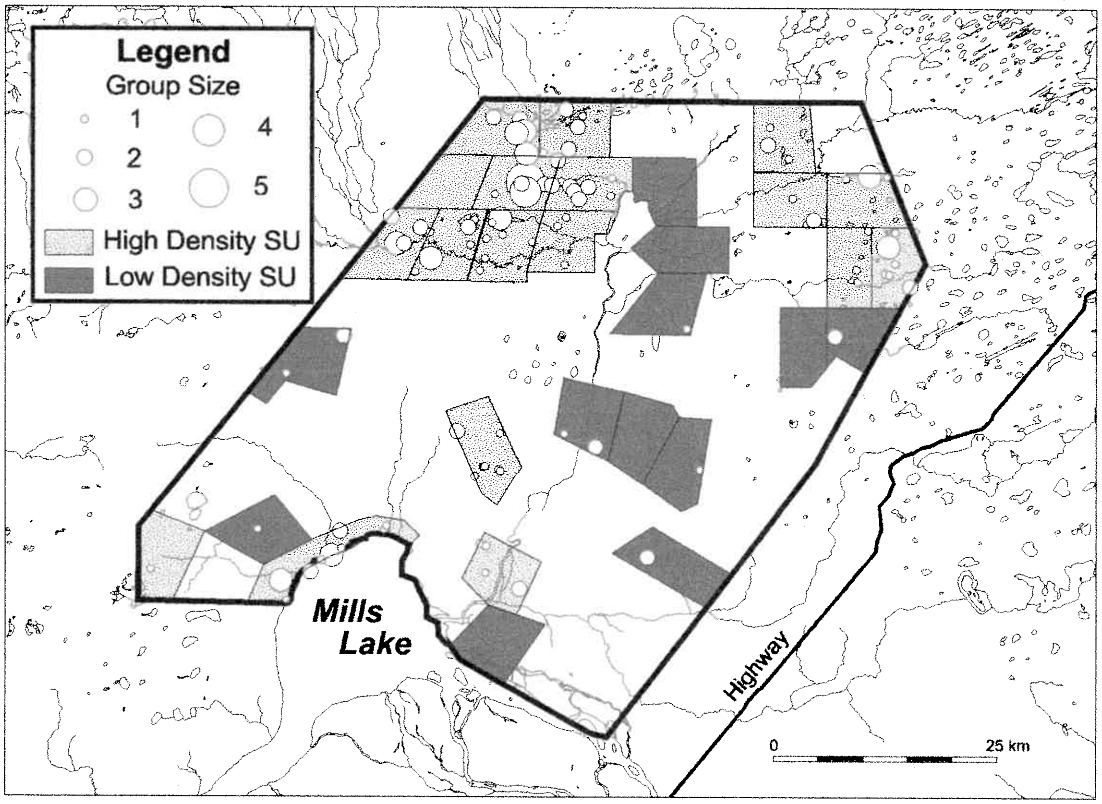

Figure 4. Location of moose sightings during the 1994 Fort Providence moose census.

Table 1. Moose population size and density for the Fort Providence study area 1994.

Strata	Low	High	Total
Total area (km^2)	2412.80	1336.50	3749.30
Area surveyed (km^2)	546.60	952.80	1499.40
Total SUs	47	27	74
#SUs surveyed	11	19	30
%SUs surveyed	23	70	40
Moose seen	13	141	154
Density (/km2)	0.02	0.15	0.07
Population Estimate	57.4	197.8	**255.2**
Variance	220.54	287.48	508.03
Degrees of freedom	10	18	27
Coefficient of variation			8.83
90% C.I. (% of population estimate)			15.04

Population Estimates: 1991 vs. 1994

To make a direct comparison with Shank's (1991) census, we calculated a second 1994 population estimate using only those SUs that fell within Shank's study areas (Figure 1). We also recalculated Shank's estimate as a single study area. Population size and density were approximately halved between 1991 and 1994. The decrease in population size was significant to the 0.01 level (Table 2).

