EVALUATING ONTARIO MOOSE HARVESTS USING A POSTCARD QUESTIONNAIRE

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Abstract: Introduction of a province-wide regulated moose harvest strategy in 1983 prompted field managers to develop a speedy and reliable method of harvest assessment. A self-addressed District postcard questionnaire was introduced to estimate licence utilization, adult bull and cow harvest, and hunter success. Correction factors were used to reduce the potential problem of hunter non-response bias, however, some inconsistency was noted. Average response rates in the North Central Region varied from 84.2% in 1984 and 1986 with prepaid return postage and a follow-up mailing to non-respondents, to 64.0% in 1985 when both features were deleted from the survey. Harvest estimates generated from the District Mail Survey varied considerably from those of the centrally conducted Provincial Mail Survey. The former is generally felt to provide more accurate results because of its timing and higher sampling rate. Average unit costs of $2.31 per returned questionnaire is considered justified.

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The effectiveness of a harvest system can only be fully assessed if the size and distribution of hunter kill is determined with reasonable accuracy (Timmermann, In Press). Most wildlife management agencies in North America sample hunters by mail questionnaires to measure annual harvests. Ontario has, since 1969, employed a centrally conducted provincial mail survey (PMS) to assess annual moose harvests (Barbowski

1972). Questionnaires are mailed to a 10-15% random sample of licenced hunters one to two months after termination of the hunting season. Compliance levels have varied from 70-85% using two or three follow-up reminders (Barbowski 1987, pers. comm.). Results are believed to provide reasonably accurate information on a regional and provincial basis. At the wildlife management unit (WMU) level, however, a low sample is frequently obtained. This yields less precise and, in many cases, inaccurate estimates (OMNR 1980).

Ontario, in 1983, introduced a province-wide sex and age selective harvest strategy for moose (Euler 1983, Timmermann and Gollat 1986). Under this system adult harvest targets are established for each WMU and a limited number of adult bull and cow validation tags (AVT) are offered to hunters to achieve these targets. Impact assessment requires accurate and timely information on moose population levels and hunter kill. In addition, detailed estimates of hunter success are needed to annually adjust AVT quotas to achieve kill targets.

Recognizing the limitations of the PMS, a high sample intensity, district conducted postcard survey of hunters (DMS) was initiated as a pilot study in 1983 and expanded province-wide in 1984. As a result, Ontario currently conducts two uniquely different mailed moose hunter surveys, each having distinct objectives and procedures. The centralized PMS generates detailed harvest and socio-economic data primarily at the regional and provincial level , while the field conducted DMS provides a fast and simple assessment of WMU harvests and success rates required to adjust AVT quotas.

This paper describes the evolution of the DMS in the North Central Region (NCR). We examine the utility of a follow-up mailing to

non-respondents, provision of prepaid return postage and the use of a non-response bias correction factor. Average costs are evaluated and compared to the PMS.

METHODS

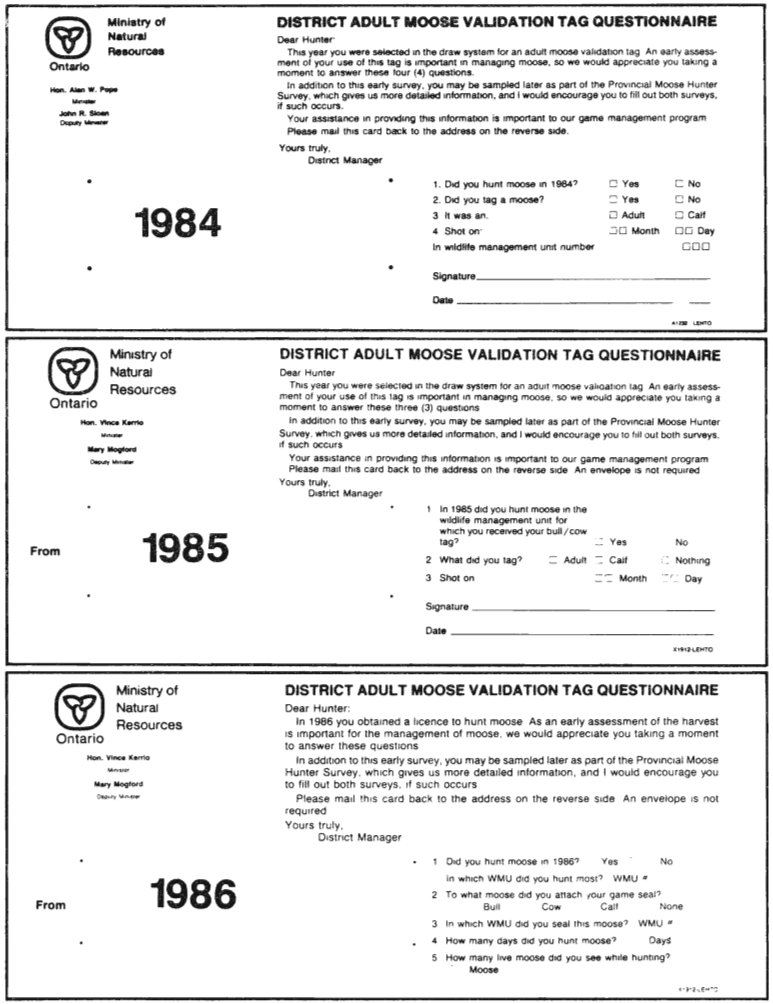
DMS questionnaire wording in 1984 and 1985 (Fig. 1) was designed to provide the following for each WMU:

