MUSKOXEN DISTRIBUTION AND ABUNDANCE IN THE AREA WEST OF THE COPPERMINE RIVER, KITIKMEOT REGION, NUNAVUT

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Summary

An aerial muskox survey was conducted from May 15 to May 19, 2007 in the Western Kitikmeot, Nunavut (area west of the Coppermine River to Bluenose Lake and from Dismal Lake in the south to the mainland shoreline of the Dolphin and Union Strait – MX12). The survey area was divided into two strata, High Density Area (HAD) covered at 42% and Low Density Area (LDA) covered at 25%. In the high density area (HDA) (13,404 km^2), we counted 159 adult muskoxen and 34 calves on the transects and estimated 377 adult muskoxen (±75 S.E., CV=0.20) with 21.4% of calves in the population. In the low density area (LDA) (16,791 km^2), we counted 33 adult muskoxen and 15 calves on the transects. And estimated 132 adult muskoxen (±71 S.E., CV=0.54) with 45.5% of calves in the population. I propose management options based on the result of this survey.

Acknowledgements

I would like to thank Perry Linton, pilot of the Helio-Courier, for his enthusiasm, flexibility and amazing piloting skills. It made the survey a pleasure and a success. Thanks to Fred Taptuna, Jonathan Niptanatiak, George Hala, Stanley Klengenberg, Isaac Klengenberg and Gary Kelogok for their participation as observers. I also want to thank Peter Taptuna, Kugluktuk HTO manager, for his assistance to provide observers (some time on a very short notice) for the survey. Thanks to the Kugluktuk HTO for supporting this project. Funding was provided by the Department of Environment (Government of Nunavut) and the Nunavut Wildlife Management Board.

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1.0. Introduction:

By the early 1900's, Muskoxen (*Ovibos moschatus*) were extirpated from a large part of their historic range, remaining only in small numbers in localized areas including the upper Rae-Richardson River area (Barr 1991). After four decades of being protected from harvest (however, subsistence harvest continued to a certain extend, Barr 1991), the muskox population North of Great Bear Lake increased and expanded to a point that a harvest quota was established in 1976 for Paulatuk (8 tags) and Kugluktuk (6 tags) (Urquhart 1980). In 1966-67, Kelsall et al. (1971) estimated at least 425 muskoxen in the area west of the Coronation Gulf and north of Great Bear Lake (area much larger that the present study survey area). In 1980, the muskox population in the Rae-Richardson Rivers watersheds was estimated to be 869±300 (S.E.) and in 1983, the muskox population was estimated to be 1295±279 (S.E.) and it led to a quota increase from 12 to 35 tags for Kugluktuk (Gunn 1995; Fournier and Gunn 1998). In 1986, the Hunters' and Trappers' Association in Kugluktuk requested an additional increase in the quota for muskox in the Rae-Richardson area (Gunn 1995). The survey conducted in March 1988 estimated the muskox population at 1,805±289 (S.E.) animals (Gunn 1995). Following the survey results, the quota was increased to 50 tags for Kugluktuk. Following the drastic decline of the muskox population in the Rae-Richardson area observed during the March 1994 survey (540±139 (S.E.)), the quota was reduced to 20 and hasn't been changed since then. 1994 was the last year the muskox population in the Rae-Richardson area was surveyed.

In the early 1990's, the discovery of a lungworm parasite (*Umingmakstrongylus pallikuukensis)* in the Rae-Richardson muskox population has been proposed as an explanation for the rapid decline of this population (Gunn and Wobeser 1993, Hoberg et al 1995; Kutz 1999). Also, grizzly bears may have become a important factor in calf and adult survival (Gunn 1995). Grizzly bear predation on muskoxen has been documented and has been observed by local hunters (Gunn and Miller 1982; Gunn and Fournier 2000, Reynolds et al. 2002, Charlie Bolt, personal communication; Mathieu Dumond, unpublished data).

Especially with the current decline of mainland caribou herds, muskoxen may become an important source of food for communities. Moreover, the coming United States ban on polar bear trophies may increase the demand for muskox sport hunts and a careful management will be needed to promote a sustainable use of the species.

I conducted an aerial survey of the area west of Kugluktuk (Western Kitikmeot, Nunavut) to estimate muskoxen abundance, estimate the productivity (percentage of calves in the population in May), assess the trend in abundance since the last survey, and provide recommendations to update the Total Allowable Harvest (TAH) for muskoxen in the area.

2.0. Project Objectives:

To estimate muskoxen abundance between the Coppermine River and Bluenose Lake and determine if the muskoxen number have significantly changed since the last survey;

To determine the proportion of muskox calves in the study area;

To recommend management actions.

3.0. Study Area

The study area is included in the Coronation Hill Eco-Region and part of the Southern Arctic Eco-zone. It is approximately comprised between 67 and 69 degree north and 114 and 199.2 degree west. It includes the edge of the tree line in the south and the south shore of the Dolphin and Union Strait in the Northeast. The study area is delineated by the Coppermine River in the east and it extends to the west to the edge of Bluenose Lake (Figure 3.1). It covers an area of 30,195 km^2.