Table 2. Comparison of census results: Shank 1991 vs. corresponding SUs from this study.

	Shank 1991	This Study
Total Area (km^2)	2,362.6	2,519.8
Area Surveyed (km^2)	926.6	1,012.5
% of Total Area Surveyed	39	40
Total # Blocks	72	50
#Blocks Surveyed	28	20
#Moose Seen	154	111
Population Estimate	399.2	190.4
Density	0.17	0.08
Variance	3,140.75	412.86
Degrees of freedom	19	17
90% C.I. (% of population estimate)	24.27	18.57
t test		$t = 3.507$, $df = 23$, $p < 0.01$

Sex and Age Ratios: 1991 vs. 1994

We calculated a sex ratio of 137 bulls per 100 cows, a calf to cow ratio of 32 calves per 100 cows, and a yearling to bull ratio of 2 yearlings per 100 bulls for the 1994 census (Table 3). The sex ratio did not differ between 1994 and 1991, but there were significantly more calves and yearlings in 1991. Also, we did not see any twins in 1994, while 2 sets of twins were seen in 1991 (Table 3).

Table 3. Moose population characteristics for the Fort Providence study area 1994.

Sex/age class	1991	1994	
Total moose	154	154	
Total cows	60	59	
Lone cows	29	42	
Cows w/1 calf	29	17	
Cows w/2 calves	2	0	
Total calves	33	17	
Total bulls	61	78	
Yearling bulls	8	2	
	Ratio + 90%CI		
	Shank 1991	This study	t-test
Bulls:100 cows (w/yearlings)	103 + 26%	137 + 31%	t = 1.197, df = 36, p = 0.12
Calves:100 cows (w/yearlings)	55 + 21%	31.5 + 23%	t = 3.004, df = 33, p < 0.01
Yearlings:100 bulls	13 + 49%	2.15 + 94%	t = 2.845, df = 16, p < 0.01
Twinning Rate	10%	0%	

Weather: 1991 vs. 1994

During the 1994 census temperature ranged from -20 to -29 °C, wind ranged from 0 to 40 km/hr and cloud cover ranged from 0 to 100% (Figure 4). Visibility was good throughout our census, except for one day (December 1) when blowing snow prevented us from flying.

If we compare the weather recorded during the 1991 and 1994 censuses (Figure 5), we see that it was warmer in 1991 (Mann-Whitney T = 1152.0, p = <0.01), but that there was no difference in wind speed (Mann-Whitney T = 747.5, p = 0.58). Cloud cover was impossible to compare because of differences in data recording.

