EA1318

Moose Inventory in and around the Tsay Keh Dene Traditional Territory, North-central British Columbia

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Prepared for

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INTRODUCTION

In northern British Columbia, moose (*Alces alces*) are very important as a source of sustenance for native peoples. Moose are also sought by a considerable number of licensed, resident hunters. In order to properly allocate moose harvests, wildlife managers require quantitative information on the size and structure of hunted populations. In addition, members of the Tsay Keh Dene (TKD) Treaty Table have identified the lack of an accurate moose population estimate as a major information gap. Reconnaissance-level moose surveys have been conducted in the past (e.g., Hatler 1989 and 1990), but none of those surveys attempted to accurately estimate the size of the moose population in the area surveyed in this study. Consequently, funding for a complete moose inventory was obtained for the 1999-2000 fiscal year through the provincial Corporate Land Inventory Branch (CLIB) of the BC Ministry of Aboriginal Affairs. Slocan Forest Products contributed to the survey to address several wildlife inventory objectives, allowing for a greater area to be covered. Funds were also contributed by the Peace/Williston Fish and Wildlife Compensation Program.

The objectives of this inventory are to provide resource managers, treaty negotiators, and wildlife researchers with population estimates, bull:cow ratios, and calf:cow ratios that will serve their needs and assist in moose conservation within the Tsay Keh Dene traditional territory and adjacent areas.

SURVEY AREA AND METHODS

The survey area reflects two independent interests. First and foremost, it contains most of the TKD traditional territory, and thus, the main hunting grounds used by the Tsay Keh Dene, as well as surrounding areas to provide comparative data on moose population dynamics. Second, the survey area falls within the study area where Slocan Forest Products is presently studying the interactions of moose, caribou (*Rangifer tarandus*) and gray wolves (*Canis lupus*). Additionally, some northern areas outside the TKD traditional territory and Slocan's study area, but contiguous with winter ranges to the south, were also included.

The survey area falls within seven provincial management units: 7-28, 7-29, 7-37, 7-38, 7-39, 7-40, and 7-41 (Figure 1). The majority of the best moose winter range in these management units is believed to lie within the surveyed area. The majority of the survey area falls within the Sub-Boreal Interior Ecoprovince and the northern ≈1/3 of the survey area is within the Northern Boreal Mountains Ecoprovince (Demarchi et al. 1990).

The survey design followed the stratified random block sampling method (Resources Inventory Committee 1997). As a cost-saving measure, stratification was conducted

Figure 1. Survey area (black = "high" stratum; grey = "low" stratum) for moose in and near the Tsay Keh Dene traditional territory. The dashed line separates the north and south survey zones. Provincial management units are indicated.

prior to going into the field. Within the survey boundary, only habitats with a reasonable potential to support moose were chosen. According to S. McNay (Slocan Forest Products) and D. Heard (BC Ministry of Environment, Lands and Parks), suitable moose wintering habitat in this region occurs predominantly at elevations <1200 m ASL. Thus, areas above 1200 m only support very low densities of moose, and were therefore, excluded from the survey area. Below 1200 m (according to 1:250,000 NTS mapping), provincial Broad Ecosystem Inventory (BEI) mapping (1:250,000) was used to derive survey polygons in each of two strata: "high" (believed by the author to support relatively higher densities of moose), and "low" (believed by the author to support relatively lower densities of moose). This assignment was based on ecosystem type and seral stage. Ecosystem units consisting of >40% wetland or riparian ecosystem units (e.g., WL, WR, PR) were assigned to the high stratum, as were units consisting of >50% seral stages 1 (recent disturbance-fire, logging), 2 (young coniferous forest <60 years), or 3 (young broadleaf or mixed forests <60 years). All remaining forested units were assigned to the low stratum. Non-forested BEI types (e.g., reservoirs, lakes, large rivers, etc.) were excluded from the survey area. Because BEI polygons ranged in size from <1 km^2 to >100 km^2, it was necessary to standardize the sampling units. BEI units were grouped by stratum, and survey blocks (polygons) of approximately 25 km^2 were delineated. Universal Transverse Mercator (UTM; NAD 83) gridlines and landscape features such as waterways and roads were used as polygon boundaries where practical to assist with navigation during the survey. Suitable sampling units ranged in size from 15 km^2 to 35 km^2. To ensure thorough sampling coverage, the entire survey area was divided into a north zone and south zone approximately along the height of land between the Omineca and Mesilinka drainages (Figure 1).

A small fraction of the area was represented by polygons <15 km^2 and was not available for random sampling (i.e., 323 km^2 (4.2%) in the north zone, and 181 km^2 (4.4%) in the south zone). Some of those polygons were complete BEI polygons, but most were "sliver" polygons resulting from the GIS intersection of the BEI data and the 1200-m contour. Such polygons, typically along the outside perimeter of the survey area, were excluded from the sampling area as a means of reducing the variance of the population estimate (Resources Inventory Committee 1997). Survey mapping was prepared at 1:50,000 from digital information that consisted of 1:250,000 NTS data (contours, waterbodies, and roads), a 1-km^2 UTM grid, and survey polygons. Survey polygons were assigned a unique identifier, and a random number (as generated by Microsoft Foxpro). Polygons were "drawn" for sampling by grouping polygons into high and low strata for each of the north and south zones, then sorting the random numbers by ascending order. Sampling in the south began with the five "high" and five "low" blocks. Subsequent sampling was directed to the stratum whereby the probability of reducing the 90% confidence interval of the population estimate was greatest. In the north, ten "high" and ten "low" blocks were sampled prior to directing effort as described above.