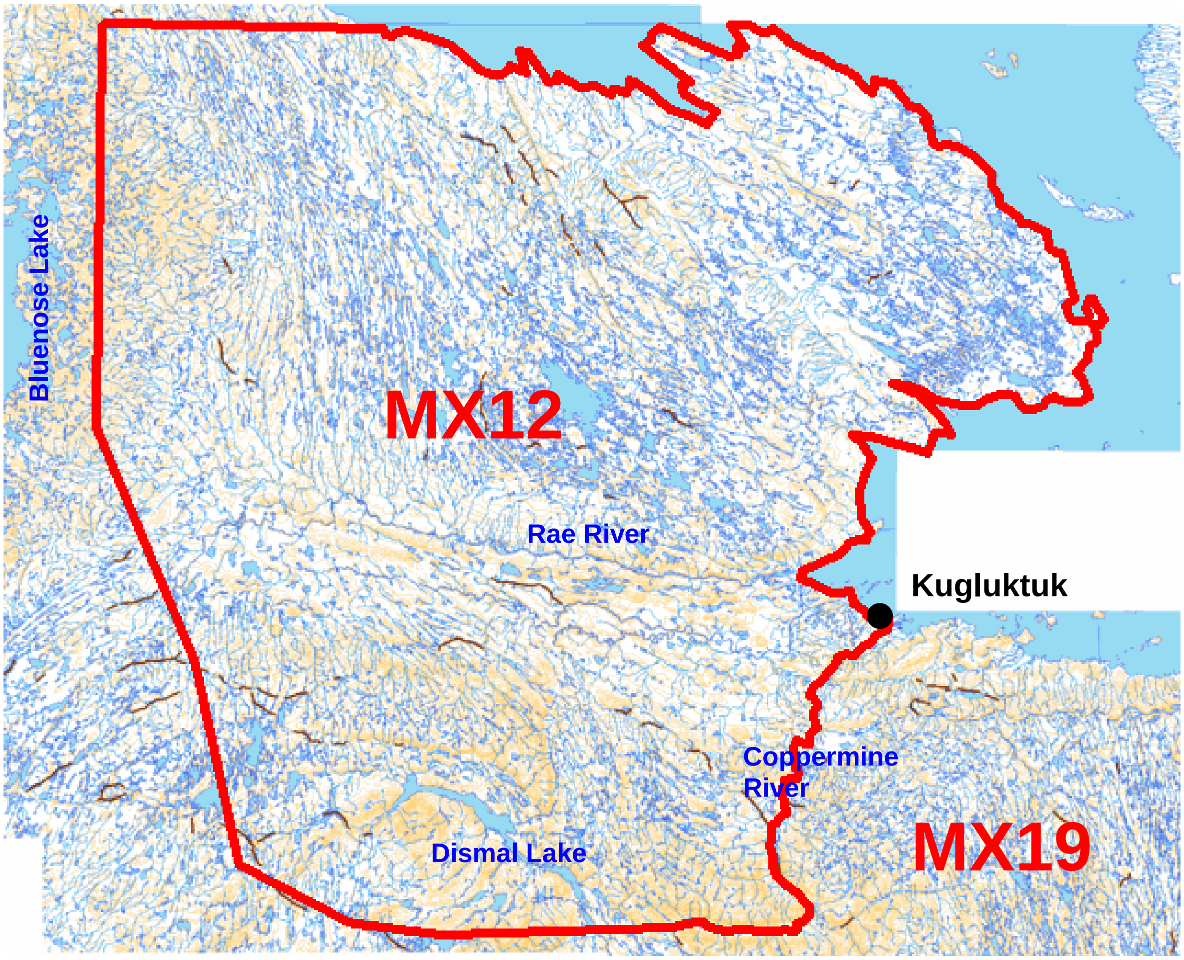

Figure 3.1: General study area for the muskox aerial survey conducted from May 15 to May 19, 2007 in the Western Kitikmeot, Nunavut.

4.0. Methods

I conducted an aerial survey using stratified random/systematic strip transects (the first transect was randomly placed and then each sequential line was evenly spaced at a set interval within each survey block). The stratification was based on local knowledge, previous surveys (Gunn 1995; Gunn and Fournier 2000), habitat information, and aircraft capability rather than a reconnaissance survey to reduce study costs. We use the Helio-Courier at a speed of 160km/h, at 500 feet above ground level (154m), and set up markers to record muskoxen within 1500m on each side of the aircraft. The survey was conducted from May 15 to 19, 2007 covering 3283 km of transects (after excluding lengths where visibility was poor), representing an area of 9848 km^2. The study area was 30,195 km^2 covered at 33% overall (42% in Stratum 1= HAD; 6.5km spacing between transects and 25% in Stratum 2 = LDA; 10km spacing between transects). Barren-ground caribou (*Rangifer tarandus groenlandicus*) and grizzly bear (*Ursus arctos horribilis)* observations were also recorded during the survey and are presented in Figure 4.1. For all observations a way point was added on a GPS and the track of the airplane was recorded during the whole survey (Figure 4.1).

One to two observers from the community (Kugluktuk) were on board during the survey.

When muskoxen were observed, I recorded the number of individuals ≥1 year old (non-calves) and the number of observed calves. For large group I took high resolution digital pictures (Canon EOS Digital Rebel XTi10.1 MegaPixels / 18mm – 55mm zoom lense) and recounted the number of individuals ≥1 year old (non-calves) and the number of observed calves. When necessary, I would ask the pilot to make a loop around a group in order to count calves and non-calves. The loop was made at a distance from the muskox group to avoid the formation of a defence circle that make the count difficult for adults and impossible for calves.

For the calculation of the estimate, I used only the individuals observed within the 3km strip of the transects. Muskoxen observed outside the 3km strip were presented to illustrate the distribution and were used in strata 2 (LDA) to adjust the lower limit of the confidence interval.

The muskox population estimate for the whole area and within each stratum (HAD and LDA) was calculated using Jolly's Method 2 for unequal sample sizes (Jolly 1969 *In* Norton-Griffiths 1978). Only counts of non-calves were used for the final population estimates. Lake areas were not subtracted from the total area calculations used in density calculations (Statistical analysis based on Campbell and Setterington 2001).

To determine if there was an increase in muskox numbers in the study area, comparison of the 2007 population estimate to the 1994 estimate was conducted using equation 5.3 of Thompson et al. (1998):

$$z = \frac{Y_{1991} - Y_{1999}}{\sqrt{Var(Y_{1991}) + Var(Y_{1999})}}$$

Where:

z = z statistic;

Y_x = population estimate for year x

$Var(Y_x)$ = variance of the population estimate.

The statistics were based on the hypothesis that the population estimate did not change between surveys and therefore I used the two tailed probability of the z statistic.