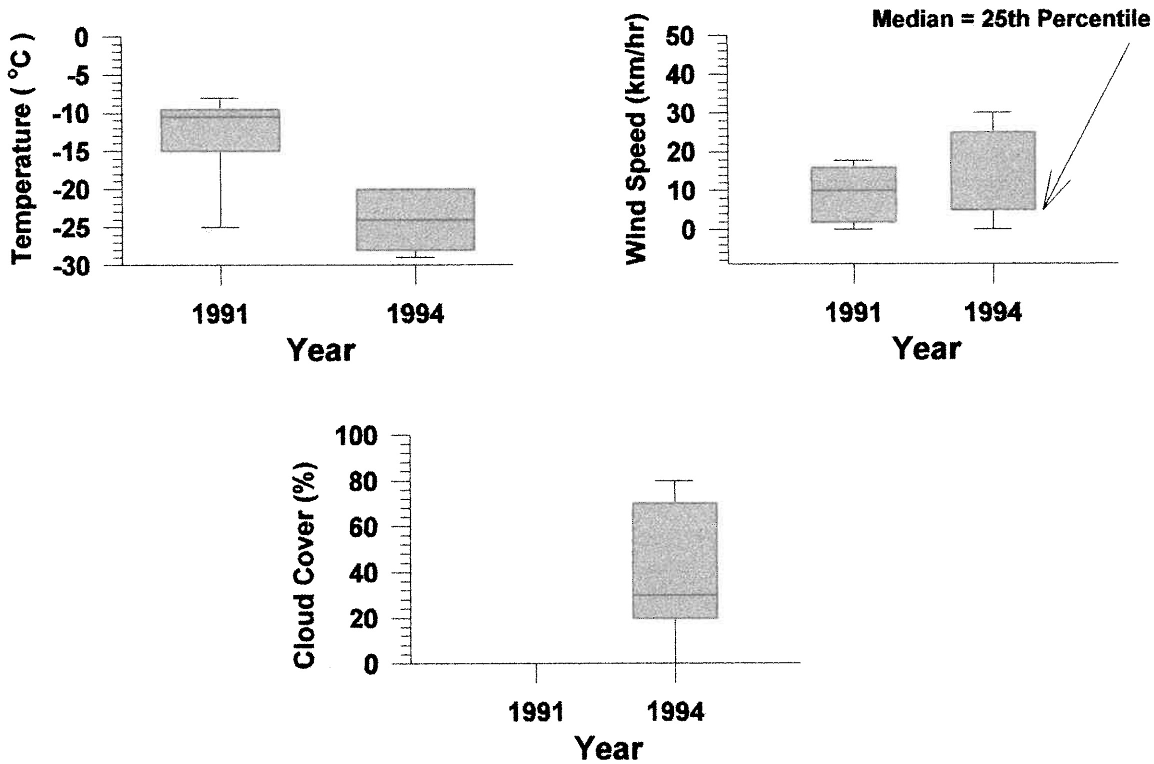

Figure 5. Weather experienced during SU searches. Lines inside the boxes represent medians, boxes represent 25th and 75th percentiles, while error bars represent 10th and 90th percentiles.

Habitat

We saw very few moose in thickly forested habitat (Figure 6). Eightyfive% of our moose sightings were in open habitats, with only 9% being in forested habitat (the other 6% were in forest edge habitat).

In terms of the landscape as a whole however, we considered 77% of the SUs in the study area to be predominantly forested (Figure 7). Bog, which accounted for over 50% of the habitat classed by moose sightings (Figure 6), represented only 18% of the habitat classed by SUs (Figure 7).

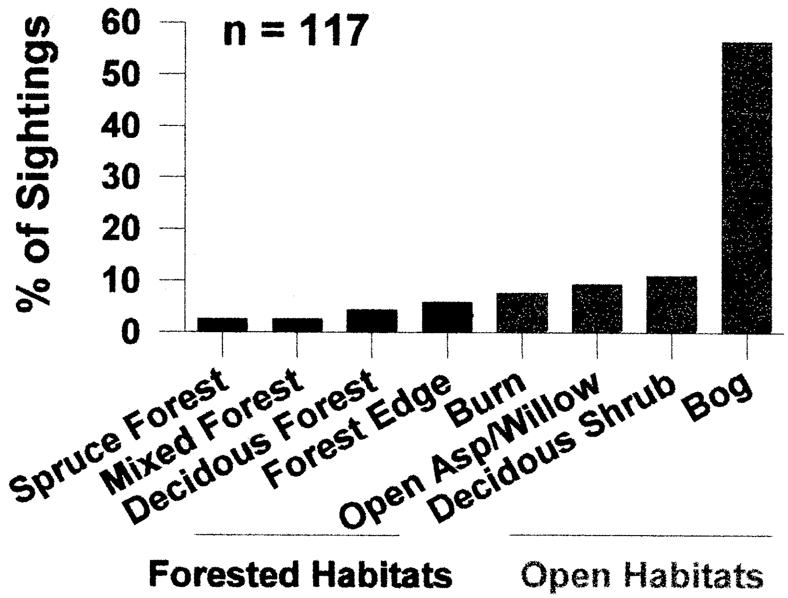

Figure 6. Habitat in the immediate area of moose sightings.