1) an estimate of the adult bull and cow harvest;
2) an estimate of the calf harvest by AVT holders;
3) an estimate of bull and cow tag holder success;
4) harvest temporal distribution.

In 1986, date of kill was deleted and replaced with two questions designed to estimate hunter effort and establish a trend-through-time index of relative moose density (Fig. 1).

During the initial two years, sampling efforts were directed specifically at hunters who had received an AVT through the Resident Draw (Timmermann and Gollat 1986). In 1986, sampling was expanded to also include a 100% sample of both resident and non-resident hunters receiving AVT's through the Tourist Industry (Bisset and Timmermann 1983). This replaced the previously used 'mandatory' report.

Minimum acceptable sample rates for the Resident Draw were determined from a table provided by Wildlife Records and Surveys Section, Toronto, tempered by manpower and funding considerations. Sampling levels used in the 1986 survey (Table 1) ranged from 25 to 100 percent, representing anywhere from a low of 45 cow hunters sampled in WMU 18B to a high of 800 cow hunters contacted in WMU 15B. Similar sample rates were applied in 1984 and 1985.



Ministry of Natural Resources
Ontario
Hon. Alan W. Pope, Minister
John R. Sloan, Deputy Minister

DISTRICT ADULT MOOSE VALIDATION TAG QUESTIONNAIRE

Dear Hunter:

This year you were selected in the draw system for an adult moose validation tag. An early assessment of your use of this tag is important in managing moose, so we would appreciate you taking a moment to answer these four (4) questions.

In addition to this early survey, you may be sampled later as part of the Provincial Moose Hunter Survey, which gives us more detailed information, and I would encourage you to fill out both surveys, if such occurs.

Your assistance in providing this information is important to our game management program. Please mail this card back to the address on the reverse side.

Yours truly,
District Manager

1984

1. Did you hunt moose in 1984? ☐ Yes ☐ No
2. Did you tag a moose? ☐ Yes ☐ No
3. It was an: ☐ Adult ☐ Calf
4. Shot on: ☐☐ Month ☐☐ Day

In wildlife management unit number ☐☐☐

Signature _____

Date _____

X1238 LEHTO

Ministry of Natural Resources
Ontario
Hon. Vince Kerrio, Minister
Mary Mogford, Deputy Minister

DISTRICT ADULT MOOSE VALIDATION TAG QUESTIONNAIRE

Dear Hunter:

This year you were selected in the draw system for an adult moose validation tag. An early assessment of your use of this tag is important in managing moose, so we would appreciate you taking a moment to answer these three (3) questions.

In addition to this early survey, you may be sampled later as part of the Provincial Moose Hunter Survey, which gives us more detailed information, and I would encourage you to fill out both surveys, if such occurs.

Your assistance in providing this information is important to our game management program. Please mail this card back to the address on the reverse side. An envelope is not required.

