APPLICATION OF STRATIFIED RANDOM CENSUS PROCEDURES TO THE 1976 AERIAL MOOSE CENSUS IN THE AOSERP STUDY AREA

by

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for

ALBERTA OIL SANDS ENVIRONMENTAL RESEARCH PROGRAM

PROJECT TF 7.2.1
March 1978

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The Hon. D. J. Russell
Minister of the Environment
222 Legislative Building
Edmonton, Alberta

and

The Hon. L. Marchand
Minister of State of the Environment
Parliament Buildings
Ottawa, Ontario

Sirs:

Enclosed herein is the interim rebort on "Application of Stratified Random Census Procedures to the 1976 Aerial Moose Census in the AOSERP Study Area".

The interim report was prepared as a result of field studies in Winter, 1976, which were initiated by the Terrestrial Fauna Technical Research Committee of the Alberta Oil Sands Environmental Research Program, under the Canada-Alberta Agreement of February 1975 (amended September 1977).

Respectfully,

W. Solodzuk, P. Eng.
Chairman, Steering Committee, AOSERP
Deputy Minister, Alberta Environment

for J. P. Bruce
Member, Steering Committee, AOSERP
Assistant Deputy Minister
Environment Management Service
Environment Canada

Application of Stratified Random Census Procedures to the 1976 Aerial Moose Census in the AOSERP Study Area

DESCRIPTIVE SUMMARY

ABSTRACT

A stratified random sampling procedure using square-mile (2.6 km^2) quadrats was tested on a helicipter census of moose (*Alces alces*) in a 630 square-mile (1638 km^2) pilot area in the AOSERP study area in northeastern Alberta during January 1976. Under the assumption that moose are differentially associated with different habitat types during January, the study area was divided into three major habitat types: predominately aspen, predominately muskeg, and river bottom.

The census produced a weighted mean estimate of 0.58 moose per square mile (0.22/km^2), or a survey area estimate of 363 moose ± 30 percent. Small group sizes resulted in a variance/mean ratio of 0.819 and prevented any visibility bias analysis. Potential causes of, and remedial measures for, the releatively high variance and low group sizes are discussed. Helicopter quadrat censusing appears to be a statistically feasible aerial moose census methodology for the AOSERP study area.

The recommendations of the report are:

1. The only feasible aircraft-technique alternative for a moose census on the AOSERP study area with today's technology is a helicopter flying square-mile quadrats. A direct comparison of a fixed-wing census of 0.2 km wide strip plots with a fixed wing quadrat census indicated an efficiency differential as high as 30 percent.

2. Restratification of this survey area, or stratification of future survey areas, should follow procedures outlined by Hildebrand and Jacobson (1974) to eliminate the problem of islands of one type (aspen) within another type (muskeg) biasing overall variance estimates.
3. An attempt should be made to schedule the census when survey area moose have at least partially moved to the river bottom, to increase the potential of larger group sizes for the visibility bias model.
4. As many of the visibility bias variables as possible should be identified, and a rigid quality control procedure instituted to measure and hold the variables within predetermined bounds of acceptability on all censuses.

BACKGROUND AND PERSPECTIVE

This report gives the first-year interim results of an ongoing project which will be completed in 1978. The project is one of a series to establish the baseline states of the terrestrial fauna in the AOSERP study area.

The purpose of this project is to determine the population size of moose in the survey area with regard given to sex and age ratios and distribution according to habitat and seasonal climatic features. The changes in these characteristics will be monitored yearly.

ASSESSMENT

The report entitled "Application of Stratified Random Census Procedures to the 1976 Moose Census in the AOSERP Study Area" which was prepared by J. O. Jacobson (Inter-disciplinary Systems Ltd.) has been reviewed by the Alberta Oil Sands Environmental Research Program, the former Terrestrial Fauna Technical Research Committee and the Oil Sands Environmental Study Group. In view of the value of the data, the Alberta Oil Sands Environmental Research Program recommends that the report be published and made available.

Although the report does not meet the standards set by AOSERP for publication and wide distribution, it is fairly comprehensive and includes flight logs, a summary of sample distribution and census results and analysis of the data. As an interim report, "Application of Stratified Random Census Procedures to the 1976 Moose Census in the AOSERP Study Area", represents a working document which contains data that should be of some use as a basis for research on moose populations in the AOSERP study area. Readers should note the autocorrelation of means and variances, and use the data with the appropriate reservation.

The content of this report does not necessarily reflect the views of Alberta Environment, Environment Canada, or the Alberta Oil Sands Environmental Research Program. The mention of trade names for commercial products does not constitute an endorsement or recommendation for use.

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ABSTRACT

A stratified random sampling procedure using square-mile (2.6 km^2) quadrats was tested on a helicopter census of moose (*Alces alces*) on the AOSERP survey area (Figure 1) in northeastern Alberta during January 1976. The census produced a weighted mean estimate of 0.58 moose per square mile (0.22/km^2), or a study area estimate of 363 moose ± 30 percent. Small group sizes resulted in a variance/mean ratio of 0.819 and prevented any visibility bias analysis. Potential causes of, and remedial measures for, the relatively high variance and low group sizes are discussed. Helicopter quadrat censusing appears to be the only statistically feasible aerial moose census methodology available for the AOSERP study area.

ACKNOWLEDGEMENTS

This research project TF 7.2.1 was funded by the Alberta Oil Sands Environmental Research Program, a joint Alberta-Canada research program established to fund, direct, and co-ordinate environmental research in the Athabasca Oil Sands area.

The assistance of G. Kemp in the study area stratification, and A. Bibaud, R. Frokjer, T. Hauge, T. Fuller, and J. Nyborg, and conducted the Census, is gratefully acknowledged.