Surveys were flown by three crews using Bell 206 JetRanger helicopters: one in the south zone and two in the north zone. Each crew consisted of a pilot, navigator/observer (left front) and two observers in the bubble-windowed rear seats. Gridlines were flown approximately 500 m apart (according to a GPS), at a groundspeed of 70-90 km/h, and height of approximately 50-150 m AGL. For each observation, animals were classified by sex and age class (calf, adult) when possible, and an estimate of the percentage cover within a 9-m-radius zone around each observation was made according to Anderson and Lindzey (1996) in order to estimate the probability of sighting each individual or group. Adjustments for sightability were made by multiplying the number of moose seen by a correction factor (Table 1).

Calculations for the population estimates followed that for unequal-sized sample units as presented by Caughley (1977:31), using the formula for effective degrees of freedom presented by Krebs (1998:277). Calculations for sex and production ratios followed Krebs (1998:268). All parameters were bounded by 90% confidence intervals. All calculations were performed in MS Excel 98.

Table 1. Vegetation cover ranges and their associated sightability correction multipliers (adapted from Anderson and Lindzey 1996).

Percentage Cover	Multiplier
0-17	1.038
18-35	1.222
36-53	2.315
54-71	8.696
72-89	45.455
90-100	not used

RESULTS & DISCUSSION

Spatial features of the survey area are summarized in Table 2. Only 4.5 percent of the total area was represented by polygons <15 km^2 that were excluded from the survey area.

In the north zone, 313 moose were observed in a total surveyed area of 1039 km^2 during 39 hours of survey time reflecting a mean search intensity of 2.3 min/km^2. In the south zone, 112 moose were observed in a total surveyed area of 401 km^2 during 19.1 hours of survey time reflecting a mean search intensity of 2.9 min/km^2. Numbers of observed moose in each sex and age class are presented in Table 3. After applying the sightability corrections (Table 1), the corrected total number was 812; for an overall sightability multiplier of 1.91. The study area contains extensive tracts of dense vegetation (forest) cover. Yet, because moose made substantial use of low-cover areas such as cutblocks (Figure 2), this overall adjustment for sightability bias represents a modest adjustment to the raw data. The incidence of twinning was extremely low, as only one set of twins was observed in each of the north and south zones. Raw data collected during the survey are presented in Appendix 1 and summary statistics for population calculations are presented in Appendix 2.

Table 2. Features of the moose survey and area in and near the Tsay Keh Dene traditional territory, February 2000. Units <15 km^2 were not sampled.

Zone	Stratum	Total Area (km^2)	Sum Area of Units >15 km^2	Sample Units (N)	Sampled Area (km^2)	Sampled Units (n)
North	High	2285	2162	91	512	20
	Low	5353	5153	206	527	22
	subtotal	*7638*	*7315*	*297*	*1039*	*42*
South	High	745	617	26	116	5
	Low	3376	3302	132	285	12
	subtotal	*4121*	*3919*	*158*	*401*	*17*
	Grand Total	**11,759**	**11,234**	**455**	**1440**	**59**

Table 3. Summary of uncorrected numbers of moose observed during the moose survey in and near the Tsay Keh Dene traditional territory, February 2000. Numbers in parentheses indicate the number of pairs of twins observed.

Zone	Bulls	Cows	Calves	Unknown	Total
North	91	184	33(1)	5	313
South	36	52	18(1)	6	112
Total Area	**127**	**236**	**51(2)**	**11**	**425**

Weather conditions were variable, but winds were calm throughout the survey. The entire survey area was covered with snow ranging in depth from ≈30-100+ cm. Snow depths were greatest at higher elevations and latitudes and the last significant snowfall occurred on 8 February. On 8-9 February, sky conditions were overcast, air temperatures ranged from -5 to -20 ºC. From 10-13 February, sky conditions were generally clear and air temperatures ranged from ≈-15 to -35 ºC. Temperatures tended to increase with elevation due to localized inversions.

Several population estimates and their respective 90% confidence intervals were calculated (Table 4). Observations during the survey suggested that the riparian BEI units (i.e., WL, WR, and PR) in the north zone did not support the relatively higher moose densities assigned to these units during the a priori stratification. For this reason, and as a means of refining the population estimate, a post hoc adjustment to the stratification and sampling scheme was made. Survey polygons consisting mainly of these BEI units were assigned to the low stratum and the data from those polygons were used in calculations for the low stratum. While this approach is not in keeping with the protocol of the SRB sampling design, the implications of this adjustment to the sampling design were believed to be minor, while at the same time possibly conferring more accuracy to the population estimate and thereby serving the best interests of moose conservation. According to data in Table 2, it is apparent that this adjustment had an inconsequential effect on the population estimates.

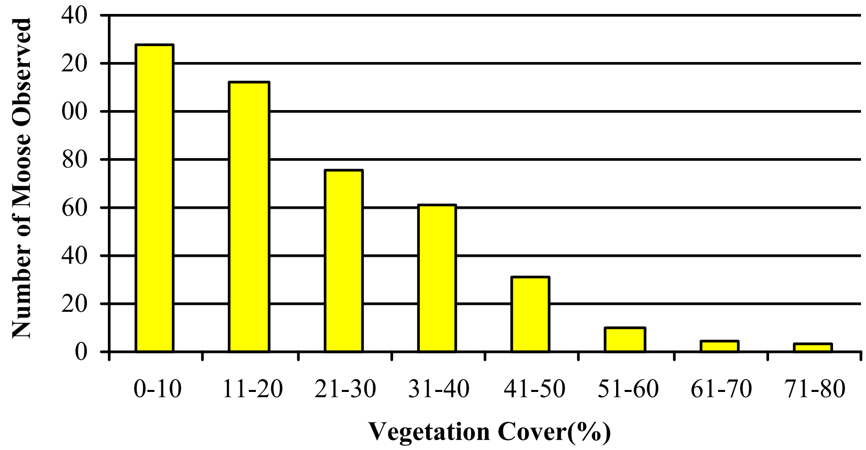

Figure 2. Histogram of moose sightings vs. vegetation cover class. Moose survey in the Tsay Keh Dene traditional territory, north-central British Columbia, 8-13 February 2000.

