MOOSE DENSITY AND COMPOSITION IN THE LOWER McGREGOR RIVER AND HERRICK CREEK WATERSHEDS, BRITISH COLUMBIA, JANUARY 2001.

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ABSTRACT

We estimated 1,290 $\pm$ 202 (0.45 moose/ km^2) moose within a 2,850 km^2 area in the lower McGregor River and Herrick Creek watersheds, British Columbia, in January 2001 using a stratified random block survey design where stratification was based on forest cover type and sightability bias was estimated from the vegetation cover density around each moose seen. The population estimate for the 2,850 km^2 study area was 1,290$\pm$ 200 moose for an average density of 0.45 moose/km^2. Moose density was much higher in the portion of the study area covered by the Sub-Boreal Spruce wk1 biogeoclimatic subzone (2.4 moose /km^2) than in the Sub-Boreal Spruce vk (0.21/km^2) which made up the remainder of the study area. There were about 120 moose in the lower Herrick Creek watershed. There were 64 bulls and 32 calves per hundred females. Neither the number of moose shot by licenced hunters nor hunter success rates showed any trend over time. Moose density, composition and hunting statistics were all consistent with what we expect for a stable moose population that has been sustaining kill by hunters.

INTRODUCTION

Moose (*Alces alces*) are abundant in the central interior of British Columbia (Heard et al. 1999a, b, Demarchi 2000) and sustain a high kill by both licenced and Aboriginal hunters. Members of the Lheidli T'enneh First Nation were especially interested in the moose population in the Herrick Creek watershed (Fig 1) because it was one of their preferred hunting areas, because of its overall cultural significance, and because that area had never previously been surveyed. In January 2001, we estimated moose composition and abundance in the lower McGregor River and Herrick Creek watersheds so we could relate the density, population composition (calf:cow and sex ratios) and the number of moose shot by licenced hunters, to future opportunities for use by Aboriginal hunters.

STUDY AREA

The 2,850 km^2 study area comprised the rolling hills and low elevation (560 – 1200 m) forests north-east of Prince George, British Columbia, including parts of Management Units (MU's) 716, 717 and 718. The study area was bounded to the south-west, west and north by the location of previous moose surveys (Heard et al. 1999a, b), and to the north-east, east and south-east by an arbitrary line approximating the elevation at the headwaters of the McGregor River and Herrick Creek tributaries, above which we did not think there would be any moose (Fig 1). We defined the census zone by excluding from the study area 64 km^2 of large lakes, and those areas >1100 m asl where our experience indicated there would be few moose (Fig 2). We had used a 1200 m elevation cut-off for past surveys (Heard et al. 1999b), but we reduced the threshold here because the study area typically has deeper snow, earlier in the year.

The southwestern third of the census zone lay within the Sub-Boreal Spruce (SBS) wk1 biogeoclimatic subzone, and northeast was in the SBS vk (MacKinnon *et al.* 1992, DeLong *et al.* 1993). Both SBS subzones have a relatively cool wet climate, but the SBS vk gets more precipitation than the SBS wk1 (Ministry of Forests 1996), with > 73 cm of precipitation and > 300 cm of snow annually (DeLong *et al.* 1993). Snow usually covers the ground from late-November through mid-May. There was 100% snow cover in the census zone during this survey but much shallower than normal (e.g., snow depths on 1 Jan 2001 for places in and around the study area were; 19 cm at Prince George, 79 cm at Hedrick Lake and 94 cm at Longworth representing 52%, 55% and 65% of the means from the previous 4 years respectively, for that date). The SBS typically has a mean annual temperature of 2.6 °C.

Climax Sub-Boreal Spruce forests consist primarily of hybrid white-Engelmann spruce (*Picea glauca* x *engelmannii*) and subalpine fir (*Abies lasiocarpa*), with extensive successional stands of lodgepole pine (*Pinus contorta*) and trembling aspen (*Populus tremuloides*) caused by recurrent disturbances.

Natural fires, once the dominant disturbance in those forests, have been largely eliminated. The primary disturbance is now logging. Selective large tree removal was typical until clearcut logging began in about 1965. Logging along Herrick Creek has been more recent, primarily occurring within the last 20 years.