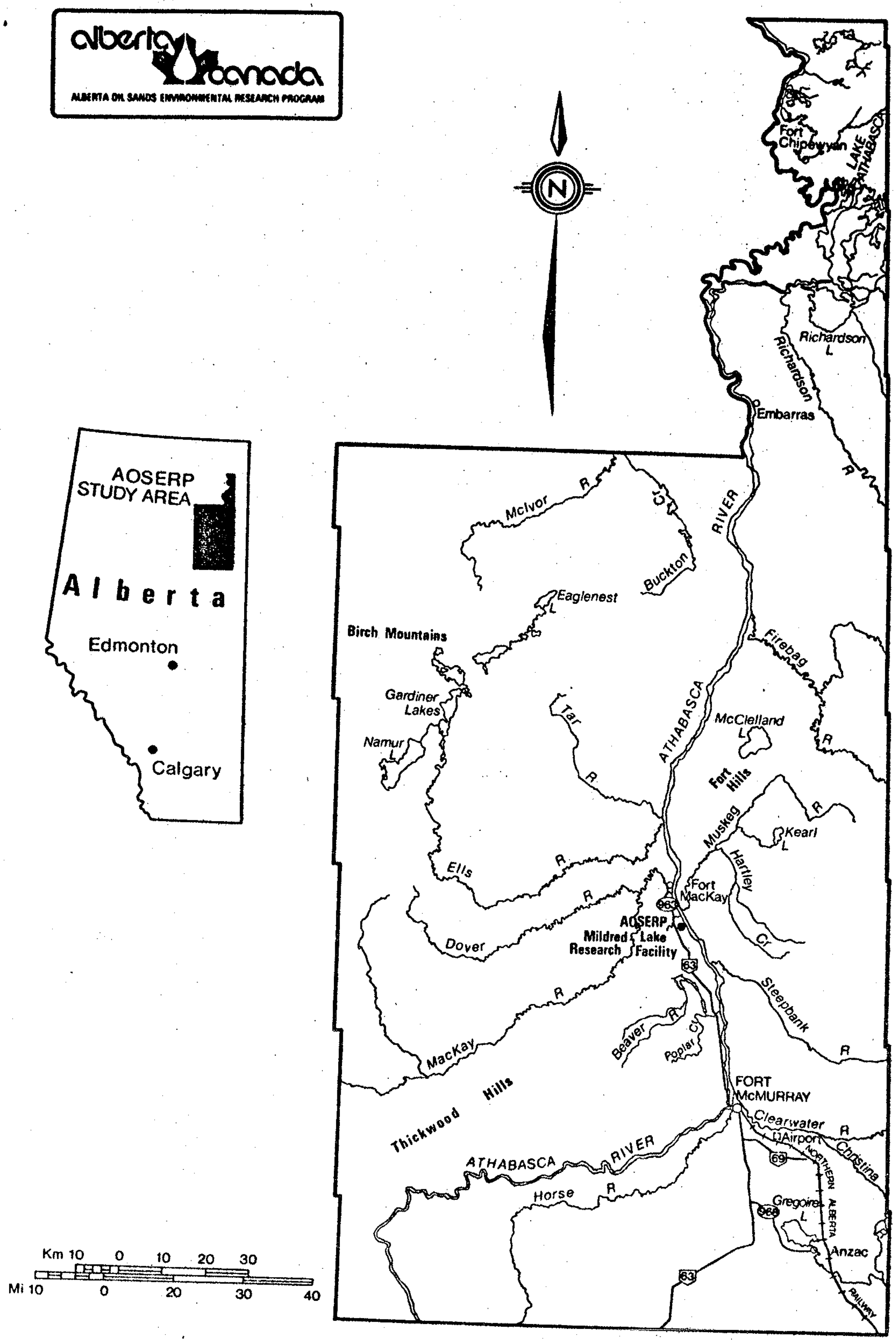

Figure 1. Location of the AOSERP study area.

1. INTRODUCTION

This study was initiated in December 1976 to determine the feasibility and statistical adequacy of an aerial census technique for moose in the AOSERP study area of northeastern Alberta.

Although aerial census techniques have become an increasingly important tool for obtaining moose population estimates in northern North America, application of these techniques for population estimation have been recently questioned by LeResche and Rausch (1974). They concluded that aerial census results, because of inherent visibility biases, could only be used as trend indicators under carefully controlled conditions.

Cook and Martin (1974) and Caughley (1974) also recognized the importance of visibility bias in aerial census data; however, rather than suggesting aerial census data be treated only as indices, they proposed unique methodologies to adjust population estimates for visibility bias.

This pilot study was designed to provide a statistically adequate estimate of the moose population based on a stratified random sampling procedure, with the data also collected in a format suitable for analysis by the Poisson visibility bias model developed for moose in northern Minnesota by Cook and Martin (1974).

2. METHODS

A 630 square mile (1638 km^2) pilot survey area was selected in the AOSERP study area north of Fort McMurray. (Figure 1). This area encompasses the Athabasca River and contains a representative sample of the wooded cover available on the area. Under the assumption that moose are differentially associated with different habitat types during January, the study area was gridded into square-mile (2.6 km^2) quadrats, and, using 1974 1:63,360 forest inventory maps, was divided into three major habitat types: predominantly aspen, predominantly muskeg, and river bottoms (Figure 2).

Stratification resulted in 52 river quadrats, 407 aspen quadrats and 171 muskeg quadrats (Table 1 and Figure 3). Preliminary analysis of expected variance in moose numbers by strata (Cochran 1963) indicated 225 (Table 2) would be required to estimate the study area population with a precision ± 20 percent ($P<0.05$).

Sample quadrats were allocated to respective strata using Neyman's optimum allocation (Cochran 1963) and represent and overall sampling intensity of 36 percent of the study area (Table 1). Quadrats were numbered sequentially within each stratum and sample quadrats were randomly selected using the random number generating function of the Hewlett-Packard 9820 computer. Sample quadrats were outlined on 3 inch per mile aerial photos for navigation.

The census was flown in a Hughes 500 helicopter at an altitude of 150-300 feet and an airspeed of 50-65 miles per hour.