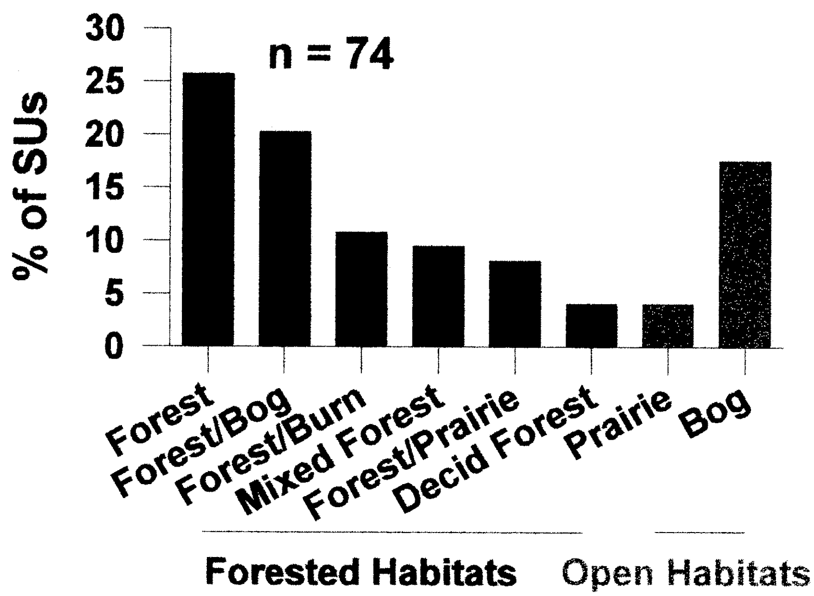

Figure 7. Habitat type of SUs within the study area.

Search Effort: 1991 vs. 1994

Moose density in 1991 was approximately twice that in 1994, so there must have been a greater proportion of time spent classifying moose in 1991. Therefore, before calculating search effort, we subtracted 1 minute/moose seen for each census. Even so, more time was spent searching per unit area in 1991 compared to 1994 (Figure 8). The 1994 fixed wing group's search time was about 92% of the 1991 group's search time, while the 1994 helicopter group's search time was about 68%.

Within the range of search times for the 1994 census there was no relationship between search time and moose seen for fixed wing crew ($r^2 = 0.04$, $P = 0.60$, $n = 9$), or for the helicopter crew in the low density stratum ($r^2 = 0.22$, $P = 0.25$, $n = 8$), suggesting that search times were adequate. There was a significant relationship between search time and moose found by the helicopter crew in the high density stratum ($r^2 = 0.43$, $P = 0.04$, $n = 10$, Figure 9), so search times may have been inadequate in that situation.

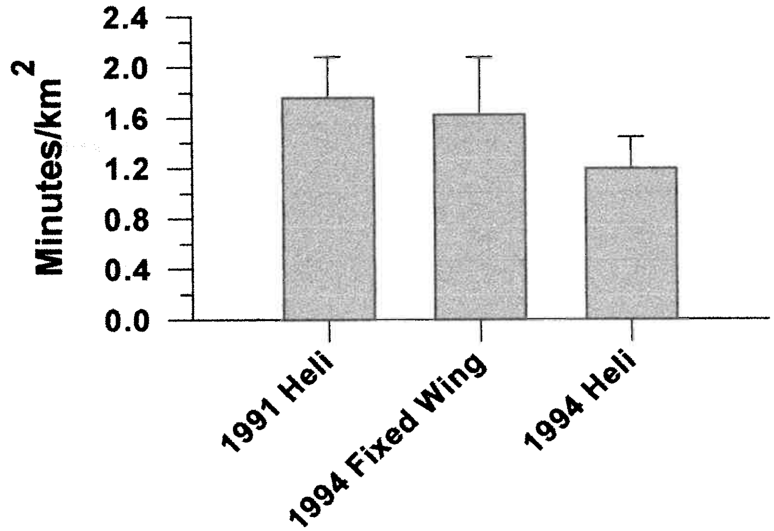

Figure 8. Search time per km² for the 1991 and 1994 Fort Providence moose censuses.