Although no specific studies were available on moose movements, we knew that most moose in the area moved to lower elevations by early winter, so the distribution found during this survey are unlikely representative of moose distribution during the fall (10 Sep -5 Nov) hunting seasons. Moose were probably the predominant ungulate prey for wolves (*Canis lupus*), black bears (*Ursus americanus*), and grizzly bears (*U. arctos*) because the other ungulates present, white-tail deer *Odocoileus hemionus*, mule deer *O. virginianus*, elk *Cervus canadensis,* and caribou *Rangifer tarandus*) were rare. Resident and non-resident hunters required licences, but hunting by members of the Lheidli T'enneh First Nation was unregulated.

METHODS

Sampling Strategy

We divided the census zone into 3 strata based (Fig 2) on forest cover data provided by BC Ministry of Forests, Forest Inventory Program database and, for Tree Farm Licence 30, Canadian Forest Products Limited. Stratum 1 (S1) included the area covered by the 3 forest cover classes that were predominantly used by moose in early winter (Heard *et al.* 1999a, b): 1) Age Class 1 (AC1) - forests 1-20 years old; 2) Age Class 2 (AC2) - forests 21-40 years old; and 3) Not Sufficiently Restocked areas (NSR) - productive forest land covered with commercial deciduous or coniferous species, but where the conifer density was below commercially acceptable standards. Forest age refers to the age of the trees at the time of forest inventory map updates. The map updates varied across the census zone from 1993 to 1995, resulting in reported tree ages being up to 7 years less than their actual ages at the time of the census. Stratum 2 (S2) was composed of the remaining forest cover types, primarily forests > 40 years old, with small amounts of gravel bars, swamps, muskegs, roads, and recently logged areas that had not yet been entered into the database. Stratum 3 was the Herrick Creek watershed in the northeast quadrant of the census zone.

We divided the census zone into 36 km^2 (5.5 x 6.6 km) blocks. Each block was therefore made up of variable amounts of S1, S2 and area outside of the census zone. Where a block covered < 6 km^2 of S1, we joined adjacent blocks to form sample units of $\geq$ 6 km^2 of S1, in an attempt to ensure that there would be some moose in every sample unit. Each individual block had $\geq$ 6km^2 of S2. We randomly selected S1 sample units (SU) for survey, and randomly subsampled from those to obtain the S1 sample. Thus, for SU's selected for both S1 and S2, we flew the entire block and simply recorded moose observations by stratum depending on their location. If an S1 sample unit contained more than one block, we randomly selected one to survey for the S2 sample.

Between and 16 and 22 January 2001, a crew consisting of 2 observers (one of whom recorded the data), a navigator, and the pilot, surveyed SU's from Bell 206B Jet Ranger Helicopters, flying 65-95 km/hr, 30-50m above the ground (Appendix A). To cover the SU's we began a search pattern consisting of transects that were 200-300 m apart depending on vegetation cover density. SU boundaries were located using the helicopter's Global Positioning System (GPS), but flight track was determined using a map and compass.

We circled each moose and recorded its age and sex (based on the presence/absence of a white vulva patch, bell size and shape, face colouration and antler morphology) as a cow, calf ($\leq$ 8 months old), teen bull, sub-prime bull, prime bull, antlerless bull, or unknown, and the vegetation cover to the nearest 5%, within 9 m of where the moose was first seen, according to standards developed by Unsworth *et al.* (1991) and that we had experience using (Heard et al. 199b).

Data Analysis

We used the vegetation cover estimates to correct for sightability bias. Vegetation cover estimates were grouped into 5 classes, each with a specific detection probability correction factor, as determined by Quayle et al (2001) using sightability data from British Columbia (Table 1) and following the approach described by Anderson and Lindzey (1996). Each moose observed was divided by the detection probability to correct for the number of moose missed. The overall sightability correction factor was determined by dividing the corrected number of moose by the observed number of moose.

For each stratum, the naïve population estimate and sampling variance for unequal sized sample units was calculated using Jolly (1969) for the observed number of moose in each sample unit. Then the overall sightability correction factor, its variance and the model variance were calculated using the program AERIAL SURVEY (Unsworth *et al.* 1998), modified to use data from Quayle et al. (2001). We did not use that program to calculate the population estimate, because our survey was designed to use the area of the SU's surveyed divided by the area of the study area as the sampling fraction, but the model used the number of sample units surveyed divided by the number of sample units in the study area as the sampling fraction. The final population estimate was the product of the naïve population estimate and the sightability correction factor and its variance was the sum of the sampling, sightability, and model variances (Heard 1987).