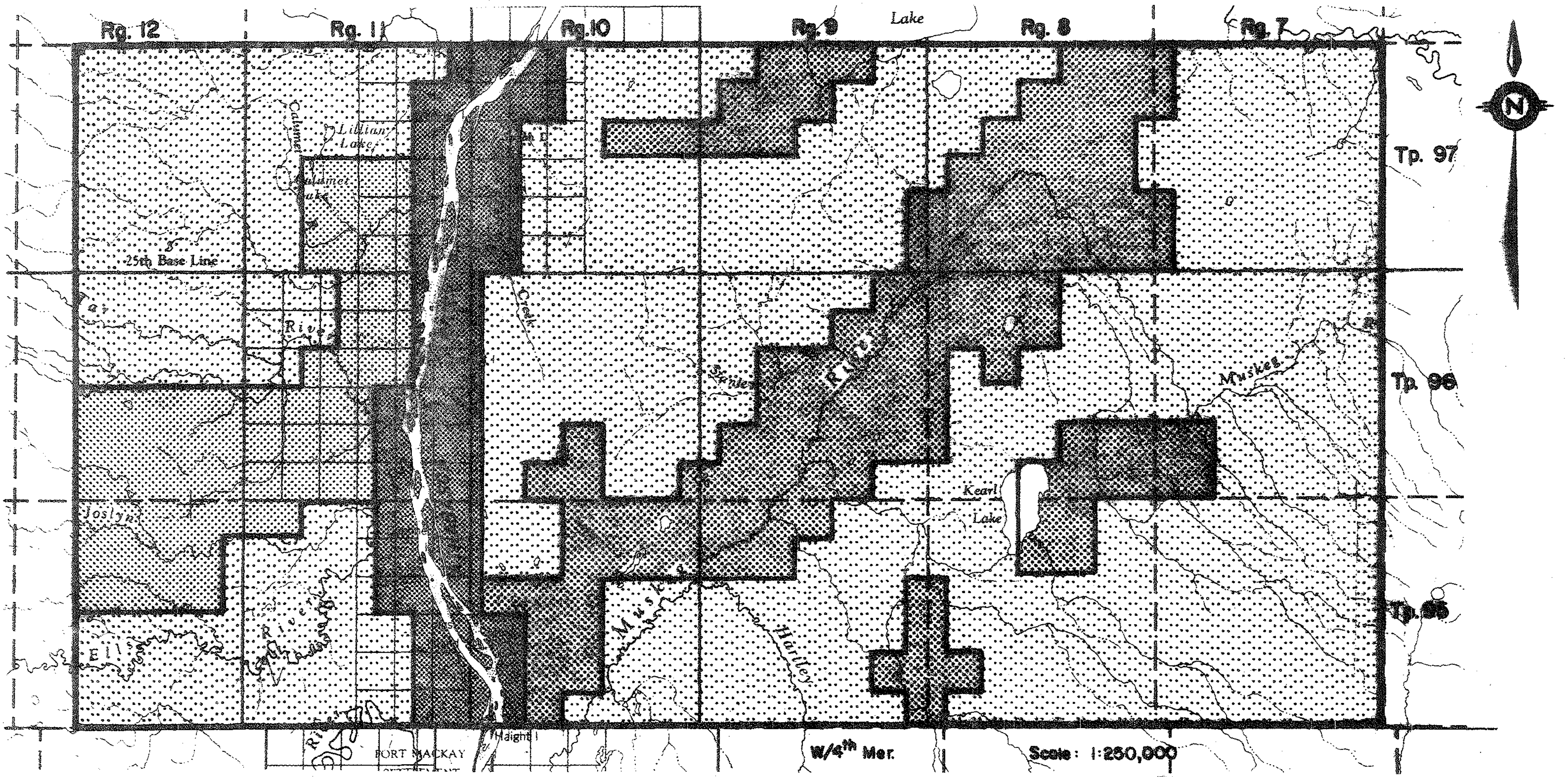

Figure 2 Distribution of the 1976 moose density strata in the AOSERP survey area

Legend

Areas of high density		predominantly river bottom
Areas of medium density		predominantly aspen
Areas of low density		predominantly muskeg

Table 1. Summary of quadrat sample distribution and aerial moose census results on the AOSERP survey area, 7 - 22 January 1976.

	River stratum	Aspen stratum	Muskeg stratum	Total
Total square miles	52	407	171	630
Square-mile quadrats sampled	34	163	28	225
Sampling intensity (% of area)	65	40	16	36
Quadrats with moose	4	46	6	56
Total moose counted	7	97	18	122
Range (moose/quadrat)	0-3	0-6	0-6	0-6
Stratum mean	0.21	0.60	0.64	
Stratum variance	0.411	1.403	2.386	

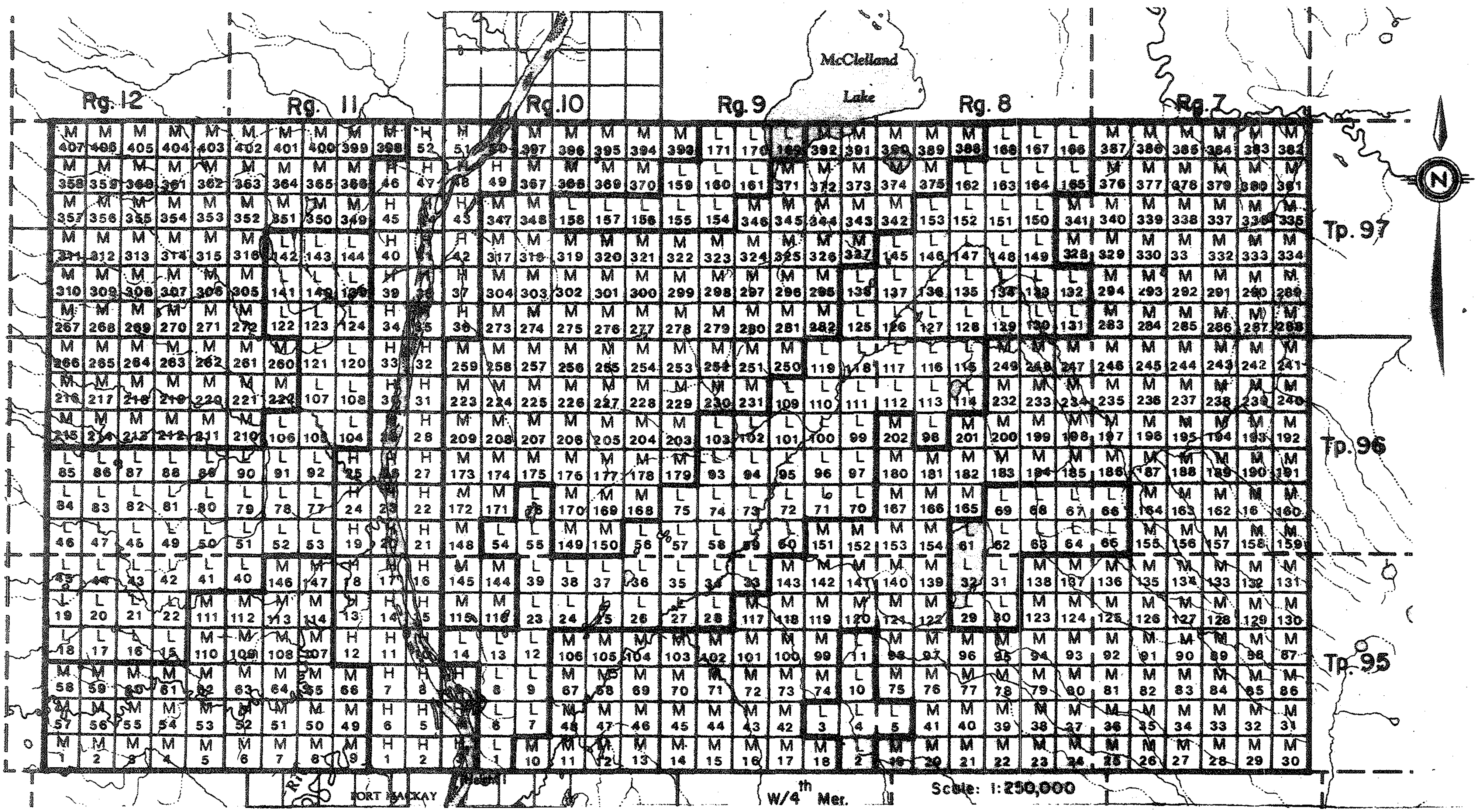

Figure 3 Distribution of the 1976 aerial survey quadrats in the AOSERP survey area.