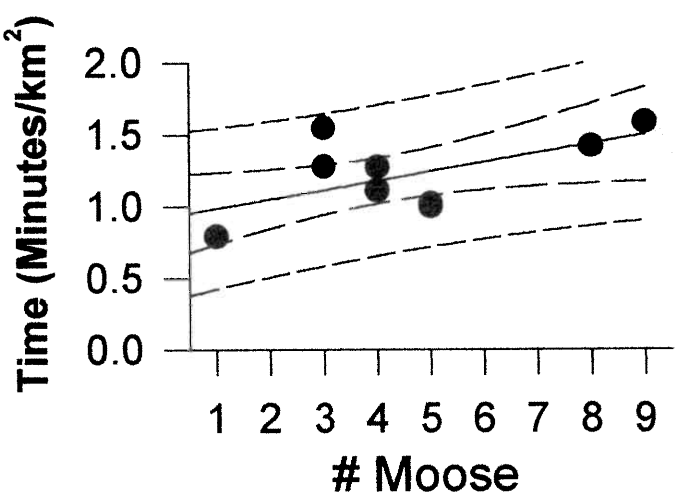

Figure 9. The effect of search intensity on moose sightability for the helicopter crew in the high density stratum.

Discussion

Population Density

Moose density in the N.W.T. ranges from 0.03 to 0.17 moose/km^2. The moose density of 0.07 moose/km^2 for our study is therefore just below the middle of this range (Figure 10). Data for this graph represent block censuses in the N.W.T.

The highest moose density yet published for the N.W.T. was in Fort Providence in 1991 (Figure 10, Shank 1991), so there appears to have been a precipitous decline in moose numbers in the intervening three 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 accuracy.

Table 4. Literature cited in Figure 10.

A	Hawley, V. and R. Antoniak, 1983.
B	Hawley, V. and R. Antoniak, 1983.
C	Stenhouse and Kutney, unpubl. data
D	Hawley, V. and R. Antoniak, 1983.
E	Hawley, V. and R. Antoniak, 1983.
F	Hawley, V. and R. Antoniak, 1983.
G	Jingfors and Kutney, 1989.
H	Case, R., unpubl. data.
I	**Bradley, et al this study.**
J	Hawley, V. and R. Antoniak, 1983.
K	Graf, R., and R. Case, 1991.
L	Case, R., unpubl. data.
M	Jingfors, et al., 1987
N	Donaldson and Fleck, 1980
O	Jingfors, et al., 1987
P	Latour, 1992.
Q	Bradley et al,. unpubl. data
R	Graf, R., and R. Case, 1992
S	**Shank, C. unpubl. data.**

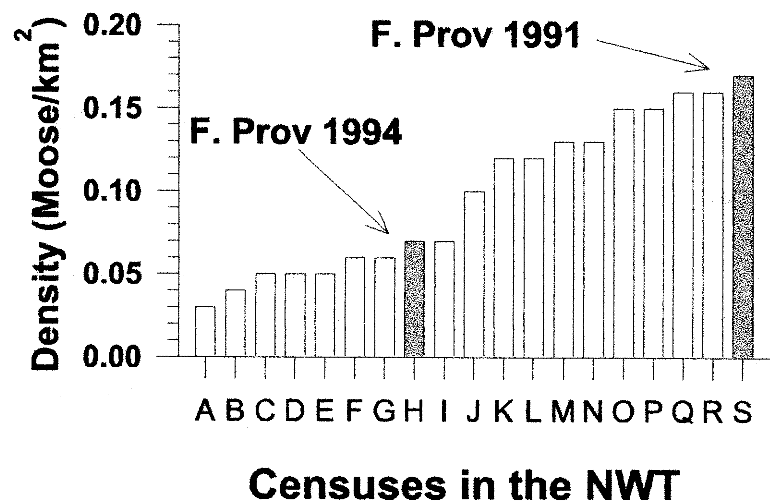

Figure 10. Summary of densities reported for N.W.T. moose populations.