The variance of the calf:cow and bull:cow ratios was based on all 26 SU's (i.e., not segregated by stratum), using the ratio variance formula provided in Manly *et al.* (1993).

Hunter Kill

Licenced hunting of calves and spike or 2-point bulls was open to anyone who purchased a moose hunting licence, but for most years, permits to hunt larger antlered bulls and cows were limited and distributed at random among applicants (limited entry hunting, LEH). We estimated the mean annual number of bulls, cows, and calves shot by hunters in MU's 716, 717 and 718, based on hunter surveys from 1976-2000. Resident hunters were surveyed via questionnaires that requested information about hunter effort and success. Questionnaires were mailed to all LEH permit holders and 50% of those who purchased a licence to hunt in the open seasons. Recipients who did not respond to the first questionnaire were mailed a second, and repeat non-respondents may have been further queried by telephone. Around 75% of hunters responded (J. Thornton, personal communication). All non-resident hunters were required to have a guide, and guides were required to submit information on the success and effort for all their non-resident clients. We made no attempt to estimate the number of moose shot by Aboriginal people.

RESULTS

Population Size and Density

We counted 239 moose in S1, 10 in S2, and 101 in S3 (Table 2, Appendix B). Sightability correction was similar among strata and resulted in an overall expansion factor of 1.16. The corrected study area population estimate was 1,290 $\pm$ 202 moose, for an overall density of 0.45 moose/km^2. Stratification by forest cover effectively lumped areas of similar density and variance (Table 2), but post-census inspection of the data suggested that the S1 sample units in the Sub-Boreal Spruce wk1 biogeoclimatic subzone were less variable and of much higher density than other SU's (Table 3). Post-census stratification on the basis of biogeoclimatic subzones indicated that there were about 900 moose in the Sub-Boreal Spruce wk1 biogeoclimatic subzone (2.4 moose /km^2) and 400 moose in the Sub-Boreal Spruce vk (0.2/km^2) in S1 and S2 and 500 (0.21/km^2) in the Sub-Boreal Spruce vk including S3.

Composition

The bull:cow and calf:cow ratio estimates were similar for both the observed number of moose and the numbers corrected for sightability (Table 4). Both the bull:cow and calf:cow ratios were intermediate between those obtained for the Prince George and Parsnip areas, and similar to previous composition estimates for the study area (Fig 3, Table 4).

Distribution

All but 4 moose were in vegetation cover classes 1 and 2 and most were in class 1 (Table 5). With 71% of the cows without calves in cover class 1 and 67% of the cows with calves in class 1, there was no indication that the presence of a calf affected use of different cover types. There was a slight trend for bulls to select for lower vegetation cover classes as proportionally more bulls were in vegetation cover class 1 than class 2, and mean vegetation cover for bull groups was less than for cows and cows with calves.

Most moose in S3 were along lower Herrick Creek near the confluence with the McGregor River. Bulls were especially common in S3 (Table 4).

Hunter Kill

The annual kill by licenced hunters averaged 309 /yr, 62% of which were bulls. Overall there was no long-term trend but the kill in MU 718 has shown a general increase, probably associated with increasing access created by logging roads (Table 6) . Regulation changes and number of LEH permits have changed little over the past 25 years. The only change since 1991 was a 20% reduction in the number of cow moose LEH permits in 1998. Hunter success rates averaged 50% for LEH holders and 23% for all hunters combined, and showed no trend over time.

DISCUSSION

Survey Methods

A priori stratification of the census zone using GIS, forest cover data, and the moose habitat use pattern found in the Parsnip River and around Prince George (Heard *et al.* 1999a, b), was effective at defining high and low density strata, but stratification based on biogeoclimatic subzones would have been better in the lower McGregor River and Herrick Creek study area because moose densities in the SBS wk1 were less variable and much higher than in the SBS vk. The SBS wk also maintains high moose densities around Prince George (Heard *et al.* 1999b). Pre-census reconnaissance flights to assist with stratification decisions may have led us to that method of stratification.