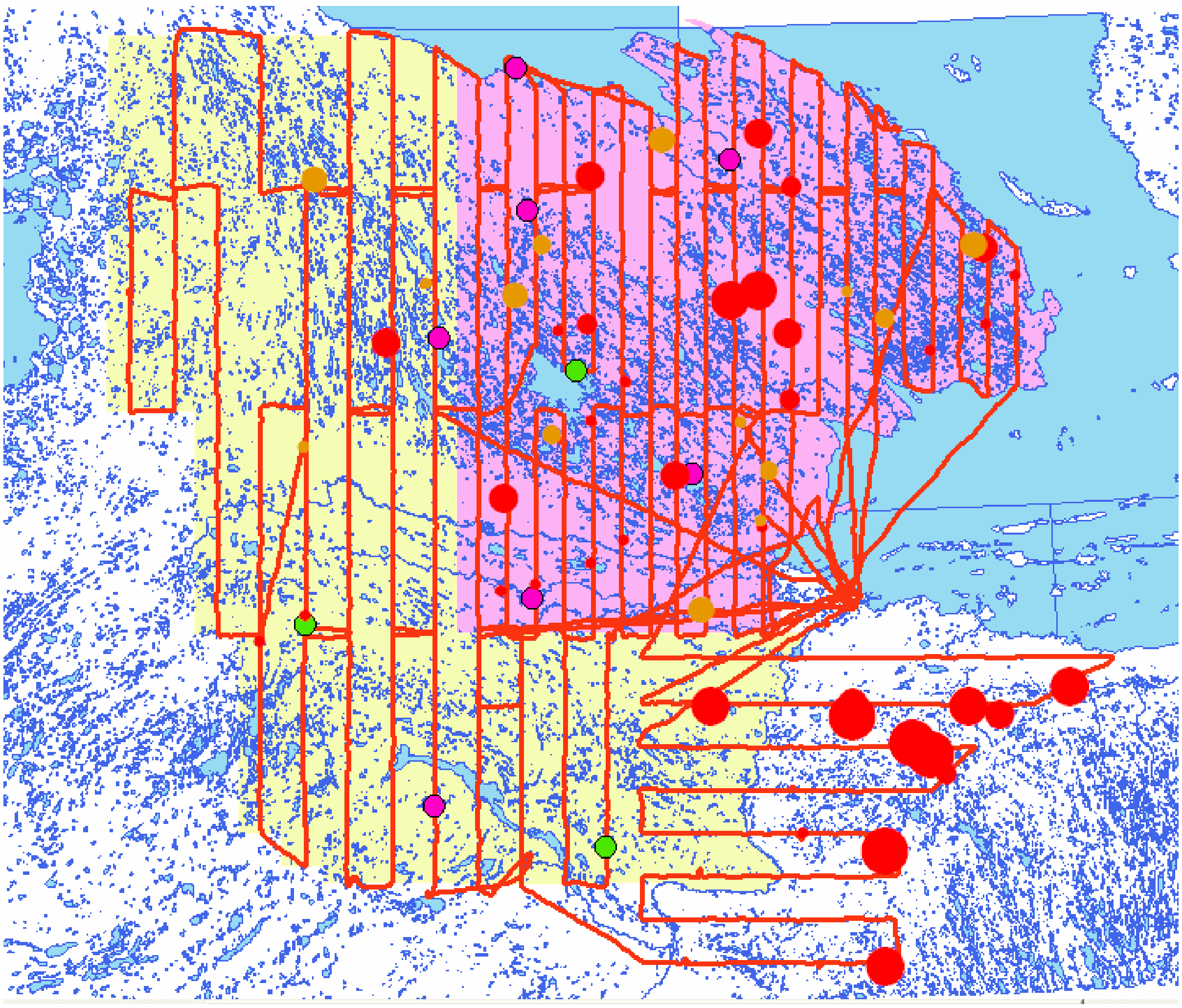

Figure 4.1: Survey track (red line) and strata (High Density Area in purple and Low Density Area in beige). Muskoxen observed on the transect are in red and other muskoxen are in orange (symbols are proportional to group size (variation from 1 to 53). The green dots are caribou and the purple dots are Grizzly bears.

5.0. Results

A total of 290 adult muskoxen (≥ 1year old) were observed, including 98 individuals observed outside the transect width or during taxi (I subtracted double counts from muskox groups that we observed more than once during the survey). Muskoxen were mainly distributed in the north eastern portion of the study area (Figure 4.1). The population estimate for the entire study area was 589 muskoxen (±121 S.E., CV=0.20). In the high density area (HDA) (13,404 km^2), we counted 159 adult muskoxen and 34 calves on the transects. The population estimate for that area is 377 adult muskoxen (±75 S.E., CV=0.20) with 21.4% of calves in the population. In the low density area (LDA) (16,791 km^2), we counted 33 adult muskoxen and 15 calves on the transects. The population estimate for that area is 132 adult muskoxen (±71 S.E., CV=0.54) with 45.5% of calves in the population.

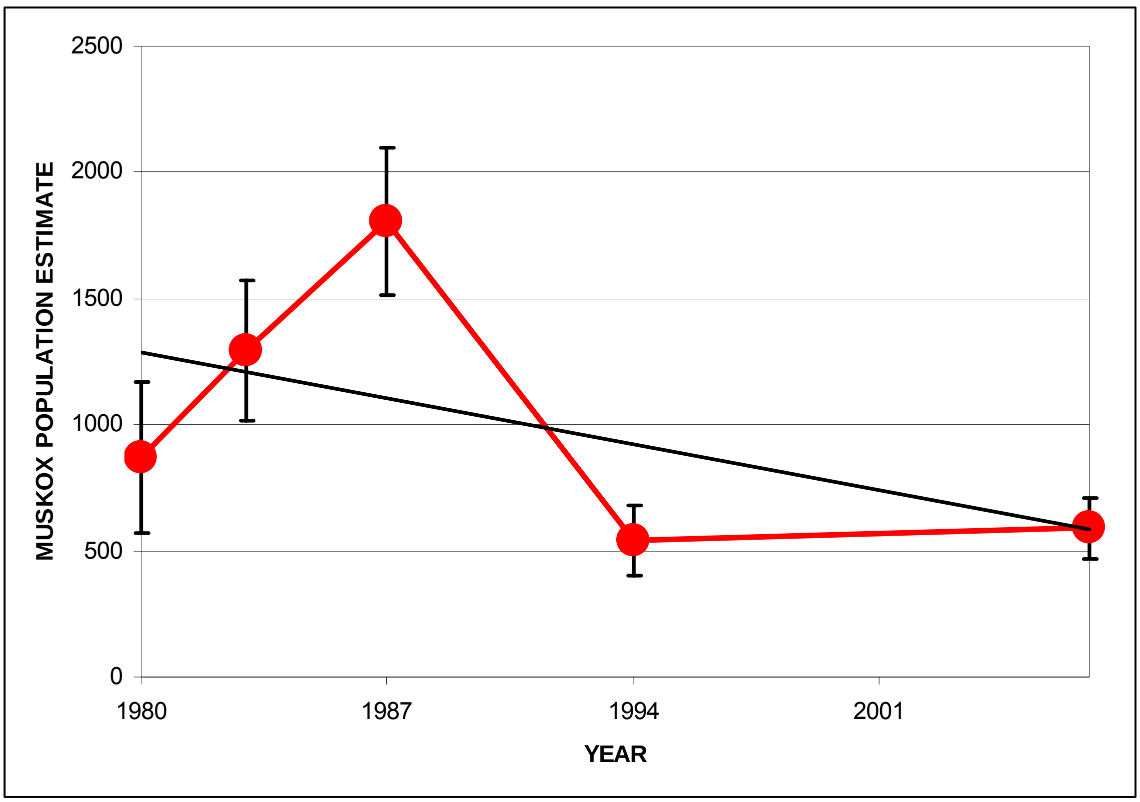

Figure 5.1: Muskox population fluctuations and trends over the past 27 years in the area between the Coppermine River and Bluenose Lake. Standard Error is shown for each estimate. The solid black line indicates the trend of the population since 1980.