Possible Sources of Bias

There are 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.

There were two differences in technique between our censuses: an increase in SU size from 1991 to 1994 (35 km^2 to 50 km^2), and the use of a fixed wing aircraft in 1994. The advantages of increasing SU size is that you reduce SU 'edge' relative to SU area (i.e. fewer 'questionable' moose on the borders between SUs, and less movement between blocks), and you have a better chance of having homogenous moose numbers among SUs. The disadvantages of increasing block size is increased observer fatigue and the increased possibility of getting lost and then either counting animals twice or missing them altogether. We believe that the increased time needed to search the larger blocks did not significantly increase observer fatigue. We would typically cover the blocks by flying lines that went beyond the borders of each SU, thereby giving the observers about a 1 minute rest at the end of each line. Observers could also rest between blocks. We also believe that the advent of GPS technology allows a larger block size because navigation is much simpler. There is now a much lower chance of getting lost, and precise locations for each moose mean a lower chance of counting the same moose twice.

We used a fixed wing aircraft as well as a helicopter to reduce the cost of the census. 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 using the two aircraft types 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. Since we could find no relationship between search time and sightability, our search time was evidently sufficient. Second, the GPS unit in the plane enabled the pilot to fly and navigate while the observer concentrated on searching for moose. If the lone observer in the plane needed time to record data, he could circle, then use the GPS unit to return to exactly the same spot to resume searching. Third, the aircraft we used (a Cessna 150) has a very slow stall speed (60 kph) therefore the Cessna's normal air speed was approximately the same as the helicopter's (100 kph). Because of lower manoeuvrability, we allocated only sparsely forested, high visibility SUs to the fixed wing crew.

Search times were greater for the 1991 census (Figure 8). Effort is a very difficult thing to analyze however, as observer experience, habitat type, moose group size, aircraft type and weather all interact to affect search time.

An examination of search time: number of moose found suggested that search effort was adequate for the 1994 fixed wing crew, and the 1994 helicopter crew in low density blocks. There was a positive relationship between search time and number of moose found for the helicopter crew in the high density blocks however (Figure 9), so search times may have been inadequate in that situation. The helicopter crew was the most experienced crew however, so we would not expect them to miss many moose.

The 1994 fixed wing crew had search times nearly identical to the 1991 crew, but given that strip width was narrower in 1994 (only one full time observer), the 1994 crew should possibly have spent more time in each SU. A mitigating factor in this case is that the 1994 fixed wing crew was assigned to unforested blocks, therefore visibility was very high and search times correspondingly lower.

Considering the above factors, all we can say is that effort in 1994 may have been slightly lower than in 1991, but we don't think it would account for the observed halving of moose density.

Our comparison of weather between the 1991 and 1994 censuses showed that wind speed was about the same, while it was about 10 degrees colder in 1994 (Figure 5). Visibility was considered good for both censuses. We do not think the drop in temperature affected moose sightability because almost all the moose we saw were in open habitats (Figure 6), indicating that the moose had not yet moved in to the heavily forested habitat, as they usually do in late winter (Gasaway et al. 1986). Conversely, one could say we just overlooked the moose in the trees, but the extensive experience of our observers at spotting moose and tracks makes this unlikely.

As mentioned in the above sections, we believe that if anything the 1994 observers were more experienced than the 1991 observers, so observer experience should not be a factor in the observed decline.

Habitat Classification

We observed moose almost exclusively in open habitats, mainly bogs (Figure 6), yet we classified the majority of SUs as forested (Figure 7), therefore the moose were selecting open habitats.