Yours truly,
District Manager

From **1985**

1. In 1985 did you hunt moose in the wildlife management unit for which you received your bull/cow tag? ☐ Yes ☐ No
2. What did you tag? ☐ Adult ☐ Calf ☐ Nothing
3. Shot on ☐☐ Month ☐☐ Day

Signature _____

Date _____

X1912-LEHTO

Ministry of Natural Resources
Ontario
Hon. Vince Kerrio, Minister
Mary Mogford, Deputy Minister

DISTRICT ADULT MOOSE VALIDATION TAG QUESTIONNAIRE

Dear Hunter:

In 1986 you obtained a licence to hunt moose. As an early assessment of the harvest is important for the management of moose, we would appreciate you taking a moment to answer these questions.

In addition to this early survey, you may be sampled later as part of the Provincial Moose Hunter Survey, which gives us more detailed information, and I would encourage you to fill out both surveys, if such occurs.

Please mail this card back to the address on the reverse side. An envelope is not required.

Yours truly,
District Manager

From **1986**

1. Did you hunt moose in 1986? Yes No
   In which WMU did you hunt most? WMU #
2. To what moose did you attach your game seal?
   Bull Cow Calf None
3. In which WMU did you seal this moose? WMU #
4. How many days did you hunt moose? Days
5. How many live moose did you see while hunting?
   Moose

Figure 1. Samples of District Mail Survey questionnaires mailed to Ontario moose hunters 1984-86.

Table 1. A summary of hunters sampled in the 1986 Ontario Ministry of Natural Resources NC Region District Mail Survey.

	No. Adult Validation Tags Issued		First Mailing Sample Size (#/%[1.])	
WMU	Bull	Cow	Bull	Cow
11A	100	70	100/100	70/100
11B	145	65	145/100	65/100
12A	285	110	285/100	110/100
12B	675	160	675/100	160/100
13	1,415	780	710/ 50	780/100
14	170	70	170/100	70/100
15B	1,598	800	640/ 40	800/100
16C	157	105	157/100	105/100
17	135	92	135/100	92/100
18A	253	45	253/100	45/100
18B	91	59	91/100	59/100
19	515	160	515/100	160/100
21A	1,585	440	396/ 25	220/ 50
21B	1,756	540	439/ 25	270/ 50
Total	**8,880**	**3,496**	**4,711**	**3,006**

1. % of total adult validation tags issued

Survey questionnaires were printed centrally and supplied to each of five NCR districts responsible for managing a total of 14 wildlife management units (WMU's). A business reply stamp was used in 1984 to provide return postage for Canadian resident hunters. In addition, a second reminder questionnaire was sent to hunters who failed to respond to the initial mailing. In 1985, return postage and follow-up reminders were deleted in an effort to minimize costs and accelerate data analysis. Both were reinstated in 1986 due to a substantial reduction in the 1985 response.

To ensure consistency, a standard set of instructions and analyses forms were distributed to each district along with survey questionnaires and a duplicate set of computer generated address labels. District staff were responsible for mailing out questionnaires following termination of various season closing dates. A second mailing to non-respondents was made approximately one month later. Completed questionnaires were date-stamped upon receipt and data entered on daily summary tabulation forms.

A method of correcting non-response bias (Filion 1980) was applied in 1984 and 1986 using regression analysis where hunter return rates fell below 90% and a statistically significant response pattern was detected. Cumulative percent success was plotted against cumulative percent return and a curve fit was projected to 100% return. This allowed calculation of a hunter bias correction factor obtained by dividing the success rate at a projected 100% return by the observed success rate at survey cut-off (Fig. 2).

Trends in questionnaire response rates were examined for the three years - 1984 through 1986. Response rate data for the 1984 and 1986