Mean group size in the HAD and LDA was 7.2 and 8.3 individuals ≥ 1year old respectively.

The Figure 5.1 shows the muskox population fluctuations and trends over the past 27 years in the area between the Coppermine River and Bluenose Lake. There was no significant difference between the population estimate in March 1994 (Fournier and Gunn 1998) and my estimate in May 2007 ($z = 0.266$, $P = 0.79$).

During the survey, I observed one muskox killed by a Grizzly bear (Figure 5.2). I went to the site 8 days later by helicopter. The meat, most of the bones and a large part of the guts were gone. Grizzly bear tracks were old and a wolverine had been dragging meat from the site to an unknown location (I tracked it on foot for a distance but did not reach the food cache and the snow condition did not allow an efficient tracking from the helicopter). We observed a total of 7 Grizzly bears during the survey. Six of them were in the general area of relative high muskoxen density and one was within the migration route of the Bluenose East caribou herd.

Figure 5.2: Picture of a grizzly bear walking away from a freshly killed muskox. The insert shows a close up of the dead muskox.

6.0. Discussion

The muskox population estimate produced by this survey is similar to the estimate obtained in 1994. From local observations (Allen Niptanatiak personal communication), it is likely that the muskox population in the study area continued to decrease after 1994 and recently started to increase again. The increase in muskox abundance east of the Coppermine River (MX19, Dumond 2006) may contribute to an increase in muskox on the west side of the Coppermine (MX12) provided that the number of animals crossing the Coppermine River is significant. Research is on-going to establish the amount of exchange between the two areas (Dumond 2007). Nevertheless, because muskox movements and re-colonization is usually slow, it is unlikely that immigration from the east will dramatically change the dynamics of muskoxen on the west side of the Coppermine, especially in the HAD located further away northwest from the Coppermine River.

The productivity (estimated as the percentage of calves in the population in May) in the HAD was relatively low 21.4% (compared to 45.5% in the LDA) but likely represents a minimum because visibility of the calves from a fixed-wing can vary, especially when muskoxen are regrouping in defence formation. In the HAD, between May 24 and May 28, 2007, classification work from the ground provided an estimate of productivity of 36.7% (Dumond and Niptanatiak, *in prep.*). Productivity was low on the east side of the Coppermine River (17%, Dumond and Niptanatiak, *in prep.*). The low productivity on the east side of the Coppermine River is consistent with the very low percentage of calves (5.7%) observed in August 2005 (Dumond 2006).

In the west side of the Coppermine River, the productivity seems to have been enough to compensate for natural mortality and harvest. Based on the use of the full TAH between 1994 and 2007, the harvest level can be estimated to have been between 3% and 4% of the population which is the recommended rate of harvest for a stable population. However, this means that natural mortality is quite high and the level of predation and mortality as a result of parasites and diseases need to be investigated. Research is on-going to shed some light on these aspects (Dumond 2007).

The observation of a Grizzly bear at a muskox kill site and the past documentation of muskox mortality as a result of grizzly bear predation suggest that predation could be an important factor in the dynamics of this muskox population.

The distribution of the Grizzly bear observations can reflect actual differences in densities between the north and the south of our study area (and thus a distribution reflecting the distribution of muskoxen). However, it could also be the result of a difference of terrain and habitat that allow Grizzly bears to hide more easily within the south portion of the study area (taller vegetation, less snow, more rugged terrain). This could also explain the absence of Grizzly bear observation on the east side of the Coppermine River.

Lungworm can also be a direct or indirect (through increased vulnerability of infected individuals) cause of mortality and samples have been collected to investigate the prevalence of the parasite in the muskox population.

7.0. Management Recommendations

Since the muskox population seemed to have reached a low between 1997 and 2007 and could be increasing, I recommend two management options and associated monitoring requirements:

Option 1: Management goal is to promote the maintenance of the muskox population at its current abundance in the muskox management zone MX12. Provided that natural mortality does not increase dramatically, I recommend maintaining the current TAH of 20 for the muskox management zone MX12. The productivity and recruitment will be important to monitor regularly (every two to three years) as well as the prevalence of parasites and diseases (yearly through the harvest and reports from local hunters) in the area. A new survey should be planned in 2012 to assess the trend of the population and confirm that this management strategy if efficient to achieve management goals in the area. Productivity, recruitment and population trend over 5 years would give us good information to adjust the TAH level in order to achieve management goals.

Option 2: Management goal is to increase the muskox population in the muskox management zone MX12. In that case, a decrease in the TAH will be necessary. I would recommend setting the TAH at 3% of the estimate which would mean a reduction of the TAH by 5 tags, giving a TAH of 15 tags for the muskox management zone MX12. A new survey should be planned in 2012 to assess the trend of the population and confirm that this management strategy if efficient to achieve management goals in the area.

8.0. Reporting to Communities/Resource Users

The draft of this report has been sent to the Kugluktuk HTO and NWMB. A meeting with the HTO will be organized to discuss the results and management implications. The final report will be available through GN-DoE and will be distributed to relevant co-management partners and other interested organizations and individuals.

9.0. Literature Cited

Barr, W. 1991. Back from the brink: The road to muskox conservation in the Northwest Territories. The Arctic Institute of North America of the University of Calgary, Alberta, Canada. *Kamotik Series* No. 3. 127pp.

Campbell, M. and M. Setterington. 2001. The re-evaluation of Kivalliq and Northeast Kitikmeot Muskox (*Ovibos moschatus*) populations, management zones and quotas. Technical Report Series 2001 – No. 1-02. Nunavut Wildlife Division, Department of Environment, Arviat, Nunavut. 97pp.