Legend
- High density quadrats: H
- Medium density quadrats: M
- Low density quadrats: L

Table 2. Optimum allocation of sampling effort for the square-mile quadrats with an estimated population of 500 moose quadrats on the AOSERP survey area.

	Total quadrats	Estimated Variance	Estimated sample size at given precision level: 30%	25%	20%	15%	10%
River	52	8.0	19	25	34	46	52
Aspen	407	3.0	93	122	163	219	301
Muskeg	171	0.5	16	21	28	38	52
Totals	630		129	168	225	303	405
Total sampling intensity (%)			20	27	36	48	64

Both observers were seated on the right side of the aircraft and the recorder was seated in the left rear seat. Quadrats were flown in a clockwise pattern of ever decreasing "square-circuits". Moose were recorded as groups (one or more moose observed in close proximity (Bergerud and Manuel 1969)). One additional restriction on this definition, necessary for visibility bias analysis (Cook and Martin 1974), is that group size is determined by the number of individuals mutually observed or observed as a result of other group individuals.

Observations were reported to the recorder who recorded group size and location on a special census data sheet (Appendix 7.1). All censuses were flown between 930-1600 hours under generally good census conditions with complete snow cover (Table 3).

Table 3. Flight log for helicopter moose census, Fort McMurray AOSERP study area, January 1976.

	7 January	8 January	9 January	10 January	11 January	12 January	15 January	16 January	19 January	20 January	21 January	22 January
Aircraft	Hughes 500 Helicopter	Hughes 500 Helicopter	Hughes 500 Helicopter	Hughes 500 Helicopter	Hughes 500 Helicopter	Hughes 500 Helicopter	Hughes 500 Helicopter	Hughes 500 Helicopter	Hughes 500 Helicopter	Hughes 500 Helicopter	Hughes 500 Helicopter	Hughes 500 Helicopter
Pilot	D.Peterson	D.Peterson	D.Peterson	D.Peterson	D.Peterson	D.Peterson	D.Peterson	D.Peterson	D.Peterson	D.Peterson	D.Peterson	D.Peterson
Navigator/ Observer	A. Bibaud	A. Bibaud	A. Bibaud	A. Bibaud	A. Bibaud	A. Bibaud	A. Bibaud	A. Bibaud	T. Hauge	T. Hauge	T. Hauge	T. Hauge
Observer	R.Frokjer	R.Frokjer	T.Hauge	T.Hauge	R.Frokjer	R.Frokjer	T.Hauge	T.Hauge	T.Fuller	J. Nibourg	J.Nibourg	J.Nibourg
Recorder	T.Hauge	T.Hauge	R.Frokjer	R.Frokjer	T.Hauge	T.Hauge	T.Fuller	T.Fuller		T.Fuller	T.Fuller	T.Fuller
Total Hours Flown	4.6	4.4	3.0	4.2	3.8	2.7	2.4	4.5	4.3	4.5	6.0	4.9
Time On Census Quadrats	2.1	2.4	1.4	1.8	1.9	1.1	1.2	2.2	1.6	1.8	2.2	2.2
Quadrats Flown	15	21	11	21	19	12	12	23	20	24	23	24
Percent Cloud Cover	Clear Ice Fog	Clear Afternoon Haze	Light High Overcast	Clear	High Overcast	Cloudy	Clear Afternoon Overcast	Clear	Partly Cloudy	Overcast	Overcast	Clear
Wind (Km/hr)	0-16	0-16	Calm	0-16	0-16	0-16	--	0-8	0-16	0-5	0-24	Calm
Temperature (°C)	-37	-39	-31	--	-24	-18	-32	-18	-2	-2	-12	0
Snow Coverage	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete	Complete
General Observation Conditions	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good	Good

3. RESULTS

The 225 sample quadrats were censused during the period of 7 - 22 January 1976 (Table 3), and produced a total of 122 moose counted on 56 of the sample quadrats (Table 1). Moose per quadrat ranged from 0-3 on the river strata, 0-6 on the aspen strata, and 0-6 on the muskeg strata. The weighted mean of the combined strata was 0.58 moose per quadrat (Table 4), resulting in a weighted survey area population estimate of 363 moose ± 30 percent ($P<0.05$).

Data were also collected on group sizes and the number of groups per quadrat. A total of 80 groups were observed on the 56 quadrats. Groups per quadrat ranged from 0-1, 0-5, 0-4 on the river, aspen and muskeg quadrats, respectively. Group size ranged from 1-4, and Chi-square analysis of the observed group excess distribution (group size - 1) indicated no significant difference from a poisson distribution (Chi-square = 2.806, $P= 0.243$).

The census required a total of 49.3 flying hours, of which 21.9 were actual census hours (Table 3). Mean census time per quadrat varied from 6.9 minutes on the river quadrats, to 5.8 minutes on the aspen and 4.8 minutes on the muskeg quadrats; this difference between strata was highly significant ($P<0.001$, Table 5).

Table 4. Moose population estimated from 1 square mile (2.6 km^2) quadrat census, AOSERP survey area, January 1976. See Cochran (1963) for detailed explanation of symbols and calculations.

	N_h	n_h	$\bar{y}_h$	s_h^2	$\bar{y}_{st}$	$s_{\bar{y}_{st}}$	Population estimate [a]
River	52	34	0.21	0.411			
Aspen	407	163	0.60	1.403			
Muskeg	171	28	0.64	2.386			
Total	630	225			0.58	0.086	363 ± 110^b
							or $363 \pm 30\%$

a $(N)(y_{st}) \pm (t)(N)(s_{\bar{y}_{st}})$ where t = Student t=($P<0.05$) with effective degrees of freedom calculated as in Cochran (1963:95).

b degrees of freedom = 53

DEFINITIONS

N_h = Square mile sample units per stratum (h)

$\bar{y}_h$ = Stratum mean

n_h = Samples per stratum (h)

s_h^2 = Stratum mean

$s_{\bar{y}_{st}}$ = Standard error of weighted mean

$\bar{y}_{st}$ = Weighted population mean per quadrat

Table 5. Analysis of individual quadrat search time by stratum for the Fort McMurray AOSERP aerial moose census, January 1976.