Table 4. Moose Population parameters for two scenarios: (1) the surveyed area[a] and (2) the entire area whereby survey units dominated by riparian BEI units are assigned to the low stratum. Moose survey in the Tsay Keh Dene traditional territory, north-central British Columbia, 8-13 February 2000.

Zone	Mean Density (moose/km^2)	Population Estimate	90% Confidence Interval	Total ± %
North	0.589	4312[a]	2868 to 5755	33
South	0.272	1064[a]	547 to 1581	49
Total Area	**0.490**	**5508[a]**	**3940 to 7076**	**28**
North (adjusted stratification)	0.569	4159	2808 to 5511	33
South (adjusted stratification)	-	-	-	-
Total Area (adjusted stratification)	0.495	5565	3982 to 7149	28

[a] Extrapolating the observed mean densities in the high and low strata of the north and south zones to the respective strata of unsampled units <15 km^2 modestly increased the population estimates as follows: north, 4509; south, 1170; total area, 5811.

The mean bull:cow ratio was lower in the north zone than in the south zone (Table 5), but there was considerable overlap between the confidence intervals of these parameters, indicating no significant difference ($Z=1.42$; $Z_{0.10(2)\ critical}=1.64$; Zar 1984:395). Conversely, the calf:cow ratio was significantly lower in the north zone ($Z=1.71$; $Z_{0.10(2)\ critical}=1.64$) (Table 5).

Table 5. Bull:cow and calf: cow ratios observed during the moose survey in the Tsay Keh Dene traditional territory, north-central British Columbia, 8-13 February 2000. The 90% confidence interval is indicated.

Zone	Ratio	90% CI	± %
North	49 bulls:100 cows	39 to 60 bulls:100 cows	21.2
South	69 bulls:100 cows	43 to 95 bulls:100 cows	37.7
Total Area	**54 bulls:100 cows**	**44 to 64 bulls:100 cows**	**18.8**
North	18 calves:100 cows	11 to 25 calves:100 cows	41.3
South	35 calves:100 cows	26 to 44 calves:100 cows	25.9
Total Area	**22 calves:100 cows**	**15 to 28 calves:100 cows**	**31.2**

As shown in Figure 3, the observed number of bulls per 100 cows in the total survey area was within the highest 25% of the ratios reported from 26 other moose inventories in Region 7 (north-central and northeastern B.C.) during the 1980s and 1990s (Hatter 1998). Compared to those surveys, the mean number of bulls per 100 cows in the north zone was in the 75-100th percentile, and in the south zone, was above the limit of the 100th percentile (excluding the outlier) (Figure 3). The mean bull:cow ratio of 54 bulls:100 cows is above the threshold of 50 bulls:100 cows as proposed for moose management in northern B.C. by Hatter (1998).

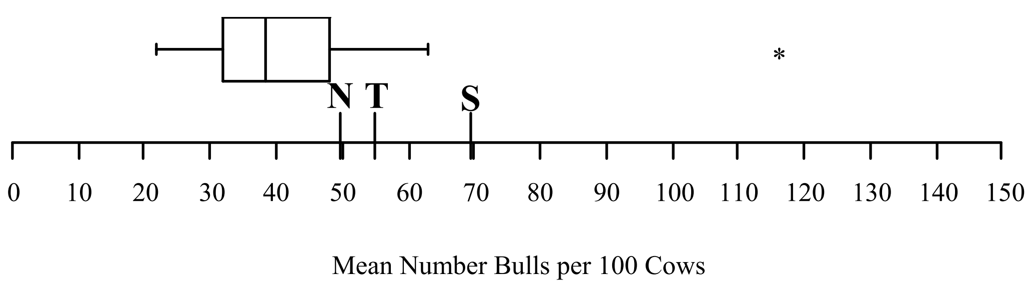

Figure 3. Boxplot of mean number of bulls:100 cows calculated from aerial surveys in provincial wildlife management Region 7 (n=26; Hatter 1998). The box and whiskers break the data into quartiles. The vertical line that bisects the box represents the median. The asterisk represents an outlier. Mean ratios calculated in this study are indicated on the axis: N=north zone, S=south zone, and T=total area surveyed.

As shown in Figure 4, the observed number of calves per 100 cows in the total survey area was within the lowest 25% of the ratios reported from 26 other moose inventories in Region 7 (north-central and northeastern B.C.) during the 1980s and 1990s (Hatter 1998). Compared to those surveys, the mean number of calves per 100 cows in the north zone was in the 0-25th percentile, and in the south zone, was in the 50-75th percentile (excluding outliers) (Figure 4).