Dumond, M. 2006. Muskoxen distribution and abundance in the area between Bathurst Inlet and the Coppermine River, Kitikmeot Region, Nunavut (MX19 and West of MX14) – August 2005. Interim report to the Nunavut Wildlife Management Board.

Dumond, M. 2007. Caribou and Muskox population status, dynamics and health in Nunavut Western mainland. Research proposal to the Nunavut Wildlife Management Board (funded).

Fournier, B. and A. Gunn. 1998. Muskox Numbers and Distribution in the Northwest Territories, 1997. File Report #121, Department of Resources, Wildlife and Economic Development, Yellowknife, NWT.

Gunn, A. 1995. Distribution and abundance of muskoxen west of Coppermine, N.W.T. 1987-88. File Report No109. Department of Resources, Wildlife and Economic Development, Government of the Northwest Territories. Yellowknife. 28pp.

Gunn, A. and B. Fournier. 2000. Calf survival and seasonal migrations of a mainland muskox population. File Report No.124. Department of Resources, Wildlife and Economic Development, Government of the Northwest Territories. Yellowknife.

Gunn, A. and F.L. Miller. 1982. Muskox bull killed by a Barren Ground Grizzly Bear, Thelon Game Sanctuary, N.W.T. Arctic 35(4):545-546.

Gunn, A. and G. Wobeser 1993. *Protostrongilid* lungworm infection in muskoxen, Coppermine, NWT, Canada. Rangifer 13(1):45-47

Hoberg, E.P., L. Polley, A. Gunn, and J.S. Nishi. 1995. *Umingmaktstrongylus pallikuukensis* gen.nov. et sp.nov. (Nematoda : *Protostrongylidae*) from muskoxen, *Ovibos moschatus*, in the Central Canadian Arctic, with comments on biology and biogeography. Canadian Journal of Zoology 73(12):2266-2282.

Jolly, G.M. 1969. Sampling methods for aerial census of wildlife populations. East Afr. Agric. For. J. 34:46–49.

Kelsall, J.P., V.D. Hawley and D.C. Thomas. 1971. Distribution and abundance of muskoxen north of Great Bear Lake. Arctic. 24(3):157–161.

Kutz, S. 1999. *Umingmakstrongylus pallikuukensis* in Muskoxen. PhD Thesis. University of Saskatchewan, Saskatoon, SK. 208pp.

Norton-Griffiths, M. 1978. Counting animals. Serengetti ecological monitoring programme Handbook No. 1. Afropress Ltd., Nairobi Kenya. 139 pp.

Reynolds et al. 2002. Ursus.

Thompson, W.L., G.C. White and C. Gowan. 1998. Monitoring vertebrate populations. Academic Press Inc. San Diego. 365 pp.

APPENDIX 1

Aircraft Configuration

Aircraft Configuration

The survey was flown using a Helio Courier. The Helio Courier has no wing struts and therefore I ran a string from the wing to the body of the aircraft to position the markers.

Strip widths were established using strings with a little weight that would stay horizontal during the flight and attached to the main string (Figure 4.2). Strip width (w) was calculated using the formula of Norton-Griffiths (1978):

$$w = W * h/H$$

where:

W = the required strip width**;**

h = the height of the observer's eye from the tarmac; and

H = the required flying height

Strip width calculations were confirmed by flying perpendicularly over a set of ground markers positioned to represent the 1.5km strip on the ground on each side of the plane.

The strip width area for density calculations was 1500 m, for a total of 3000 m along each transect.

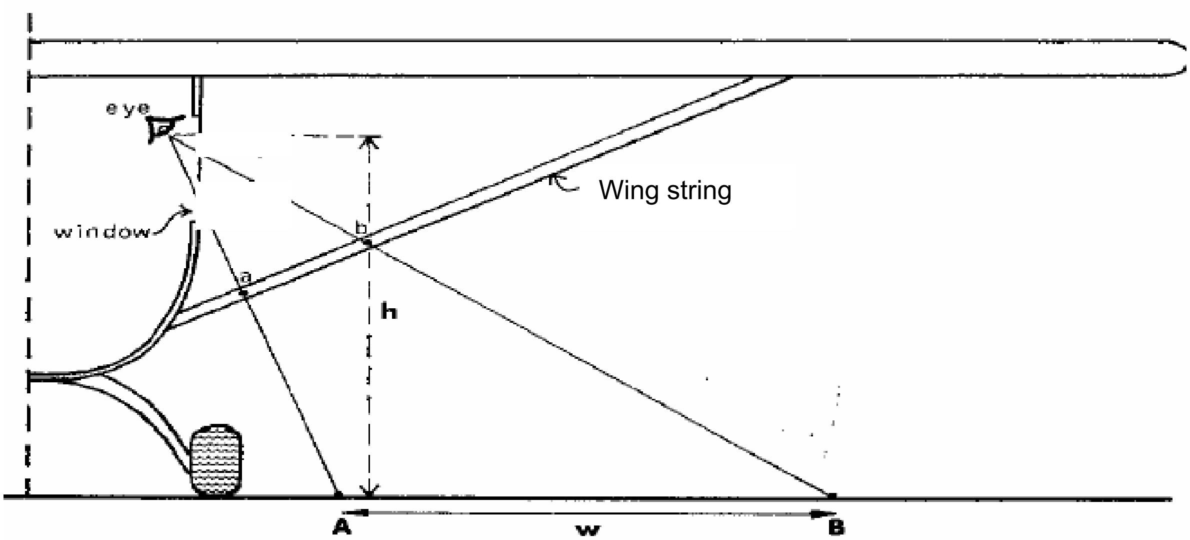

Figure 4.2: Schematic diagram of aircraft configuration for strip width sampling (Norton-Griffiths, 1978). W is marked out on the tarmac, and the two lines of sight a – A and b – B established. The dowels are attached to the wing string at a and b. a' and b' are the window marks (adapted from Campbell and Setterington 2001).