The resulting mean survey rate was 3.3 min/km^2, substantially less than in previous surveys (e.g., 5.2 min/ km^2, Heard 1999b). Survey rate is a function of transect spacing, flight speed, and, because we circle each moose, the number of animals observed. All of those variables are influenced by vegetation cover density, which is primarily related to the age of the forest. Although we knew that navigation difficulties occasionally resulted in transect spacings >300 m, we suspected that the primary reasons for the low survey rate were low moose density and low vegetation cover where we saw moose. Overall moose density in the study area was only 0.45 moose/km^2, and the overall sightability correction factor, an index of vegetation cover density, was of 1.16. In comparison, moose density in 1998 around Prince George was 1.33 moose/km^2 and the sightability correction factor was 1.41.

Composition and Distribution

The absence of strong sexual segregation by vegetation cover was consistent with past surveys (Heard et al. 1999b).

Population Dynamics

We believe that the moose population we found is large enough to maintain mean annual kill by hunters. The absolute number of moose shot by hunters cannot be directly related to population dynamics because moose probably move between the fall hunting season and January when we carried out this survey, and because kills are recorded by MU, whereas the survey covered only parts of the MU's. The absence of any trend in the number of moose shot over time, by licenced hunters, medium to high and relatively constant hunter success rates, are characteristic of a stable moose population. The impact of the kill by resident hunters on the moose population appeared to be small, because even though 3 times as many bulls than cows were shot, the population sex ratio was not strongly biassed.

ACKNOWLEDGEMENTS

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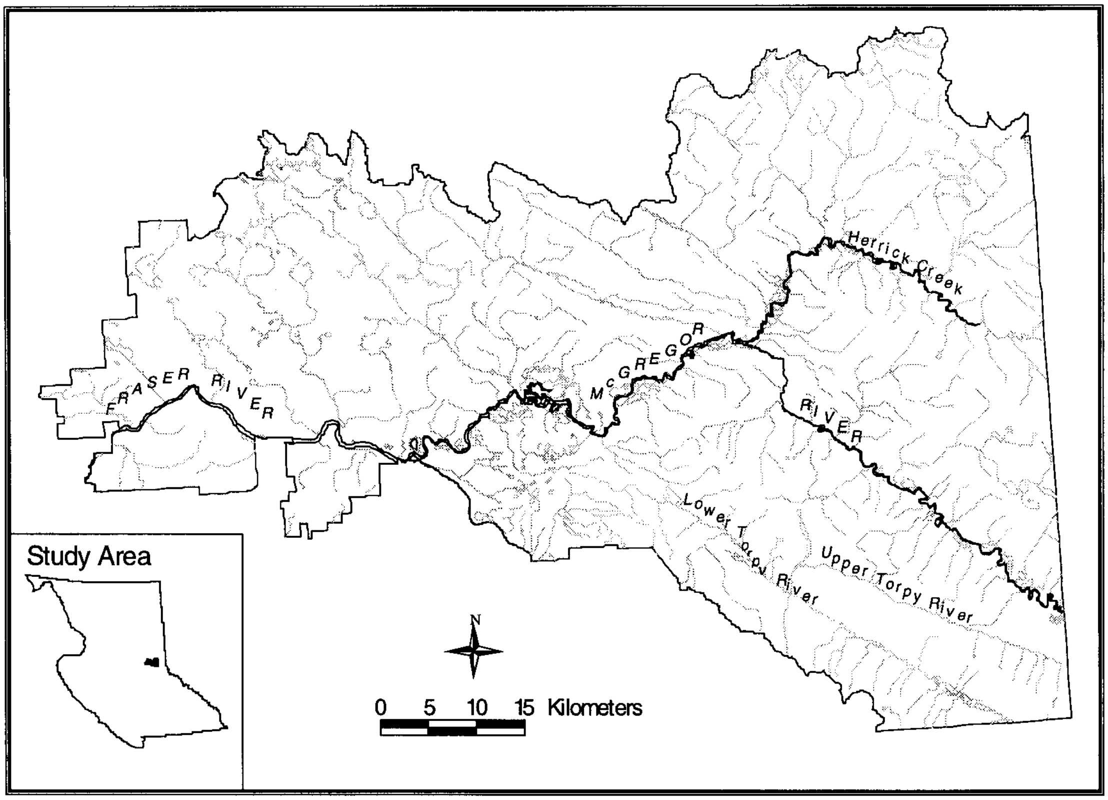

Figure 1. Location of the lower McGregor River and Herrick Creek study area.