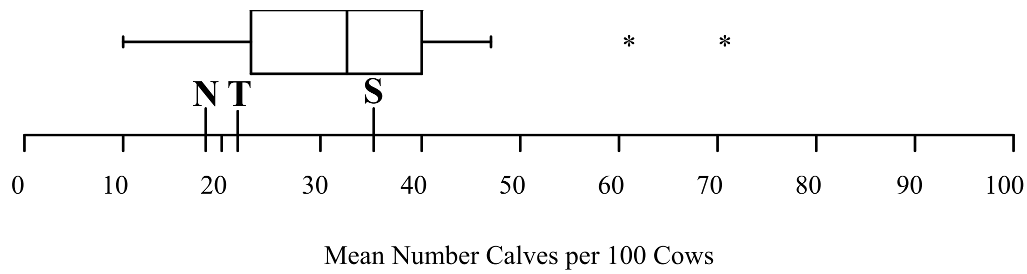

Figure 4. Boxplot of mean number of calves:100 cows calculated from aerial surveys in provincial wildlife management Region 7 (n=26; Hatter 1998). The box and whiskers break the data into quartiles. The vertical line that bisects the box represents the median. The asterisks represent outliers. Mean ratios calculated in this study are indicated on the axis: N=north zone, S=south zone, and T=total area surveyed.

Moose densities observed in this survey were not compared to those presented in Hatter (1998) for two reasons (D. Heard pers. comm.). First, substantial ecological differences among the survey areas summarized in Hatter (1998) are expected to explain a considerable portion of the differences among reported densities, restricting the utility of inter-survey comparisons. Second, of all stratified random block surveys ever conducted in northern B.C., this survey was the second largest. Because winter moose density in B.C. is inversely proportional to the size of the area surveyed, the large area covered by this survey is expected to result in a density that is lower than if a smaller area was covered.

A total of 50 wolves and 60 caribou were observed during the survey (Appendix 3). It should be noted that some sightings may be re-sightings of the same animals on different days—especially wolves.

CONCLUSIONS AND RECOMMENDATIONS

Moose Abundance and Ecology

This study has provided population information that will serve the interests of the Tsay Keh Dene treaty table, will assist BC Ministry of Environment, Lands and Parks in the management of moose in this part of Region 7, and will provide important information to Slocan Forest Products' wildlife research program.

The precision of stratified random block surveys is affected by many factors, including the size of the survey area. As survey area increases, precision of the population estimate will likely decline if sampling effort is held constant (Krebs 1998). This survey was the second largest ever conducted in northern B.C, (Hatter 1998), yet it yielded a very precise population estimate; implying that total survey intensity was adequate. Confidence intervals around the remaining parameters are also adequate for the purposes of harvest allocation and population management. The mean bull:cow ratio of 54 bulls:100 cows in the total area is above the threshold of 50 bulls:100 cows proposed for moose management in northern B.C. by Hatter (1998). Conversely, the mean calf:cow ratio of 22 calves:100 cows for the total area is well below the level of 30 to 45 calves:100 cows required to maintain stability in populations that sustain a harvest of 5 to 10% per year (Hatter and Bergerud 1991). From the perspective of population conservation, the observed calf:cow ratio would probably be adequate only if hunting pressure was reduced.

Because this was the first survey of its kind in this area, it is not possible to state, with certainty, the status (i.e., stable, increasing, decreasing) of the local moose population. However, because of concerns expressed by members of the Tsay Keh Dene Band about a decreased abundance of moose, and because of the low calf:cow ratios observed, the available evidence is more suggestive of a population in decline than of one that is stable or increasing. According to D. Hatler, a wildlife biologist with considerable experience with moose in the present survey area, and in northern B.C. in general, it is unlikely that the area supports the same densities of wintering moose that it did in the few decades prior to flooding of the Williston Reservoir. Past fires and forestry practices have created a mosaic of highly suitable seral stages for moose, and have probably offset some of the winter-range losses to the flooding (D. Hatler pers. comm.). However, with the loss of the lowest elevation habitats to flooding (i.e., the Parsnip and nearby valleys) and of opportunities to migrate across the Finlay Valley, winters with a deep snowpack are more likely to act as a population bottleneck than in the past. Further, intensive silvicultural practices such as herbiciding and manual brushing occur on many harvested sites in the study area. Herbiciding can effectively lower the suitability of treated areas for moose because of the resulting reductions in forage biomass (Raymond et al. 1996). While the effects of herbiciding on browse availability are not entirely understood, the effects of brushing on browse availability are probably understood even less so. It is also possible that wolf predation is acting to affect the density and sex and age-class structure of the population. Research presently being conducted by Slocan Forest Products, Mackenzie Operations, might provide some information about moose in this region, however, that study does not include much of the areas that are of particular importance to the sustenance needs of the Tsay Keh Dene. A long-term moose study near the northern end of the Williston Reservoir could serve to fill this information gap. Information gained from such a study should include, at a minimum: pregnancy rates, natality rates, calf and adult mortality rates, migration patterns, home range size, and habitat use and selection as determined from an adequate sample of radio-collared cow and bull moose.

Moose Inventory

There are advantages and disadvantages to a priori stratification of the survey area. Perhaps the greatest advantage is the considerable cost-saving in not having to visually assess a large number of blocks covering a vast area. Where suitable up-to-date habitat mapping exists, it is reasonable to conclude that costs saved by avoiding stratification flights can be applied to increased sampling intensity that may compensate for shortcomings in the accuracy of the a priori stratification process. The main disadvantage to a priori stratification is that it is insensitive to non-habitat factors that can influence the distribution and density of moose independent of habitat (e.g., weather, predation, localized harvests). Another disadvantage is that BEI units are not necessarily homogenous, and can contain a patchwork of up to three different ecosystem types and seral stages. For very large BEI units (e.g., >50 km^2) the probability increases that a given sample polygon (25 km^2) within that unit does not contain the habitat features that determined the BEI unit rating (e.g., proportion of the unit in early seral stages).