Stratum	Mean	Variance	ANOVA				
			Source	df	SS	MS	F
River	6.9[a] (34)[b]	5.86	strata	2	73.01	36.51	12.23***
Aspen	5.8 (163)	2.66	error	222	662.38	2.98	
Muskeg	4.8 (28)	1.40	total	224	735.40		

a Mean search time in minutes

b Sample size (n)

*** Significant at $P < 0.001$

4. DISCUSSION

Bergerud (1968) recommended that minimum standards of precision for aerial surveys be ± 20 percent with $P<0.05$; our sampling procedures and intensity were designed to meet this criteria. Very little prior information was available on moose density and distribution on square-mile quadrats in the AOSERP study area. Bibaud and Archer (1973) conducted an aerial helicopter census of 90 randomly selected quadrats in approximately 900 square miles (2330 km^2) of the oil sands area in January-February 1973. They estimated a mean of 0.8 moose per square mile, with a variance of 2.139 (my calculation based on their original data). This variance, however, was associated with a random sample of the total area, without any stratification. The 1976 stratified sample allocation, therefore, was based on a combination of personal experience with the area and results of a similar census in Manitoba (Hildebrand and Jacobson 1974).

The precision of the 1976 census was somewhat less than anticipated, primarily due to two factors. First, although the observed variances in the river and aspen strata were considerably less than expected, the variance in the muskeg stratum was 5 times that expected. The lower than expected variance in the river stratum was probably due to a relative lack of snow and severe weather to force moose into the Athabasca River bottoms. Conversely, these conditions resulted in larger than expected populations on the muskeg stratum. Secondly, the high variance in the muskeg stratum also appeared to be a function of the relatively high counts on quadrats of aspen within the area generalized as muskeg stratum.

This deviation from expected relative variances resulted in less than optimum allocation of sampling effort, with too many samples in the river stratum and not enough in the muskeg stratum. The net result was a stratification and sample allocation that increased the estimated variance (Cochran 1963) by 65 percent.

Reallocation of sampling effort between strata for future census work does not appear to be a complete solution to the higher than expected overall variance, since reallocation based on 1976 results would require a total of 252 quadrats or a sampling intensity of 40 percent (Table 6). A more satisfactory solution would be a precise restratification, using forest inventory maps and following the procedures outlined in Hildebrand and Jacobson (1974). This restratification, together with some modification in sampling effort, should result in reasonable estimates and sampling intensities.

Two major cautions should be noted relative to interpretation and comparison of these stratified random estimates. First, although the methodology provides statistically unbiased estimates of the mean and standard error, regardless of underlying statistical distributions, the 95 percent confidence limits are based on the assumption of a normal distribution of sample means. Because the distribution of the number of moose per quadrat is positively skewed these confidence limits should be considered only an approximation since the actual frequency with which the mean is greater than ($\bar{y}$ + $ts\bar{y}_{st}$) will be greater than 2.5 percent and the frequency with which the mean will be less than ($\bar{y}$ + $ts\bar{y}_{st}$) will be less than 2.5 percent. This departure from normality is a function of sample size and magnitude of skewness, and normality can only be assumed when $n>25G_1^2$ (Cochran 1963).

Under these conditions of distributional uncertainty, the coefficient of variation ($100s/\bar{y}$), rather than the confidence limits, may be more appropriate to compare relative precision of different censuses. Comparison of mean will require

Table 6. Revised optimum allocation of future sampling effort for an estimated population of 375 moose on the AOSERP survey area based on January 1976 census results.

	Total quadrats	Estimated variance	Estimated sample size at given precision level				
			30%	25%	20%	15%	10%
River	52	0.4	6	8	11	14	19
Aspen	407	1.4	90	117	156	209	277
Muskeg	171	2.4	50	65	86	115	153
Totals	630		146	190	252	339	449
Total sampling intensity (%)			23	30	40	54	71

a non-parametric test (e.g., square root) before using a parametric test such as the analysis of variance.

The second caution to interpretaton of the stratified random estimates is that these estimates are based on the assumption of accurate counts in each sampling unit. Any visibility bias present in the sampling procedure violates this assumption and results in an underestimate of the population total directly proportional to the amount of visibility bias present in the sample. Cochran (1963) suggests, as a working rule, the effects of bias on the accuracy of an estimate are negligible if the absolute value of the bias (standard deviation) is less than 0.1, and is only modest at 0.2. Applying this to 1976 results (Table 4) indicates toleration of a bias of less than 3 percent of the estimated mean.

LeResche and Rausch (1974), Cook and Martin (1974) and Caughley (1974) all recognized that aerial census results underestimate the population total as a result of visibility bias introduced by a large number of variables, many of which are interrelated.

Cook and Martin (1974) developed a visibility bias model for quadrat sampling utilizing the information contained in the distributions of the numbers of groups per quadrat and larger groups will have, on the average, a higher probability of being observed than will smaller groups. The model utilizes the observed groups per quadrat and the observed group size distributions to generate maximum likelihood estimates of the adjusted groups per quadrat and adjusted group size, based on the assumption that both parameters follow an underlying Poisson distribution. Although originally designed for simple random samples, the computer program for the model has been modified by Jacobson and Cook to handle stratified random samples following a Poisson distribution, and the structure of the model has been modified to accomodate data following the negative binomial distribution (Jacobson and Cook, in prep.).

The moose group size distribution on the AOSERP survey area showed a good fit to a Poisson distribution (Table 7). Unfortunately, the variance/mean ratio of 0.819 for the group excess distribution would not allow an estimate of the amount of visibility bias present in the data by either the Poisson or negative binomial models since, in general, this ratio is less than 1 for the binomial, equal to 1 for the Poisson, and greater than 1 for the negative binomial distribution (Johnson and Kotz 1969).

This problem has occurred in several other sets of moose census data I have reviewed from both Alberta and Manitoba. It appears to be a function of small group size (hence a small number of cells in the distribution) which in turn appears to be a function of relatively low densities. The basic assumption of a Poisson distribution appears conceptually sound for moose, since most of the group size distributions observed to date do not depart significantly from this distribution. The visibility bias model, however, may only be functional on data from populations with means large enough to generate sufficient numbers of the larger group sizes, or on data collected during a period of the moose annual cycle when they have greater tendencies toward aggregation.

Inability to adjust census estimates for visibility bias severely limits the usefulness of aerial census techniques. Without adjustment, census estimates are subject to continuing underestimation of an unknown amount. This bias is the result of variables associated with the animals being counted (density, dispersion, diurnal and seasonal behavior and movement patterns, differential reactions to aircraft); observers (experience, fatigue, individual variations in efficiency); physiography (terrain, vegetation, snow cover); weather (cloud cover, turbulence, temperature,

Table 7. Goodness of fit analysis of the January 1976 AOSERP moose group excess distribution (group size minus 1) to the Poisson distribution.