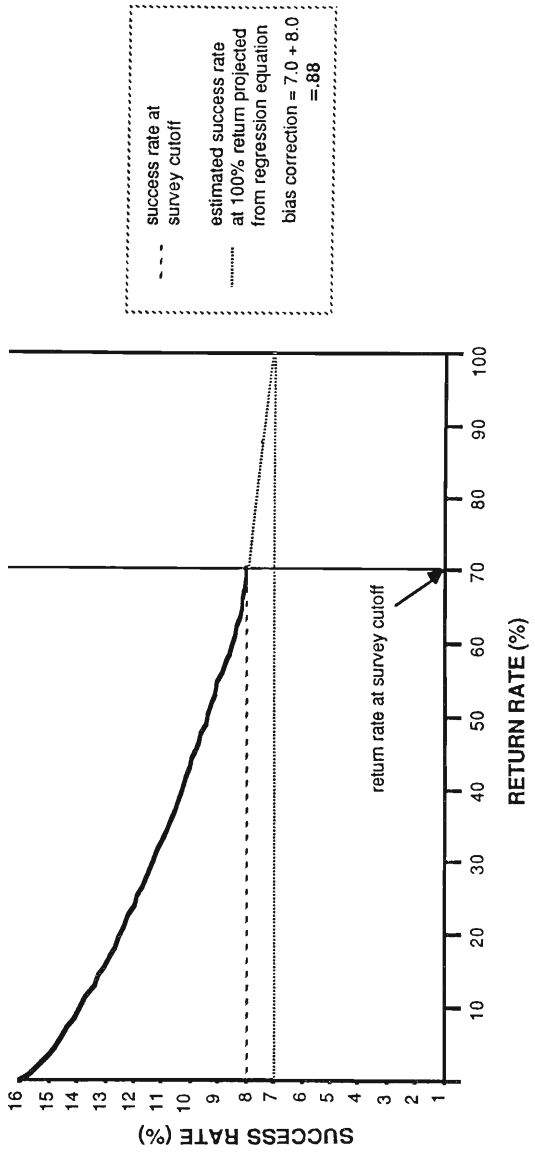


Figure 2. Calculation of hunter non-response bias correction factors utilized in the 1984 and 1986 Ontario Ministry of Natural Resources NC Region District Mail Survey.

survey years were lumped after being tested using a Student t-test (Snedecor and Cochrane 1967) and no significant difference (P>.05) detected. Pooled 1984/86 data were further compared with 1985 survey response rates which employed neither prepaid return postage or follow-up reminder (Student t-test @ 95% confidence level).

Nineteen eighty-six Resident Draw response rates after one mailing with prepaid return postage were compared with 1985 results adjusted to a single mailing duration equivalent to the 1986 survey. This allowed a more accurate assessment of the impact of prepaid return postage. Similar comparisons with the 1984 data were not possible because of our inability to separate first and second mailings.

Trends in hunter non-response bias correction factors 1984 and 1986 were examined for consistency among WMU's, between survey years and sex of animal hunted.

Comparisons were made between 1986 bias-corrected harvest estimates after one and two mailings respectively. This allowed us to determine the effectiveness of using a non-response bias correction factor as a compensatory adjustment for low response rates.

Harvest projection and corresponding sample database comparisons are made between 1986 PMS and DMS.

Finally, survey expenditures are examined and evaluated as to cost effectiveness of single and multiple questionnaire mailings.

RESULTS AND DISCUSSION

Response Rate

Resident Draw hunter DMS response rates averaged 84.2% for the combined 1984 and 1986 surveys (Table 2). These were significantly higher ($P<.001$) than the 64.0% mean obtained during the 1985 survey. This difference is largely attributed to a second reminder notice and prepaid return postage employed in 1984 and 1986. The question remains whether differences in average survey duration (mailing date to cut-off date) may also have influenced results ($\bar{X}_{1984}$= 53 days, $\bar{X}_{1985}$= 43 days, $\bar{X}_{1986}$= 62 days). To resolve this question, response rates for four WMU's in which data continued to be collected after the "official" survey termination date were examined. Day 58 was chosen to correspond with the longer survey duration $\bar{X}$ 1984/86 (Table 2). As expected, a marginal increase in response rate was achieved. Returns, however, continued to remain well below mean 1984/86 levels.

Examination of DMS 1986 first mailing response rates and 1985 single mailing results corrected to the average 1986 initial mailing duration showed 1986 response rates to be significantly higher ($P<0.01$) than those achieved in 1985 (Table 3). Adjustment to a common base removes the influence of the follow-up reminder and differential survey duration, suggesting a strong correlation between response rates and the provision of prepaid return postage.

Hunter Non-Response Bias

Filion (1980) discusses the difficulty in obtaining replies from every hunter contacted in a large sample. This leads to the potential

Table 2. Response rate variation between 1985 and combined 1984/86 Resident Draw gun hunters sampled in the Ontario Ministry of Natural Resources NC Region District Mail Survey.