In this survey, a priori stratification performed better than would have been achieved by simple random sampling according to test results[1]. However, several recommendations can be made to improve the process of a priori stratification:

1. In this region, riparian habitats dominated by mature conifers were not observed to support relatively high densities of wintering moose. It is likely that more use of such areas would occur during winters with a greater snowpack, but any such increases are not expected to be substantial for the majority of such areas. Therefore, for future reference, riparian BEI units (i.e., WL, PR, and WR) could be assigned to the low stratum during a priori stratification.
2. The elevational cut-off of 1200 m ASL used in this survey appeared to be adequate. A few moose were observed in burned areas of the Ingenika watershed above this elevation, but the vast majority of moose were observed well below 1200 m. Because the inclusion of areas above 1200 m can substantially increase the survey area, it is believed that the loss of accuracy of the population estimate as caused by this expansion would outweigh any benefits of counting moose above 1200 m. Further, in years with greater snowfall, it is likely that the acceptable elevational cut-off could be in the range of 1000-1100 m ASL. Unfortunately, such weather vagaries are difficult to accommodate efficiently during the process of pre-survey planning.
3. Some sampled polygons that were assigned to the low stratum contained an abundance of clearcut areas that were used intensively by moose. Assuming that habitat mapping is current, the threshold for the proportion of the unit that is represented by early seral stages could be decreased from the value of >50% (as used in this survey). For BEI units larger than the sample unit size, supplemental information should be examined. For example, current forest cover mapping could be used to provide a finer scale of resolution of the distribution of seral stages in the landscape. Given the high observed affinity of moose for early seral stages as created by fire and logging in this region, and the expanding role of forestry in modifying the local landscape, this approach appears particularly worthwhile for any future surveys done in this area that use a priori stratification.

ACKNOWLEDGEMENTS

Members of the Tsay Keh Dene Treaty Table were pivotal in initiating this survey. Chief Ella Pierre and elder Jean Isaac clearly articulated Tsay Keh Dene's concerns regarding moose ecology and management in their traditional territory. Karl Sturmanis, B.C. Ministry of Aboriginal Affairs secured funding for a considerable portion of this work. Scott McNay, Slocan Forest Products, and Mari Wood, Peace-Williston Fish and Wildlife Compensation Program also contributed funds. Mike Demarchi; Glen Watts, B.C. Ministry of Environment, Lands and Parks; Kathi Zimmerman, Slocan Forest Products, and Doug Heard served as navigators/observers. Steve Johnson, LGL Limited;

[1] These results were calculated for exploratory purposes, but are not presented here.

Robert Tomah; Robin Scott; Pam Hengeveld; Leanne Brown; Shannon Walshe; Jacques Perreault; Emily Mueller; Heidi Mueller; and Scott Mueller served as observers. Robin Tamasi, LGL Limited, assisted with survey mapping. Pierre Bock and Nick Konecny, Canadian Helicopters; and Steve Pronger, Northern Mountain Helicopters, were the pilots. Ron Ell, B.C. Ministry of Environment, Lands and Parks, provided digital broad ecosystem inventory data. Doug Heard, Steve Johnson, and Scott McNay provided input to the survey design. Steve Johnson and Doug Heard reviewed a draft of this report and provided constructive comments.

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APPENDICES

Appendix 1. Data collected during the moose survey in and near the Tsay Keh Dene traditional territory, north-central British Columbia, 8-13 February 2000.

Zone	SU#	Stra-tum	Area (km^2)	Bulls	Cows	Cows+ 1calf	Cows+ 2calves	Lone Calves	Un-known	Total	Cover (%)	Corrected Total
N	94B/5-4	High	20.8		1					1	45	2.3
					1					1	55	8.7
					1					1	55	8.7
					1					1	50	2.3
									1	1	45	2.3
N	94C/11-16	High	29.8	1	3					4	5	4.2
N	94C/11-6	High	27.3		1					1	25	1.2
						1				2	0	2.1
				1						1	60	8.7
				1						1	75	45.5
						1				2	20	2.4
					1					1	10	1.0
								1		1	40	2.3
					2					2	25	2.4
					1					1	20	1.2
					1					1	15	1.0
					1					1	15	1.0
						1				2	20	2.4
						1				2	45	4.6
					1					1	80	45.5
				1						1	80	45.5
						1				2	16	2.1
N	94C/13-10	High	22.9	1	1					2	30	2.4
					2					2	40	4.6
				1						1	34	1.2
						1				2	17	2.1
N	94C/16-8	High	22.6	1						1	20	1.2
					1					1	20	1.2
				1						1	50	2.3
				1						1	65	8.7
					1					1	25	1.2
				1					1	2	40	4.6
				1	1					2	30	2.4
				1						1	35	1.2
N	94C/2-6	High	25.0	1	1					2	5	2.1
					2					2	10	2.1
					1					1	10	1.0
								1		1	30	1.2
N	94C/2-9	High	21.3							0	45	0.0
N	94C/6-15	High	24.6		1					1	0	1.0
				1	1					2	5	2.1
				1						1	5	1.0
						1				2	5	2.1
N	94C/7-1	High	24.7		2					2	50	4.6
				1						1	35	1.2
					1					1	35	1.2
				1						1	30	1.2