Group excess	Observed frequency	Expected poisson frequency
0	44	47.32
1	31	24.85
2	4	6.52
3	1	1.31

SUMMARY STATISTICS

total cells	= 4
total groups	= 80
mean group excess	= 0.525
variance	= 0.430
index of dispersion (S^2/mean)	= 0.819
Chi-square	= 2.806
degrees of freedom	= 2
tail classes combines	= 0
probability exceeding Chi-square	= 0.243

wind speed); and equipment and methodology (aircraft type, pilot, altitude, speed, search technique and intensity, time of day). In addition, without visbility bias adjustment, subsequent estimates of the same population are subject to fluctuations of these variables that, unless controlled or adjusted for, negate any valid year-to-year comparisons.

The results of the aspen stratum can be used to indicate the influence of just one of these variables, time of day, on overall census results. The mean value for 77 aspen quadrats flown in the morning was 0.45 compared to a mean of 0.69 for the 86 quadrats flown in the afternoon. Regression of the time of day (expressed as the mid-point of the census time on quadrat) produced a significant linear regression model of $Y=-0.4457 + 0.083\ X$ ($F=4.37$, $df=1,161$, $P<0.05$) (Figure 4). Using this relationship, a population estimate based solely on afternoon counts would be approximately 53 percent higher than one based solely on morning counts.

This example illustrates the influence a single variable from the large number listed above can have on final census results. Interpretation of the influence of time of day is even more complex because if it is a function of visibility bias the model, where applicable, will account for the variable in the adjusted estimate. If, however, the relationship is a behavioral characteristic of the moose population with no changes in visibility from morning to afternoon, the visibility bias model cannot account for it in the adjusted estimate.

As an illustration of the range of fluctuations possible, the negative binomial model adjusted a dozen sets of deer census data in Manitoba from 10-50 percent (Jacobson and Cook, in prep.). Adding a complexity of interpretation on top of numerical uncertainty graphically illustrates the

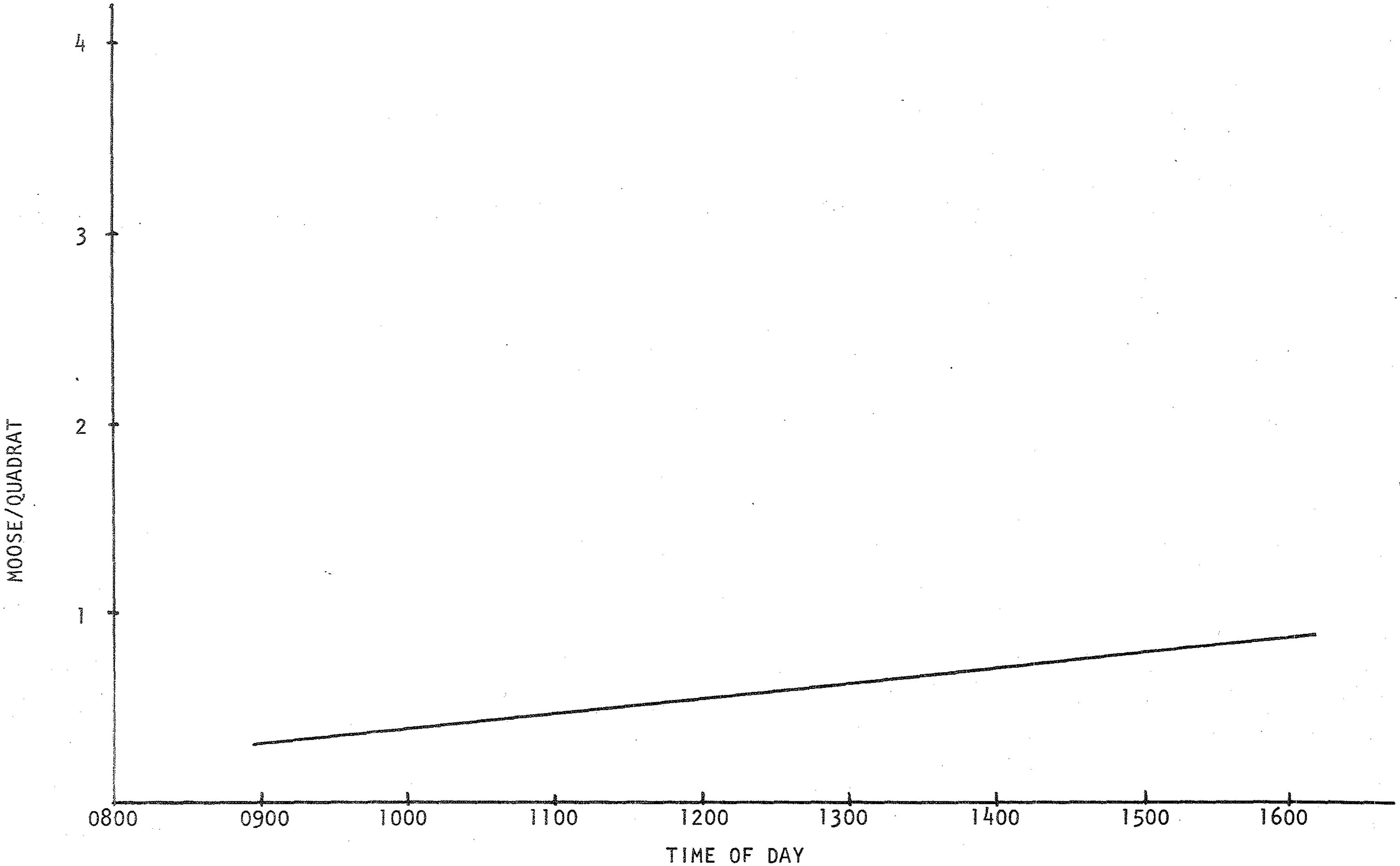

Figure 4. Regression of total moose/quadrat on time of day, where y = 0.4457 + 0.083X.

importance of being able to control census variables and adjust for visibility bias. In fact, the ability to adjust for visibility bias increases the importance of controlling census variables to facilitate interpretation of visbility model results.

5. RECOMMENDATIONS

1. The only feasible aircraft-technique alternative for a moose census on the AOSERP study area with today's technology is a helicopter flying square-mile quadrats. A direct comparison of a fixed-wing census of 1/8 mile (0.2km) wide strip plots with a fixed-wing quadrat census for white-tailed deer in Manitoba indicated an efficiency differential as high as 30 percent (Jacobson and Cook, in prep.). This differential could be expected to increase using a helicopter, and may be the critical deciding factor in obtaining a reasonably accurate estimate in areas of low densities where use of the visibility bias model is uncertain.
2. Restratification of this survey area, or stratification of future study areas, should follow procedures outlined by Hildebrand and Jacobson (1974) to eliminate the problem of islands of one type (aspen) within another type (muskeg) biasing overall variance estimates.
3. An attempt should be made to schedule the census when the area moose have at least partially moved to the river bottom, to increase the potential of larger group sizes for the visibility bias model.
4. As many of the visibility bias variables as possible should be identified, and a rigid quality control procedure instituted to measure and hold the variables within predetermined bounds of acceptability of all censuses.