	1985			$\bar{X}$ 1984/86	
WMU	% Response[1] Cutoff	% Response[2] Extended	N[3]	% Response[3] Cutoff	N[3]
11A	67.2		160	81.8	162
11B	58.0		269	84.8	234
12A	62.8		505	82.8	407
12B	64.0		940	79.9	743
13	60.3		1,400	86.6	1,257
14	72.0		216	89.8	252
15B	60.5		1,000	71.1	1,062
16C	64.8		274	84.2	241
17	64.8	72.1	214	86.1	243
18A	68.0	74.0	358	87.2	328
18B	62.5	68.1	72	83.4	112
19	64.8	70.9	868	86.8	636
21A	62.5		616	88.7	557
21B	64.0		564	86.6	602
Total			**7,456**		**6,836**
$\bar{X}_{14}$	**64.0**[4]			**84.2**[4]	

1. response rate at official survey termination ($\bar{X}$ 43 day survey duration 1985, $\bar{X}$ 58 day survey duration 1984/86)
2. response rate including questionnaires received subsequent to official survey termination up to day 58
3. N = first mailing sample size
4. average of 14 WMU's 1984/86 > 1985 ($P<0.001$)

Table 3. Comparative single mailing response rates for ten wildlife management units sampled in the 1985 and 1986 Ontario Ministry of Natural Resources NC Region District Mail Survey.

	1985[1].		1986[2].	
WMU	% Response[3].	N[4].	% Response	N[4].
11A	64.4	160	63.5	170
11B	46.1	269	65.2	210
12A	57.8	505	71.1	395
12B	59.6	940	70.8	835
13	52.6	1,400	63.4	1,490
15B	49.3	1,000	53.2	1,440
17	56.7	215	64.3	227
18A	58.7	358	60.4	298
18B	55.6	72	61.3	150
19	57.3	868	64.3	675
$\bar{X}_{10}$	**55.8**		**63.7**	

1. prepaid return postage not provided

2. prepaid return postage provided

3. corrected to 1986 first mailing survey duration ($\bar{X}$ = 34 days)

4. N = first mailing sample size

situation in which respondents, who are self-selected, differ from non-respondents, thus yielding misleading results. Several researchers have reported general overestimates from hunter surveys as a result of non-response bias (Filion 1980). In Ontario we assume that successful hunters are more likely to respond earlier than those who are unsuccessful (Barbowski 1972). Calculated hunter non-response biases should then normally fall in the range .90-.99 if such a bias were present. Unbiased returns should yield a correction value of 1.0. Values greater than 1.0 suggest non-respondents are more successful on average than those submitting returns.

Bias correction estimates generated from the 1984 and 1986 surveys were examined (Table 4). No hunter response bias was detected in 12 of 24 bull and 14 of 28 cow hunter returns. Seven of 50 (14%) were projected at >1.0 suggesting in these cases that non-respondents were more successful than those submitting returns. Hunters with bull permits tended more than cow permit holders to contravene the assumption that successful hunters are more likely to respond earlier. Five of 26 (19.2%) bull permit holder non-response biases were calculated at >1.0 compared to only two (7.7%) for cow permit holders during the course of both surveys.

Some measure of subjectivity is involved in the determination of hunter non-response bias correction factors. Normally a pattern does not emerge until a response rate of about 30% is achieved. Choice of initial data point used in the regression may significantly influence this projection, especially where no clear pattern is apparent and where sample sizes are low.

Table 4. Non-response bias correction values for Resident Draw gun hunters derived from district mail surveys in the Ontario Ministry of Natural Resources NC Region, 1984 and 1986.

	Bull Hunters		Cow Hunters	
WMU	1984	1986	1984	1986
11A	1.03*	0.92	1.00	1.00
11B	1.00	0.96	0.95	1.00
12A	0.94	0.96	0.84	1.06*
12B	0.91	1.00	1.00	0.91
13	0.95	0.97	1.00	1.00
14	0.94	0.96	1.00	1.00
15B	1.00	1.00	1.20*	1.00
16C	0.92	1.00	1.00	0.88
17	0.96	1.08*	1.00	1.00
18A	1.15*	0.91	1.00	1.00
18B	1.00	1.19*	1.00	1.00
19	1.00	0.99	0.99	1.00
21A	N/A	1.12*	N/A	1.00
21B	N/A	1.00	N/A	0.93

* values >1.0 suggest non-respondents are on average more successful than those submitting returns

Strickland (1987) has shown that when applied on a regional basis, a pattern consistent with the basic concept of hunter non-response bias emerges. Managers must, however, generate credible quotas on a WMU basis. The utility of the non-response bias correction factor at the WMU level, however, appears suspect in view of the inconsistent pattern between successful and unsuccessful hunters.