Zone	SU#	Stra-tum	Area (km^2)	Bulls	Cows	Cows+ 1calf	Cows+ 2calves	Lone Calves	Un-known	Total	Cover (%)	Corrected Total
N	94C/9-7	High	22.0	1	2					3	10	3.1
					2					2	40	4.6
				1	1					2	30	2.4
						1				2	50	4.6
				2						2	15	2.1
N	94F/10-5	High	35.0		1					1	20	1.2
					1					1	30	1.2
						1				2	20	2.4
				1						1	20	1.2
					1					1	25	1.2
					2					2	30	2.4
				1						1	25	1.2
					1					1	25	1.2
					1					1	20	1.2
				1						1	20	1.2
N	94F/11-18	High	27.5		1					1	20	1.2
					1					1	20	1.2
					1					1	10	1.0
					1					1	10	1.0
					1					1	10	1.0
				1						1	10	1.0
					2					2	40	4.6
				2						2	20	2.4
					1					1	10	1.0
					1					1	20	1.2
					2					2	10	2.1
					1					1	10	1.0
					1					1	10	1.0
					1					1	20	1.2
					1					1	20	1.2
				1	1					2	10	2.1
				1	1					2	20	2.4
					2					2	20	2.4
					2					2	20	2.4
				1						1	37	2.3
				1						1	20	1.2
N	94F/3-5	High	27.8			1				2	44	4.6
					2					2	40	4.6
N	94F/3-9	High	30.9		1					1	10	1.0
				1						1	25	1.2
					2					2	40	4.6
				2						2	40	4.6
				2	1					3	20	3.7
					2					2	30	2.4
					1					1	40	2.3
					1					1	40	2.3
					1					1	20	1.2
				1						1	20	1.2
					2					2	30	2.4
					1					1	50	2.3
N	94F/4-14	High	23.5	1						1	40	2.3
				1						1	5	1.0
N	94F/5-20	High	29.5	2						2	40	4.6

Zone	SU#	Stra-tum	Area (km^2)	Bulls	Cows	Cows+ 1calf	Cows+ 2calves	Lone Calves	Un-known	Total	Cover (%)	Corrected Total
						1				2	25	2.4
						1				2	50	4.6
					2					2	30	2.4
					2					2	40	4.6
N	94F/5-5	High	25.3							0		0.0
N	94F/6-12	High	27.3		2					2	15	2.1
					1				1	2	40	4.6
						1				2	20	2.4
					1					1	40	2.3
					1					1	30	1.2
N	94F/6-13	High	16.2	1	1					2	60	17.4
					1					1	30	1.2
					3					3	30	3.7
					1					1	25	1.2
N	94F/6-18	High	28.6		1					1	10	1.0
					1					1	50	2.3
					1					1	25	1.2
N	94B/12-6	Low	28.9		1					1	55	8.7
N	94B/5-2	Low	28.8		1					1	0	1.0
				1						1	0	1.0
N	94C/10-7	Low	26.6	1	1					2	15	2.1
					1					1	20	1.2
					1					1	25	1.2
				1						1	25	1.2
				1						1	5	1.0
					1					1	5	1.0
							1			3	5	3.1
						1				2	25	2.4
						1				2	30	2.4
N	94C/14-13	Low	16.5							0		0.0
N	94C/14-27	Low	23.1		1					1	16	1.0
					2					2	5	2.1
				1						1	5	1.0
						1				2	10	2.1
					2					2	10	2.1
						1				2	10	2.1
					1					1	10	1.0
				1						1	50	2.3
					1					1	17	1.0
						1				2	25	2.4
					1					1	35	1.2
						2				4	25	4.9
					1					1	16	1.0
						1				2	20	2.4
						1				2	50	4.6
				3						3	15	3.1
				1						1	15	1.0
				3						3	10	3.1
				2						2	10	2.1
					1					1	10	1.0
				1						1	10	1.0
				1						1	10	1.0
				1	1					2	5	2.1

Zone	SU#	Stra-tum	Area (km^2)	Bulls	Cows	Cows+ 1calf	Cows+ 2calves	Lone Calves	Un-known	Total	Cover (%)	Corrected Total
					1					1	20	1.2
						1				2	10	2.1
						1				2	10	2.1
					1					1	15	1.0
N	94C/14-5	Low	23.7		1					1	55	8.7
N	94C/14-8	Low	26.7							0		0.0
N	94C/15-11	Low	17.5	1						1	10	1.0
				1						1	10	1.0
				2	1					3	10	3.1
					1					1	60	8.7
					2					2	30	2.4
						1				2	30	2.4
N	94C/15-2	Low	15.1							0		0.0
N	94C/15-6	Low	34.7	1						1	0	1.0
				1						1	10	1.0
						1				2	25	2.4
					1					1	40	2.3
				1	1					2	10	2.1
					2					2	15	2.1
N	94C/15-7	Low	27.0	2	1					3	20	3.7
N	94C/15-9	Low	20.2		1					1	30	1.2
					1					1	10	1.0
				1						1	50	2.3
				1						1	15	1.0
				3						3	15	3.1
				1						1	15	1.0
				1						1	40	2.3
				1						1	15	1.0
				1						1	40	2.3
									1	1	15	1.0
					1					1	10	1.0
					1					1	40	2.3
					1					1	30	1.2
N	94C/9-10	Low	29.3	1						1	40	2.3
				1						1	50	2.3
				2						2	25	2.4
					2				1	3	45	6.9
					1					1	20	1.2
				1						1	15	1.0
					2					2	20	2.4
				1	1					2	15	2.1
N	94C/9-11	Low	20.5							0		0.0
N	94C/9-3	Low	21.1		1					1	30	1.2
N	94E/9-1	Low	22.0		2					2	40	4.6
					2					2	60	17.4
						1				2	40	4.6
				1						1	40	2.3
					1					1	45	2.3
N	94F/10-4	Low	30.0		1					1	40	2.3
				1						1	10	1.0
					1					1	40	2.3
					1					1	10	1.0
					1					1	20	1.2