APPENDIX 2

Estimate calculation for the whole study area and per stratum (HAD and LDA)

Management Zone:	**MX/12 - ALL**
Location:	**WESTERN KITIKMEOT**
Area of strata (km^2) (Z):	**30195.36735**
Altitude (km)	**0.154**
Strip width (km)	**3.00**
Base-line (km)	**745**
Transects sampled (n)	**81**
Total transects (N)	**248.3333333**
t-value for n-1 (95%CL):	**1.99**

				z	**y_1**	**y_2**					
Block_ID	**Tran_ID**	**Length (km)**	**Width(km)**	**Area(km^2)**	**Adults**	**Calves**	**z^2**	y_1^2	y_2^2	$z*y_1$	$z*y_2$
1	1	30.8	3.0	92.4	2	0	8537.76	4	0	184.8	0
1	2	39.6	3.0	118.8	12	1	14113.44	144	1	1425.6	118.8
1	3	35.7	3.0	107.1	0	0	11470.41	0	0	0	0
1	4	45.6	3.0	136.8	1	0	18714.24	1	0	136.8	0
1	5	44.5	3.0	133.5	0	0	17822.25	0	0	0	0
1	6	28.0	3.0	84.0	0	0	7056.00	0	0	0	0
1	7	53.3	3.0	159.9	0	0	25568.01	0	0	0	0
1	8	41.1	3.0	123.3	0	0	15202.89	0	0	0	0
1	9	51.1	3.0	153.3	19	7	23500.89	361	49	2912.7	1073.1
1	10	29.7	3.0	89.1	0	0	7938.81	0	0	0	0
1	11	51.1	3.0	153.3	24	4	23500.89	576	16	3679.2	613.2

1	12	51.1	3.0	153.3	18	3	23500.89	324	9	2759.4	459.9
1	13	51.1	3.0	153.3	0	0	23500.89	0	0	0	0
1	14	51.1	3.0	153.3	0	0	23500.89	0	0	0	0
1	15	51.1	3.0	153.3	0	0	23500.89	0	0	0	0
1	16	51.1	3.0	153.3	4	1	23500.89	16	1	613.2	153.3
1	17	16.9	3.0	50.7	0	0	2570.49	0	0	0	0
1	18	26.4	3.0	79.2	0	0	6272.64	0	0	0	0
1	19	25.3	3.0	75.9	0	0	5760.81	0	0	0	0
1	20	51.2	3.0	153.6	0	0	23592.96	0	0	0	0
1	21	8.8	3.0	26.4	0	0	696.96	0	0	0	0
1	22	10.4	3.0	31.2	0	0	973.44	0	0	0	0
1	23	18.7	3.0	56.1	0	0	3147.21	0	0	0	0
1	24	24.7	3.0	74.1	0	0	5490.81	0	0	0	0
1	25	25.8	3.0	77.4	0	0	5990.76	0	0	0	0
1	26	29.1	3.0	87.3	5	1	7621.29	25	1	436.5	87.3
1	27	50.6	3.0	151.8	3	0	23043.24	9	0	455.4	0
1	28	33.0	3.0	99.0	11	3	9801.00	121	9	1089	297
1	29	50.6	3.0	151.8	0	0	23043.24	0	0	0	0
1	30	34.6	3.0	103.8	0	0	10774.44	0	0	0	0
1	31	50.6	3.0	151.8	0	0	23043.24	0	0	0	0
1	32	29.7	3.0	89.1	0	0	7938.81	0	0	0	0
1	33	50.6	3.0	151.8	12	3	23043.24	144	9	1821.6	455.4
1	34	33.0	3.0	99.0	0	0	9801.00	0	0	0	0
1	35	50.6	3.0	151.8	0	0	23043.24	0	0	0	0
1	36	17.6	3.0	52.8	0	0	2787.84	0	0	0	0

1	37	51.2	3.0	153.6	2	0	23592.96	4	0	307.2	0
1	38	51.2	3.0	153.6	5	0	23592.96	25	0	768	0
1	39	40.4	3.0	121.2	7	4	14689.44	49	16	848.4	484.8
1	40	22.0	3.0	66.0	13	3	4356.00	169	9	858	198
1	41	49.5	3.0	148.5	0	0	22052.25	0	0	0	0
1	42	41.2	3.0	123.6	2	0	15276.96	4	0	247.2	0
1	43	22.0	3.0	66.0	0	0	4356.00	0	0	0	0
1	44	50.1	3.0	150.3	1	0	22590.09	1	0	150.3	0
1	45	34.9	3.0	104.7	0	0	10962.09	0	0	0	0
1	46	23.6	3.0	70.8	0	0	5012.64	0	0	0	0
1	47	51.2	3.0	153.6	18	4	23592.96	324	16	2764.8	614.4
1	48	50.6	3.0	151.8	0	0	23043.24	0	0	0	0
1	49	50.6	3.0	151.8	0	0	23043.24	0	0	0	0
2	50	36.2	3.0	108.6	0	0	11793.96	0	0	0	0
2	51	28.6	3.0	85.8	0	0	7361.64	0	0	0	0
2	52	50.0	3.0	150.0	0	0	22500.00	0	0	0	0
2	53	35.7	3.0	107.1	0	0	11470.41	0	0	0	0
2	54	50.0	3.0	150.0	0	0	22500.00	0	0	0	0
2	55	33.0	3.0	99.0	0	0	9801.00	0	0	0	0
2	56	35.7	3.0	107.1	0	0	11470.41	0	0	0	0
2	57	51.2	3.0	153.6	0	0	23592.96	0	0	0	0
2	58	35.7	3.0	107.1	0	0	11470.41	0	0	0	0
2	59	51.2	3.0	153.6	0	0	23592.96	0	0	0	0
2	60	51.2	3.0	153.6	2	1	23592.96	4	1	307.2	153.6
2	61	35.2	3.0	105.6	0	0	11151.36	0	0	0	0