6. LITERATURE CITED

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7.0 APPENDICES

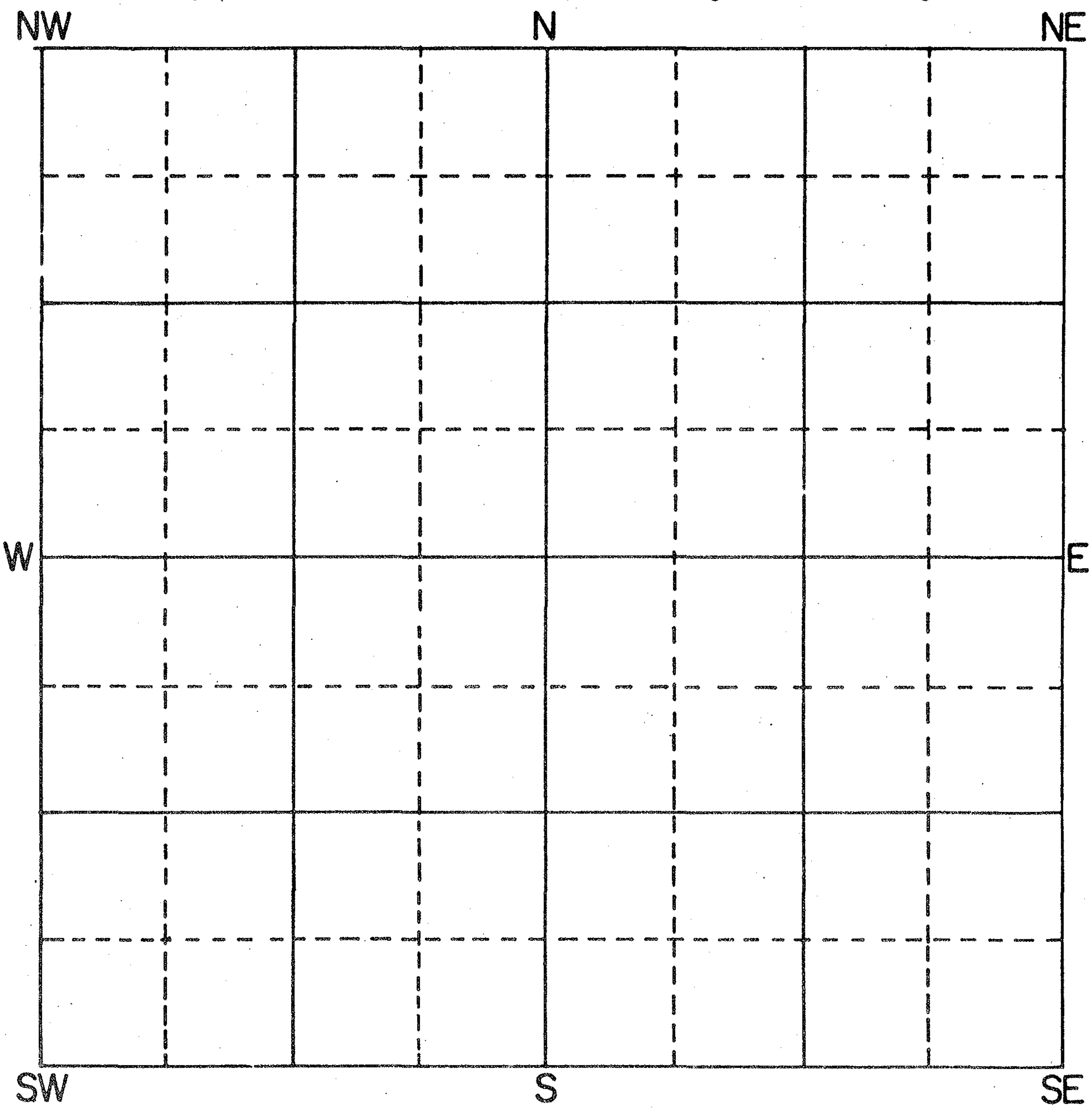
7.1 FIELD DATA SHEET

Appendix 7.1

Field Data Sheet

Aerial quadrat census

Note: always fly quadrats clockwise. Indicate starting corner and flight direction with a large arrow.



Study area

....

Quadrat no.

....

Date

....

Time in

....

Time out

....

Total census time

....

Total MOOSE

....

Scale

1 mi. = 6 in.
1 km. = 3.75 in.

7.2 RESULTS OF THE AERIAL QUADRAT CENSUS FOR MOOSE IN THE AOSERP SURVEY AREA, JANUARY 1976.

Appendix 7.2 Results of the aerial quadrat census for moose in the AOSERP survey area, January 1976.

Quadrat Number		Group size distribution	Total Groups	Total Moose
R	47	2	1	2
R	51		0	0
R	50		0	0
R	48		0	0
R	45		0	0
R	43		0	0
R	3		0	0
R	4		0	0
R	9		0	0
R	8		0	0
R	5		0	0
R	2		0	0
R	6		0	0
R	7		0	0
R	1		0	0
R	24	1	1	1
R	19	3	1	3
R	39		0	0
R	38		0	0
R	37		0	0
R	35		0	0
R	32		0	0
R	31		0	0
R	30		0	0
R	29		0	0

Appendix 7.2 continued

Quadrat Number	Group size distribution	Total Groups	Total Moose
R 28		0	0
R 20		0	0
R 17		0	0
R 21		0	0
R 22	1	1	1
R 14		0	0
R 15		0	0
R 11		0	0
R 13		0	0
A 273	2	1	2
A 275		0	0
A 301		0	0
A 300		0	0
A 277		0	0
A 254	1	1	1
A 228		0	0
A 227		0	0
A 231		0	0
A 172		0	0
A 178		0	0
A 107		0	0
A 114	1	1	1
A 9		0	0
A 66		0	0

Appendix 7.2 continued

Quadrat Number	Group size distribution	Total Groups	Total Moose
A 109		0	0
A 110		0	0
A 282		0	0
A 296		0	0
A 343		0	0
A 374		0	0
A 391		0	0
A 389		0	0
A 328	2	1	2
A 341		0	0
A 387		0	0
A 185		0	0
A 186		0	0
A 148	2	1	2
A 112	1	1	1
A 111		0	0
A 122		0	0
A 98		0	0
A 75	2	1	2
A 99	1	1	1
A 100	1	1	1
A 17		0	0
A 19	1	1	1
A 36		0	0
A 81		0	0