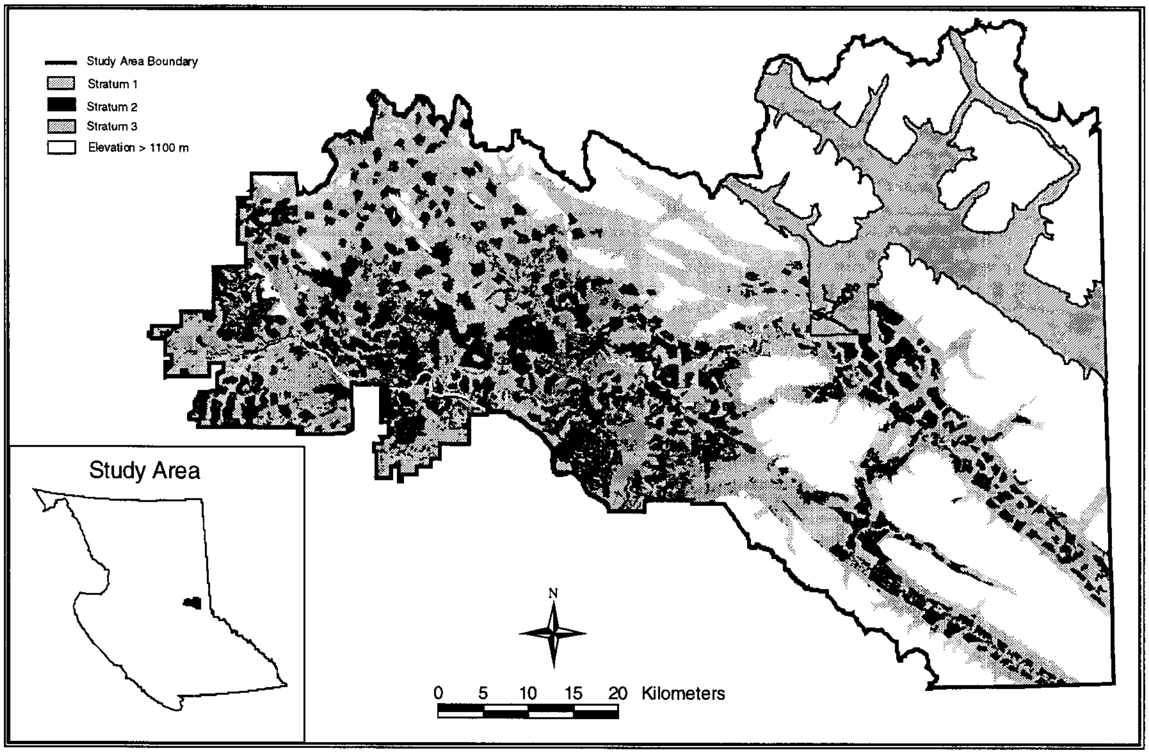

Figure 2. The lower McGregor River and Herrick Creek moose census zone, January 2001.