2	62	51.2	3.0	153.6	0	0		23592.96	0	0	0	0
2	63	50.0	3.0	150.0	0	0		22500.00	0	0	0	0
2	64	51.2	3.0	153.6	0	0		23592.96	0	0	0	0
2	65	32.4	3.0	97.2	0	0		9447.84	0	0	0	0
2	66	32.0	3.0	96.0	18	7		9216.00	324	49	1728	672
2	67	57.2	3.0	171.6	0	0		29446.56	0	0	0	0
2	68	57.3	3.0	171.9	0	0		29549.61	0	0	0	0
2	69	50.0	3.0	150.0	0	0		22500.00	0	0	0	0
2	70	57.2	3.0	171.6	0	0		29446.56	0	0	0	0
2	71	50.0	3.0	150.0	10	5		22500.00	100	25	1500	750
2	72	57.2	3.0	171.6	0	0		29446.56	0	0	0	0
2	73	50.0	3.0	150.0	0	0		22500.00	0	0	0	0
2	74	57.2	3.0	171.6	0	0		29446.56	0	0	0	0
2	75	50.0	3.0	150.0	0	0		22500.00	0	0	0	0
2	76	48.9	3.0	146.7	0	0		21520.89	0	0	0	0
2	77	45.7	3.0	137.1	3	2		18796.41	9	4	411.3	274.2
2	78	29.6	3.0	88.8	0	0		7885.44	0	0	0	0
2	79	24.2	3.0	72.6	0	0		5270.76	0	0	0	0
2	80	23.6	3.0	70.8	0	0		5012.64	0	0	0	0
2	81	31.2	3.0	93.6	0	0		8760.96	0	0	0	0
Totals		**3282.50**	**3.00**	**9847.50**	**192**	**49**		1308758.31	2738	215	25404.6	6405

Statistical Calculations

	Area	Adults(y_1)	Calves(y_2)
SUM(z)	**9847.50**		
SUM(y)		**192**	**49**
SUM(z^2) and/or SUM(y^2)	**1308758.31**	**2738**	**215**
SUM(z * y)		**25404.6**	**6405**
R = SUM(y) / SUM(z)		**0.0195**	**0.0050**
s_y^2		**28.83**	**2.34**
s_z^2	**1402.09**		
s_{zy}		**24.94**	**5.38**
Y = R x Z		**588.73**	**150.25**
Var(**Y**)		**14562.41**	**1191.61**
SE(**Y**)		**120.67**	**34.52**
95% Confidence Limits of Y (+/-)		**240.14**	**68.69**
95% Confidence Limits of Y (%)		**40.79**	**45.72**
Coefficient of Variation		**0.20**	**0.23**
% area coverage			32.61

Lower est.	ESTIMATE	Upper est.
348.59	588.73	828.87

Management Zone:	**MX12 STRATA 1 (HDA)**
Location:	**WESTERN KITIKMEOT**
Area of strata (km^2) (Z):	**13404.0489**
Altitude (km)	**0.154**
Strip width (km)	**3.00**
Base-line (km)	**348.8598268**
Transects sampled (n)	**49**
Total transects (N)	**116.2866089**
t-value for n-1 (95%CL):	**2.01**

				z	y_1	y_2					
Block_ID	**Tran_ID**	**Length (km)**	**Width(km)**	**Area(km^2)**	**Adults**	**Calves**	**z^2**	y_1^2	y_2^2	$z*y_1$	$z*y_2$
1	1	30.8	3.0	92.4	2	0	8537.76	4	0	184.8	0
1	2	39.6	3.0	118.8	12	1	14113.44	144	1	1425.6	118.8
1	3	35.7	3.0	107.1	0	0	11470.41	0	0	0	0
1	4	45.6	3.0	136.8	1	0	18714.24	1	0	136.8	0
1	5	44.5	3.0	133.5	0	0	17822.25	0	0	0	0
1	6	28.0	3.0	84.0	0	0	7056.00	0	0	0	0
1	7	53.3	3.0	159.9	0	0	25568.01	0	0	0	0
1	8	41.1	3.0	123.3	0	0	15202.89	0	0	0	0
1	9	51.1	3.0	153.3	19	7	23500.89	361	49	2912.7	1073.1
1	10	29.7	3.0	89.1	0	0	7938.81	0	0	0	0
1	11	51.1	3.0	153.3	24	4	23500.89	576	16	3679.2	613.2

1	12	51.1	3.0	153.3	18	3	23500.89	324	9	2759.4	459.9
1	13	51.1	3.0	153.3	0	0	23500.89	0	0	0	0
1	14	51.1	3.0	153.3	0	0	23500.89	0	0	0	0
1	15	51.1	3.0	153.3	0	0	23500.89	0	0	0	0
1	16	51.1	3.0	153.3	4	1	23500.89	16	1	613.2	153.3
1	17	16.9	3.0	50.7	0	0	2570.49	0	0	0	0
1	18	26.4	3.0	79.2	0	0	6272.64	0	0	0	0
1	19	25.3	3.0	75.9	0	0	5760.81	0	0	0	0
1	20	51.2	3.0	153.6	0	0	23592.96	0	0	0	0
1	21	8.8	3.0	26.4	0	0	696.96	0	0	0	0
1	22	10.4	3.0	31.2	0	0	973.44	0	0	0	0
1	23	18.7	3.0	56.1	0	0	3147.21	0	0	0	0
1	24	24.7	3.0	74.1	0	0	5490.81	0	0	0	0
1	25	25.8	3.0	77.4	0	0	5990.76	0	0	0	0
1	26	29.1	3.0	87.3	5	1	7621.29	25	1	436.5	87.3
1	27	50.6	3.0	151.8	3	0	23043.24	9	0	455.4	0
1	28	33.0	3.0	99.0	11	3	9801.00	121	9	1089	297
1	29	50.6	3.0	151.8	0	0	23043.24	0	0	0	0
1	30	34.6	3.0	103.8	0	0	10774.44	0	0	0	0
1	31	50.6	3.0	151.8	0	0	23043.24	0	0	0	0
1	32	29.7	3.0	89.1	0	0	7938.81	0	0	0	0
1	33	50.6	3.0	151.8	12	3	23043.24	144	9	1821.6	455.4
1	34	33.0	3.0	99.0	0	0	9801.00	0	0	0	0
1	35	50.6	3.0	151.8	0	0	23043.24	0	0	0	0
1	36	17.6	3.0	52.8	0	0	2787.84	0	0	0	0

1	37	51.2	3.0	153.6	2	0	23592.96	4	0	307.2	0
1	38	51.2	3.0	153.6	5	0	23592.96	25	0	768	0
1	39	40.4	3.0	121.2	7	4	14689.44	49	16	848.4	484.8
1	40	22.0	3.0	66.0	13	3	4356.00	169	9	858	198
1	41	49.5	3.0	148.5	0	0	22052.25	0	0	0	0
1	42	41.2	3.0	123.6	2	0	15276.96	4	0	247.2	0
1	43	22.0	3.0	66.0	0	0	4356.00	0	0	0	0
1	44	50.1	3.0	150.3	1	0	22590.09	1	0	150.3	0
1	45	34.9	3.0	104.7	0	0	10962.09	0	0	0	0
1	46	23.6	3.0	70.8	0	0	5012.64	0	0	0	0
1	47	51.2	3.0	153.6	18	4	23592.96	324	16	2764.8	614.4
1	48	50.6	3.0	151.8	0	0	23043.24	0	0	0	0
1	49	50.6	3.0	151.8	0	0	23043.24	0	0	0	0
Totals		**1882.70**	**3.00**	**5648.10**	**159**	**34**	725527.53	2301	136	21458.1	4555.2