Zone	SU#	Stra-tum	Area (km^2)	Bulls	Cows	Cows+ 1calf	Cows+ 2calves	Lone Calves	Un-known	Total	Cover (%)	Corrected Total
				1						1	20	1.2
					2					2	40	4.6
				2	1					3	10	3.1
N	94F/12-1	Low	25.5							0		0.0
N	94F/12-3	Low	20.9							0		0.0
N	94F/2-8	Low	20.7							0		0.0
N	94F/3-12	Low	26.8			1				2	45	4.6
				1						1	15	1.0
					2					2	5	2.1
						1				2	0	2.1
					2					2	40	4.6
N	94F/7-9	Low	21.2	1	2					3	70	26.1
S	93N/15-1	High	31.4		1					1	15	1.0
					1					1	10	1.0
				1						1	20	1.2
							1			3	5	3.1
					1					1	3	1.0
				1		1				3	35	3.7
					1					1	15	1.0
					1					1	15	1.0
					1					1	10	1.0
				1						1	15	1.0
				1						1	15	1.0
				1		1				3	15	3.1
						1				2	20	2.4
						1				2	10	2.1
				2	1					3	15	3.1
				1					1	2	40	4.6
				1	2					3	15	3.1
						2				4	20	4.9
				1						1	10	1.0
					1					1	5	1.0
					1					1	5	1.0
				1						1	10	1.0
					1					1	10	1.0
						1				2	15	2.1
				1						1	15	1.0
				2						2	20	2.4
				1						1	0	1.0
				1						1	25	1.2
					1					1	25	1.2
				1						1	25	1.2
						1				2	5	2.1
S	93N/16-8	High	24.3		2					2	5	2.1
					1					1	5	1.0
									1	1	2	1.0
					1					1	5	1.0
					1					1	5	1.0
				1						1	5	1.0
						1				2	40	4.6
					1					1	10	1.0
					1					1	30	1.2
				1						1	35	1.2

Zone	SU#	Stra-tum	Area (km^2)	Bulls	Cows	Cows+ 1calf	Cows+ 2calves	Lone Calves	Un-known	Total	Cover (%)	Corrected Total
				1						1	10	1.0
						1				2	10	2.1
						1				2	20	2.4
S	93N/7-16	High	20.0	1						1	15	1.0
S	93N/7-5	High	24.4	2						2	30	2.4
S	94C/3-4	High	15.9	1						1	20	1.2
				1						1	30	1.2
						1				2	30	2.4
				1						1	0	1.0
S	93N/10-1	Low	18.7							0		0.0
S	93N/10-12	Low	25.1							0		0.0
S	93N/11-2	Low	23.4						1	1	45	2.3
S	93N/14-2	Low	21.9							0		0.0
S	93N/15-2	Low	24.9		1					1	40	2.3
						1				2	30	2.4
									1	1	40	2.3
					2					2	40	4.6
S	93N/15-20	Low	28.9			1				2	25	2.4
				1						1	25	1.2
					1					1	25	1.2
					2					2	25	2.4
S	93N/16-12	Low	25.6		1					1	10	1.0
					1					1	0	1.0
						1				2	50	4.6
									1	1	15	1.0
					1					1	0	1.0
S	93N/8-1	Low	20.0							0		0.0
S	93O/5-13	Low	22.3	1	1					2	25	2.4
S	93O/5-19	Low	24.5		1					1	10	1.0
				1						1	15	1.0
				1						1	10	1.0
				1						1	15	1.0
						1				2	10	2.1
				1						1	5	1.0
					1					1	5	1.0
					1					1	10	1.0
				1						1	10	1.0
				1						1	10	1.0
									1	1	50	2.3
S	94C/3-13	Low	25.5		2					2	35	2.4
S	94C/3-6	Low	23.8	1						1	0	1.0
				1						1	0	1.0

Appendix 2. Summary statistics for population calculations in the north zone, south zone, and the north and south zones combined. Raw data are presented in Appendix 1.

North Zone	High Stratum			Low Stratum		
	Moose	Area (km^2)	Density	Moose	Area (km^2)	Density
	0	21.299	0.00	0	16.518	0.00
	0	25.279	0.00	0	26.658	0.00
	3.353	23.538	0.14	0	15.057	0.00
	4.152	29.785	0.14	0	20.479	0.00
	4.575	28.591	0.16	0	25.48	0.00
	6.228	24.62	0.25	0	20.899	0.00
	6.412	24.978	0.26	0	20.689	0.00
	8.296	24.686	0.34	1.222	21.063	0.06
	9.26	27.826	0.33	2.076	28.834	0.07
	10.372	22.927	0.45	3.666	26.976	0.14
	12.687	27.267	0.47	8.696	28.912	0.30
	14.664	34.955	0.42	8.696	23.714	0.37
	16.894	21.968	0.77	10.987	34.672	0.32
	18.778	29.451	0.64	14.45	26.825	0.54
	22.973	22.603	1.02	15.82	26.622	0.59
	23.502	16.157	1.45	16.894	30.016	0.56
	24.337	20.751	1.17	18.774	17.497	1.07
	29.463	30.9	0.95	20.799	29.308	0.71
	35.471	27.528	1.29	21.046	20.207	1.04
	169.048	27.298	6.19	26.088	21.152	1.23
				31.282	21.984	1.42
				52.381	23.091	2.27
Total	420.465	512.407		252.877	526.653	
Number of sampled units	20			22		
Mean density	0.821			0.480		
Total stratum area in study area	2162.0			5153.0		
Total units per stratum	91			206		
Stratum variance	1.7863			0.3593		
Total study area	7315.0					
Total units	297					
Mean density	0.589					
Efective df (n)	39.991					
SE population total	856.883					
Population Total	**4312**					
90% confidence interval	2868	to	5755	Margin= ±	33%	

Appendix 2 continued.