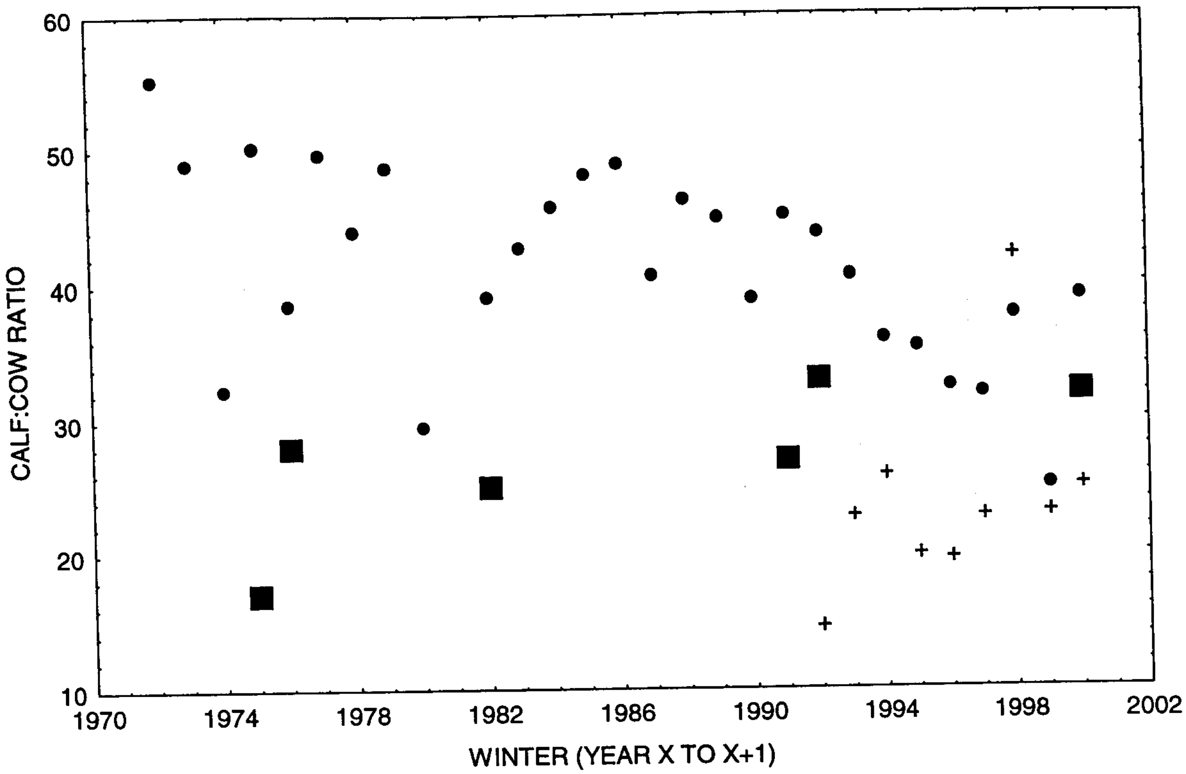

Figure 3. Calf:cow ratio estimates for the lower McGregor River and Herrick Creek (squares), Prince George (dots) and Parsnip River (crosses) areas between 1971 and 2001.

Table 1. Vegetation cover classes and their associated detection probability and sightability correction factors (from Quayle et al. 2001)

Vegetation Cover Class (VC)	Percent Vegetation Cover	Detection Probability Correction Factor (DP)*	Sightability Correction Factor (SCF)*
Class 1	0 - 20%	0.933	1.07
Class 2	21 - 40%	0.740	1.35
Class 3	41 - 60%	0.368	2.72
Class 4	61 - 80%	0.107	9.37
Class 5	81 - 100%	0.024	41.84

* DP=1/SCF
* SCF =1/((exp(4.2138-1.5847*VC))/((1+exp(4.2138-1.5847*VC)))

Table 5. Number and per cent of moose observed by vegetation cover class in the lower McGregor River and Herrick Creek watersheds, January 2001.

	Vegetation cover class			Total	Mean % Vegetation Cover
	1	2	3		
Bulls (%)	91 (81)	22 (19)	0	113	15%
Cows without calves (%)	88 (71)	32 (26)	4 (3)	124	18%
Cows with calves (%)	35 (67)	17 (33)	0	52	18%

Table 6. Number of moose shot by licenced hunters each year within the 3 management units (716, 717 and 718) covering the lower McGregor River and Herrick Creek study area, from 1976 to 2000.