<u>**Statistical Calculations**</u>

	Area	Adults(y_1)	Calves(y_2)
SUM(z)	**5648.10**		
SUM(y)		**159**	**34**
SUM(z^2) and/or SUM(y^2)	**725527.53**	**2301**	**136**
SUM(z * y)		**21458.1**	**4555.2**

R = SUM(y) / SUM(z)		**0.0282**	**0.0060**	
$\mathbf{s_y^2}$		**37.19**	**2.34**	
$\mathbf{s_z^2}$	**1551.79**			
$\mathbf{s_{zy}}$		**63.89**	**12.98**	
Y = R x Z		**377.34**	**80.69**	
Var(**Y**)		**5560.43**	**357.98**	
SE(**Y**)		**74.57**	**18.92**	
95% Confidence Limits of Y (+/-)		**149.88**	**38.03**	
95% Confidence Limits of Y (%)		**39.72**	**47.13**	
Coefficient of Variation		**0.20**	**0.23**	
% area coverage			42.14	

Lower est.	ESTIMATE	Upper est.
227	377	527

Management Zone:	**MX12 STRATA 2 (LDA)**
Location:	**WESTERN KITIKMEOT**
Area of strata (km^2) (Z):	16791.31846
Altitude (km)	**0.154**
Strip width (km)	**3.00**
Base-line (km)	**383.8564013**
Transects sampled (n)	**32**
Total transects (N)	**127.9521338**
t-value for n-1 (95%CL):	**2.04**

				z	y_1	y_2					
Block_ID	**Tran_ID**	**Length (km)**	**Width(km)**	**Area(km^2)**	**Adults**	**Calves**	z^2	y_1^2	y_2^2	$z*y_1$	$z*y_2$
2	50	36.2	3.0	108.6	0	0	11793.96	0	0	0	0
2	51	28.6	3.0	85.8	0	0	7361.64	0	0	0	0
2	52	50.0	3.0	150.0	0	0	22500.00	0	0	0	0
2	53	35.7	3.0	107.1	0	0	11470.41	0	0	0	0
2	54	50.0	3.0	150.0	0	0	22500.00	0	0	0	0
2	55	33.0	3.0	99.0	0	0	9801.00	0	0	0	0
2	56	35.7	3.0	107.1	0	0	11470.41	0	0	0	0
2	57	51.2	3.0	153.6	0	0	23592.96	0	0	0	0
2	58	35.7	3.0	107.1	0	0	11470.41	0	0	0	0
2	59	51.2	3.0	153.6	0	0	23592.96	0	0	0	0
2	60	51.2	3.0	153.6	2	1	23592.96	4	1	307.2	153.6

2	61	35.2	3.0	105.6	0	0	11151.36	0	0	0	0
2	62	51.2	3.0	153.6	0	0	23592.96	0	0	0	0
2	63	50.0	3.0	150.0	0	0	22500.00	0	0	0	0
2	64	51.2	3.0	153.6	0	0	23592.96	0	0	0	0
2	65	32.4	3.0	97.2	0	0	9447.84	0	0	0	0
2	66	32.0	3.0	96.0	18	7	9216.00	324	49	1728	672
2	67	57.2	3.0	171.6	0	0	29446.56	0	0	0	0
2	68	57.3	3.0	171.9	0	0	29549.61	0	0	0	0
2	69	50.0	3.0	150.0	0	0	22500.00	0	0	0	0
2	70	57.2	3.0	171.6	0	0	29446.56	0	0	0	0
2	71	50.0	3.0	150.0	10	5	22500.00	100	25	1500	750
2	72	57.2	3.0	171.6	0	0	29446.56	0	0	0	0
2	73	50.0	3.0	150.0	0	0	22500.00	0	0	0	0
2	74	57.2	3.0	171.6	0	0	29446.56	0	0	0	0
2	75	50.0	3.0	150.0	0	0	22500.00	0	0	0	0
2	76	48.9	3.0	146.7	0	0	21520.89	0	0	0	0
2	77	45.7	3.0	137.1	3	2	18796.41	9	4	411.3	274.2
2	78	29.6	3.0	88.8	0	0	7885.44	0	0	0	0
2	79	24.2	3.0	72.6	0	0	5270.76	0	0	0	0
2	80	23.6	3.0	70.8	0	0	5012.64	0	0	0	0
2	81	31.2	3.0	93.6	0	0	8760.96	0	0	0	0
Totals		**1399.80**	**3.00**	**4199.40**	**33**	**15**	583230.78	437	79	3946.5	1849.8

Statistical Calculations

	Area	Adults(y_1)	Calves(y_2)
SUM(z)	**4199.40**		
SUM(y)		**33**	**15**
SUM(z^2) and/or SUM(y^2)	**583230.78**	**437**	**79**
SUM(z * y)		**3946.5**	**1849.8**
R = SUM(y) / SUM(z)		**0.0079**	**0.0036**
s_y^2		**13.00**	**2.32**
s_z^2	**1036.72**		
s_{zy}		**-12.00**	**-3.71**
Y = R x Z		**131.95**	**59.98**
Var(**Y**)		**5084.20**	**905.95**
SE(**Y**)		**71.30**	**30.10**
95% Confidence Limits of Y (+/-)		**145.46**	**61.40**
95% Confidence Limits of Y (%)		**110.24**	**102.37**
Coefficient of Variation		**0.54**	**0.50**

% area coverage 25.01

Lower est.	ESTIMATE	Upper est.
33	132	277

Appendix 3:

Muskox Aerial Survey Budget Summary
Western Kitikmeot May 2007

Item	Cost
Aircraft ($646/h)	$30,362.00
Pilot Accommodation	$1,850.00
Fuel (AvGas)	$3,001.50
Field observers	$1,600.00
TOTAL	**$36,813.50**
Over-Time field work	23.5 hours

Note: Salaries of GN employees are not included