South Zone	High Stratum			Low Stratum		
	Moose	Area (km^2)	Density	Moose	Area (km^2)	Density
	1.038	19.957	0.05	0	21.929	0.00
	2.444	24.414	0.10	0	18.685	0.00
	5.926	15.933	0.37	0	25.146	0.00
	20.936	24.32	0.86	0	20.021	0.00
	57.214	31.396	1.82	2.076	23.765	0.09
				2.315	23.402	0.10
				2.444	22.338	0.11
				2.444	25.48	0.10
				7.332	28.949	0.25
				8.782	25.593	0.34
				11.704	24.922	0.47
				13.733	24.493	0.56
Total	87.558	116.02		50.83	284.723	
Number of sampled units	5			12		
Mean density	0.755			0.179		
Total stratum area in study area	617.0			3302.0		
Total units	26			132		
Stratum variance	0.5389			0.0378		
Total study area	3919.0					
Total units	158					
Mean density	0.272					
Efective df (n)	11					
SE population total	285.176					
Population Total	**1064**					
90% confidence interval	547.5	to	1581	Margin= ±	49%	

Appendix 2 continued.

North & South Zones	High Stratum			Low Stratum		
	Moose	Area (km^2)	Density	Moose	Area (km^2)	Density
	0	21.299	0.00	0	16.518	0.00
	0	25.279	0.00	0	26.658	0.00
	3.353	23.538	0.14	0	15.057	0.00
	4.152	29.785	0.14	0	20.479	0.00
	4.575	28.591	0.16	0	25.48	0.00
	6.228	24.62	0.25	0	20.899	0.00
	6.412	24.978	0.26	0	20.689	0.00
	8.296	24.686	0.34	1.222	21.063	0.06
	9.26	27.826	0.33	2.076	28.834	0.07
	10.372	22.927	0.45	3.666	26.976	0.14
	12.687	27.267	0.47	8.696	28.912	0.30
	14.664	34.955	0.42	8.696	23.714	0.37
	16.894	21.968	0.77	10.987	34.672	0.32
	18.778	29.451	0.64	14.45	26.825	0.54
	22.973	22.603	1.02	15.82	26.622	0.59
	23.502	16.157	1.45	16.894	30.016	0.56
	24.337	20.751	1.17	18.774	17.497	1.07
	29.463	30.9	0.95	20.799	29.308	0.71
	35.471	27.528	1.29	21.046	20.207	1.04
	169.048	27.298	6.19	26.088	21.152	1.23
	1.038	19.957	0.05	31.282	21.984	1.42
	2.444	24.414	0.10	52.381	23.091	2.27
	5.926	15.933	0.37	0	21.929	0.00
	20.936	24.32	0.86	0	18.685	0.00
	57.214	31.396	1.82	0	25.146	0.00
				0	20.021	0.00
				2.076	23.765	0.09
				2.315	23.402	0.10
				2.444	22.338	0.11
				2.444	25.48	0.10
				7.332	28.949	0.25
				8.782	25.593	0.34
				11.704	24.922	0.47
				13.733	24.493	0.56
Total	508.023	628.427		303.707	811.376	
Number of sampled units	25			34		
Mean density	0.808			0.374		
Total stratum area in study area	2779.0			8455.0		
Total units per stratum	117			338		
Stratum variance	1.5094			0.2650		
Total study area	11234.0					
Total units	455					
Mean density	0.490					
Efective df (n)	56.831					
SE population total	938					
Population Total	**5508**					
90% confidence interval	3940	to	7076	Margin= ±	28%	

Appendix 3. Incidental sightings of large wildlife species during the moose survey in the Tsay Keh Dene traditional territory, north-central British Columbia, 8-13 February 2000.

Species	**Number**	**Comments**
Gray Wolf	15	on ice; southern tip of Omineca Point (10 Feb.)
	13	Omineca River 5 lm north of Germansen Landing (9 Feb.)
	7	Omineca River 15 km north of Germansen Landing (9 Feb.)
	5	near Police Meadows, chasing moose (10 Feb.)
	4	in cutblock near moose carcass; northern Omineca Arm (12 Feb.)
	3	east end of Klawli Lake (9 Feb.)
	2	on ice of small lake 6 km north of Ingenika Arm (11 Feb.)
	1	20 km northwest of Ingenika Arm (9 Feb.)
Caribou	19	south of Germansen Lake (12 Feb.)
	13	Wolverine Range, parallel to top of Manson Arm (9 Feb.)
	12	in alpine near Mt. Henri, Butler Ranges (12 Feb.)
	7	north of Wolverine Lake (12 Feb.)
	5	in alpine south of Nina lake, 4 adults 1 calf (Feb. 11)
	4	on Tomias Lake (8 Feb.)
Rocky Mountain Elk		GET TOTAL FROM DOUG
	1	class 3 bull, near Ivor creek (northeast Williston Reservoir) (11 Feb.)
Stone Sheep	4-6	ewes on south-facing, windswept ridge of Russell Range (10 Feb.)
	3-4	rams on south-facing, windswept ridge of Russell Range (10 Feb.)
Mountain Goat	3	near the top of Chowika Mountain (12 Feb.)
Lynx	2	in burn near Kechika River