Year	Number of Moose Shot 716				Number of Moose Shot 717				Number of Moose Shot 718				Total Number of Moose Shot				success rate#
	Bulls	Cows	Calves*	Total	Bulls	Cows	Calves*	Total	Bulls	Cows	Calves*	Total	Bulls	Cows	Calves*	Total	
1976	73	26	0	99	107	14	8	129	25	14	0	39	205	54	8	267	0.23
1977	124	55	11	190	72	11	3	86	30	4	0	34	226	70	14	310	0.2
1978	163	59	22	244	90	51	29	170	48	4	4	56	301	114	55	470	0.29
1979	122	92	19	233	77	34	0	111	39	8	4	51	238	134	23	395	0.24
1980	37	37	15	89	49	3	3	55	22	4	4	30	108	44	22	174	0.18
1981	55	23	34	112	28	11	18	57	11	6	0	17	94	40	52	186	0.22
1982	43	18	44	105	24	22	21	67	12	0	3	15	79	40	68	187	0.22
1983	54	21	43	118	37	20	12	69	33	1	10	44	124	42	65	231	0.25
1984	55	12	55	122	25	11	24	60	22	2	7	31	102	25	86	213	0.24
1985	79	23	59	161	27	14	19	60	13	0	0	13	119	37	78	234	0.22
1986	110	52	73	235	60	20	16	96	15	6	3	24	185	78	92	355	0.29
1987	108	42	46	196	37	31	14	82	20	7	3	30	165	80	63	308	0.22
1988	109	55	43	207	67	6	13	86	20	0	1	21	196	61	57	314	0.22
1989	76	41	34	151	40	18	19	77	37	0	0	37	153	59	53	265	0.25
1990	155	52	23	230	38	18	12	68	31	3	5	39	224	73	40	337	0.25
1991	136	28	29	193	45	25	22	92	19	3	0	22	200	56	51	307	0.24
1992	132	25	37	194	48	34	8	90	28	5	3	36	208	64	48	320	0.28
1993	105	41	59	205	53	28	19	100	51	6	0	57	209	75	78	362	0.24
1994	136	71	44	251	41	17	24	82	40	7	3	50	217	95	71	383	0.26
1995	124	22	20	166	63	19	12	94	44	11	1	56	231	52	33	316	0.26
1996	153	41	33	227	58	42	18	118	58	9	7	74	269	92	58	419	0.31
1997	126	40	22	188	58	18	0	76	44	9	6	59	228	67	28	323	0.25
1998	128	40	60	228	71	39	19	129	25	8	5	38	224	87	84	395	0.26
1999	126	25	12	163	46	14	4	64	30	8	0	38	202	47	16	265	0.19
2000**	144	26	43	213	59	31	12	102	59	12	0	71	262	69	55	386	0.27
Mean of 25 years	107	39	35	181	53	22	14	89	31	5	3	39	191	66	52	309	0.23

* between 1981 and 1986 'Calves' also included 2-point bulls

** preliminary, and probably an overestimate, because sucessful hunters are the most likely to report early; best available as of 01.05.08

\# moose shot/number of hunters

Table 2. Estimated number of moose in the lower McGregor River and Herrick Creek watersheds, January 2001.

	Stratum 1	Stratum 2	Stratum 3	Total
Moose Observed	239	10	101	350
Corrected Number of Moose	270	13	123	405
Sightability Correction Factor	1.13	1.274	1.22	1.16
Area of Surveyed Sample Units (km^2)	221	91		
Total Stratum Area (km^2)	777	1594	479	2,850
No. of Sample Units Surveyed	19	6	1	26
No. of Sample Units in Stratum	67	91	1	159
Corrected Density (moose/km^2)	1.22	0.14	0.26	0.45
Corrected Population Estimate	948	223	123	**1,294**
Sampling Variance	28,643	11584	0	40,227
Sightability Variance	305	90	94	489
Model Variance	8	4	3	15
Total Variance	28,956	11,678	97	40,731
Standard Error	170	108	10	202
Coefficient of Variation	0.18	0.48	0.08	0.16

Table 3. Impact of post-census stratification of the lower McGregor River and Herrick Creek watersheds, January 2001.

	SBS* wk1	SBS vk	Stratum 3	Total
Moose Observed	213	36	101	350
Corrected Number of Moose	240	42	123	405
Sightability Correction Factor	1.13	1.17	1.22	1.16
Area of Surveyed Sample Units (km^2)	102	210		
Total Stratum Area (km^2)	375	1,996	479	2,850
No. of Sample Units Surveyed	7	18	1	26
No. of Sample Units in Stratum	27	131	1	159
Corrected Density (moose/km^2)	2.35	0.20	0.26	0.49
Corrected Population Estimate	882	399	123	**1,405**
Sampling Variance	8,833	12,797	0	21,630
Sightability Variance	305	90	94	489
Model Variance	8	4	3	15
Total Variance	9,146	12,891	97	22,134
Standard Error	96	114	10	149
Coefficient of Variation	0.11	0.28	0.08	0.11

* SBS = Sub-Boreal Spruce biogeoclimatic zone

Table 4. Number of bulls and calves per 100 cows in the lower McGregor River and Herrick Creek watersheds and from adjacent areas around the Parsnip River and Prince George, December 2000-January 2001.