We are not presenting this data as a bona fide habitat use study, since the two scales of measurement (moose sightings vs. SUs) are so different. For example a 'forested' SU would typically be quite heterogenous and have many small bogs within it, whereas a 'forested' moose sighting would be pure forest in the immediate vicinity of the moose. We present this data merely 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 32 that we observed in 1994 is at the low end of the range reported for the N.W.T. (Figure 11). The calf:cow ratio was 55 in 1991, representing a statistically significant decline in the intervening three years (Table 3). The figure of 55 for 1991 is also not particularly high for the N.W.T.

Table 5. Literature cited in Figure 11.

A	Donaldson and Fleck, 1980.
B	Bradley, unpubl data.
C	This study.
D	Jingfors et al, 1987.
E	Stenhouse and Kutney, unpubl
F	Shank, C., 1991
G	Latour, 1992.
H	Jingfors, et al, 1987.
I	Graf and Case, 1991.
J	Hawley, and Antoniak, 1983.
K	Hawley, and Antoniak, 1983.
L	Graf, R., and R. Case, 1992
M	Case, R., unpublished data
N	Case, R., unpublished data

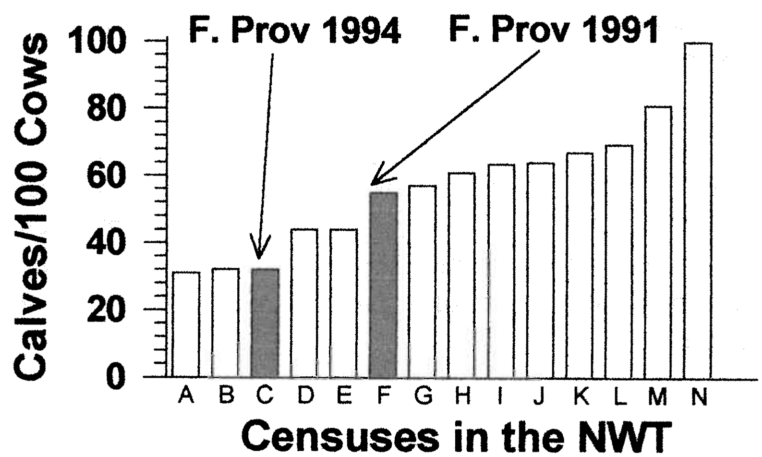

Figure 11. Summary of calf:100 cow ratios in the N.W.T.

Conclusions and Recommendations

The two major results to come out of this study are that since 1991 population density is down by about one half, and calf to 100 cow ratio dropped from 55 to 32. 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 impact moose foraging areas to such a degree. 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 1991).

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. We have not fully analysed these data, but the level of harvest appears to be well below that required to produce a halving of population density. They 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. The drop in density, with a corresponding decrease in calf to cow ratio, is consistent with their hypothesis of an increase in predation, 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), and have been at high densities in the Fort Providence area for the last few years (T. Chowns, pers comm). Severe winter weather, like that experienced in the winter of 1993/1994, could also account for the decline. Lastly, we should remember that establishing a trend with only two data points (1991 and 1994) is dubious at best, so we should strongly consider another census to strengthen our hypothesis of a population decline.

We recommend doing another census in the fall of 1997, keeping the census interval at three years. We also recommend experimenting with repeat counts of SUs using both helicopter and fixed wing aircraft to quantify any possible differences in sightability. We believe that the financial benefits of using fixed wing aircraft justifies the expense of the experiment. Crete et al. (1986) performed a similar experiment (involving counting of track networks by fixed wing and subsequent helicopter counts) and recommended further work. It may also be worthwhile experimenting with search intensity and sightability.

Personal Communications

Tom Chowns, Renewable Resource Officer, Department of Renewable Resources, G.N.W.T. Hay River, N.W.T.

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