Appendix 7.2 continued

Quadrat Number	Group size distribution	Total Groups	Total Moose
A 82		0	0
A 34		0	0
A 116		0	0
A 175		0	0
A 176		0	0
A 207		0	0
A 208	1, 2	2	3
A 209		0	0
A 223		0	0
A 258	1, 1, 1	3	3
A 393		0	0
A 324		0	0
A 323		0	0
A 281		0	0
A 261	1	1	1
A 220	1	1	1
A 2	2, 2	2	4
A 216	1, 1	2	2
A 56	1	1	1
A 214		0	0
A 265		0	0
A 218		0	0
A 213		0	0
A 212		0	0
A 219		0	0
A 260		0	0

Quadrat Number	Group size distribution	Total Groups	Total Moose
A 222		0	0
A 54		0	0
A 4		0	0
A 55		0	0
A 57		0	0
A 58	2	1	2
A 202		0	0
A 201		0	0
A 200		0	0
A 183		0	0
A 182		0	0
A 232		0	0
A 233		0	0
A 248		0	0
A 198		0	0
A 6		0	0
A 104	2	1	2
A 105	1	1	1
A 102		0	0
A 71	2	1	2
A 68		0	0
A 70		0	0
A 45		0	0
A 44		0	0
A 15		0	0
A 14		0	0

Quadrat Number	Group size distribution	Total Groups	Total Moose
A 151	1	1	1
A 95	1, 1, 2	3	4
A 79	1	1	1
A 38	2	1	2
A 141		0	0
A 142		0	0
A 143		0	0
A 11		0	0
A 10		0	0
A 29		0	0
A 77		0	0
A 93		0	0
A 22		0	0
A 353	3	1	3
A 360	2	1	2
A 405	1	1	1
A 312	1, 2, 2, 1	4	6
A 357	1	1	1
A 316		0	0
A 305		0	0
A 314		0	0
A 355		0	0
A 361		0	0
A 141		0	0
A 363	2	1	2
A 319	1	1	1
A 394	1	1	1

Appendix 7.2 continued

Quadrat Number	Group size distribution	Total Groups	Total Moose
A 297	1	1	1
A 279	2, 2	2	4
A 398		0	0
A 348		0	0
A 317		0	0
A 318		0	0
A 368		0	0
A 396		0	0
A 8	4	1	4
A 64		0	0
A 51		0	0
A 53		0	0
A 5		0	0
A 384		0	0
A 382		0	0
A 333	2, 2	2	4
A 290	1, 2	2	3
A 291		0	0
A 330		0	0
A 284	1	1	1
A 244		0	0
A 237		0	0
A 238		0	0
A 193		0	0
A 240		0	0
A 241	1	1	1

Quadrat Number	Group size distribution	Total Groups	Total Moose
A 288	1, 3	2	4
A 191		0	0
A 190		0	0
A 188		0	0
A 187		0	0
A 196	1	1	1
A 164	1, 2	2	3
A 132		0	0
A 127		0	0
A 90		0	0
A 126		0	0
A 137	1, 1, 1, 1, 2	5	6
A 89		0	0
A 84		0	0
A 85	2	1	2
A 86		0	0
A 32		0	0
A 29	2	1	2
M 30	2, 1, 2	3	5
M 59		0	0
M 73		0	0
M 72		0	0
M 95		0	0
M 61		0	0
M 31		0	0

Appendix 7.2 concluded

Quadrat Number	Group size distribution	Total Groups	Total Moose
M 29		0	0
M 122		0	0
M 65	1	1	1
M 53	3	1	3
M 82		0	0
M 47		0	0
M 48		0	0
M 49		0	0
M 79		0	0
M 5	2	1	2
M 13	1	1	1
M 54		0	0
M 76		0	0
M 124		0	0
M 153		0	0
M 147	2, 2, 1, 1	4	6
M 151		0	0
M 149		0	0
M 170		0	0
M 169		0	0
M 106		0	0

8. AOSERP RESEARCH REPORTS

1.		AOSERP First Annual Report, 1975
2.	AF 4.1.1	Walleye and Goldeye Fisheries Investigations in the Peace-Athabasca Delta
3.	HE 1.1.1	Structure of a Traditional Baseline Data System
4.	VE 2.2	A Preliminary Vegetation Survey of the Alberta Oil Sands Environmental Research Program Area
5.	HY 3.1	The Evaluation of Wastewaters from an Oil Sand Extraction Plant
6.		Housing for the North--The Stackwall System
7.	AF 3.1.1	A Synopsis of the Physical and Biological Limnology and Fisheries Programs within the Alberta Oil Sands Area
8.	AF 1.2.1	The Impact of Saline Waters Upon Freshwater Biota (A Literature Review and Bibliography)
9.	ME 3.3	Preliminary Investigation into the Magnitude of Fog Occurrence and Associated Problems in the Oil Sands Area
10.	HE 2.1	Development of a Research Design Related to Archaeological Studies in the Athabasca Oil Sands Area
11.	AF 2.2.1	Life Cycles of Some Common Aquatic Insects of the Athabasca River, Alberta
12.	ME 1.7	Very High Resolution Meteorological Satellite Study of Oil Sands Weather, a Feasibility Study
13.	ME 2.3.1	Plume Dispersion Measurements from an Oil Sands Extraction Plant
14.	HE 2.4	Athabasca Oil Sands Historical Research Design (3 volumes)
15.	ME 3.4	Climatology of Low Level Air Trajectories in the Alberta Oil Sands Area
16.	ME 1.6	The Feasibility of a Weather Radar near Fort McMurray, Alberta
17.	AF 2.1.1	A Survey of Baseline Levels of Contaminants in Aquatic Biota of the AOSERP Study Area
18.	HY 1.1	Alberta Oil Sands Region Stream Gauging Data
19.	ME 4.1	Calculations of Annual Average Area Sulphur Dioxide Concentrations at Ground Level in the AOSERP Study Area
20.	HY 3.1.1	Evaluation of Organic Constituents
21.		AOSERP Second Annual Report, 1976-77
22.	HE 2.3	Maximization of Technical Training and Involvement of Area Manpower
23.	AF 1.1.2	Acute Lethality of Mine Depressurization Water on Trout, Perch and Rainbow Trout
24.	ME 4.2.1	Review of Dispersion Models and Possible Applications in the Alberta Oil Sands Area
25.	ME 3.5.1	Review of Pollutant Transformation Processes Relevant to the Alberta Oil Sands Area

26. AF 4.5.1 Interim Report on an Intensive Study of the Fish Fauna of the Muskeg River Watershed of Northeastern Alberta

27. ME 1.5.1 Meteorology and Air Quality Winter Field Study, March 1976

These reports are not available upon request. For further information about availability and location of depositories, please contact:

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