Location		Bulls:100 Cows (SE)	Calves:100 Cows (SE)	Total number of moose classified
McGregor River Herrick Creek				
Stratum 1		57	35	235
Stratum 2		25	0	10
Stratum 3		89	30	101
	Total	64 (8.2)	32 (4.1)	346
McGregor River Herrick Creek corrected for sightability bias				
	Total	58	31	
Parsnip River		83	25	353
Prince George		35 (6.7)	39 (6.9)	1010

Appendix A. Moose survey itinerary, December 2000 and January 2001.

Date	Location	Objective	Observers	Pilot
18 Dec 00	Prince George	composition survey	Glen Watts, Doug Heard, Rob Smith	Greg Altoft
21 Dec 00	Prince George	composition survey	Glen Watts, Doug Wilson, Jason Yarmish	Greg Altoft
22 Dec 00	Prince George	composition survey	Glen Watts, Chris Ritchie	Greg Altoft
16 Jan 01	McGregor River/Herrick Creek	census survey	Glen Watts, Doug Heard, Rob Smith	Chris Norman
17 Jan 01	McGregor River/Herrick Creek	census survey	Glen Watts, Doug Heard, Rob Smith	Chris Norman
18 Jan 01	McGregor River/Herrick Creek	census survey	Glen Watts, Doug Heard, Chris Pharness	Chris Norman
19 Jan 01	McGregor River/Herrick Creek	census survey	Glen Watts, Doug Heard, Chris Pharness	Chris Norman
22 Jan 01	McGregor River/Herrick Creek	census survey	Glen Watts, Doug Heard, Doug Wilson	Chris Norman
22 Jan 01	Parsnip River	composition survey	Glen Watts, Doug Heard, Doug Wilson	Chris Norman
23 Jan 01	Parsnip River	composition survey	Glen Watts, Doug Heard	Greg Altoft

Appendix B. Number of moose observed in each sample unit during the January 2001 survey of the lower McGregor and Herrick Creek census zone.

Sample		Bulls				Cows With:			Total	Total		**Total**
Unit	Stratum	Teen	Sub-prime	Prime	Antlerless	No Calf	1 Calf	2 Calves	Cows	Calves	Unknown	**Moose**
H1	1	0	0	0	0	1	0	0	1	0	0	**1**
H11	1	0	0	1	0	0	1	0	1	1	0	**3**
H14	1	0	0	0	0	0	0	0	0	0	0	**0**
H15	1	0	2	0	3	11	5	0	16	5	0	**26**
H16	1	0	2	0	7	9	5	3	17	11	0	**37**
H20	1	2	1	1	4	14	3	1	18	5	0	**31**
H22	1	0	0	0	0	0	0	0	0	0	0	**0**
H28	1	0	2	1	2	7	2	0	9	2	0	**16**
H29	1	0	3	4	10	21	6	0	27	6	1	**51**
H35	1	0	0	1	1	0	0	0	0	0	0	**2**
H37	1	0	0	0	0	0	0	0	0	0	0	**0**
H39	1	0	0	0	0	0	0	0	0	0	0	**0**
H42	1	0	0	3	3	4	5	1	10	7	0	**23**
H47	1	0	3	0	4	9	1	0	10	1	1	**19**
H49	1	0	0	2	7	7	4	0	11	4	2	**26**
H62	1	0	0	0	0	0	0	0	0	0	0	**0**
H65	1	0	0	0	0	0	0	0	0	0	0	**0**
H69	1	0	0	0	0	0	0	0	0	0	0	**0**
H9	1	0	0	0	1	1	1	0	2	1	0	**4**
L107	2	0	0	0	0	0	0	0	0	0	0	**0**
L113.1	2	0	0	0	0	0	0	0	0	0	0	**0**
L2	2	0	0	0	0	0	0	0	0	0	0	**0**
L22	2	0	2	0	0	2	0	0	2	0	0	**4**
L37	2	0	0	0	0	6	0	0	6	0	0	**6**
L89	2	0	0	0	0	0	0	0	0	0	0	**0**
Herrick	3	3	13	2	23	32	14	0	46	14	0	**101**
TOTAL		**5**	**28**	**15**	**65**	**124**	**47**	**5**	**176**	**57**	**4**	**350**

* Hx = S1, Lx = S2, and Herrick = S3