Predictability At Low Return Rates

Comparison of 1986 projected Resident Draw harvests corrected for hunter non-response bias after one and two mailings respectively (Table 5), indicated 88 fewer bulls and 32 more cows would have been estimated overall in 14 WMU's had we relied entirely on a single mailing. This variation of ±5% at first appears relatively insignificant when compared to the Regional targeted kill. When examined on a WMU basis, however, 16 of 28 possibilities exhibit discrepancies that were $\geq$10% of the targeted harvest. Extreme variations ranged as high as a 42.3% underestimate and a 25.6% overestimate of WMU 19 and WMU 21A cow harvests respectively. Response rates after one mailing averaged 64.8% compared to 84.6% achieved with the follow-up reminder. We assume a more accurate estimate results from the latter, leading us to conclude that the hunter non-response bias correction factor cannot be relied upon at the WMU level to compensate for low response levels. These results, coupled with the unpredictable non-response bias patterns discussed previously, suggests a need to reconsider the utility of the hunter non-response bias correction factor. Three options exist: (i) the bias correction factor for non-respondents could continue to be applied in all WMU's; (ii) in selected WMU's depending on response patterns; or (iii) its

Table 5. Variation between initial and follow-up bias corrected 1986 District Mail Survey harvest estimates in the Ontario Ministry of Natural Resources NC Region.

	Variation 1st Mailing[1]. Estimate From Follow-up		Targeted Resident Draw Gun Harvest	
WMU	Bull Harvest	Cow Harvest	Bull	Cow
11A	-10*	- 1*	32	10
11B	+ 3	- 2*	31	12
12A	- 1	0	71	28
12B	- 1	+ 6*	147	49
13	+ 9	- 3	244	163
14	+ 8*	0	49	18
15B	-25	+ 5	323	130
16C	+ 1	+ 2*	53	18
17	0	0	70	23
18A	+ 4*	+ 1*	29	9
18B	+ 4*	- 1*	30	8
19	+ 8*	-11*	79	26
21A	-37*	+20*	235	78
21B	-51*	-14*	238	79
$\bar{x}_{14}$	**-88**	**+32**	**1,631**	**651**

1. bias corrected harvest estimate after two mailings minus single mailing estimate corrected for hunter non-response bias

* difference in the estimated kill generated by single and multiple mailings $\geq$10% of the targeted harvest

use eliminated altogether. We recommend the latter because of previous bias inconsistencies observed, the very substantial workload increase required to calculate WMU/sex specific bias correction values and the subjectivity surrounding the selection of the regression starting point. To help offset the potential effects of response bias, however, we stress the importance of striving for a high rate of return (i.e., $\geq$90%).

Provincial vs. District Survey

The PMS consistently underestimated 1986 harvests in 11 of 14 WMU's when compared to DMS generated values (Fig. 3). Comparable values were yielded in two WMU's (11B and 19) while only one PMS estimate (WMU 13) exceeded that derived from the DMS. Determination of confidence limit overlap between the two surveys was not possible as standard error values for the PMS were unavailable.

Regionally, a 16.2% higher harvest estimate was obtained from the DMS (2,138 vs. 2,550). Individual WMU discrepancies varied from -94.3% in WMU 16C to +22.2% in WMU 13. In 11 of 14 WMU's, the difference between the two estimates exceeded 10%. We attribute a low sample rate used in the PMS, for the majority of the variation. An average of 5.7x more samples were applied in the calculation of the DMS estimate than were used in the PMS (Fig. 4).

We assume that the DMS generally yields more accurate results in light of its higher sampling intensity. It is interesting to note, however, that one anomaly was detected. In WMU 11B, identical harvest estimates were generated based on a minimal PMS return sample of 16 compared to 183 for the DMS.

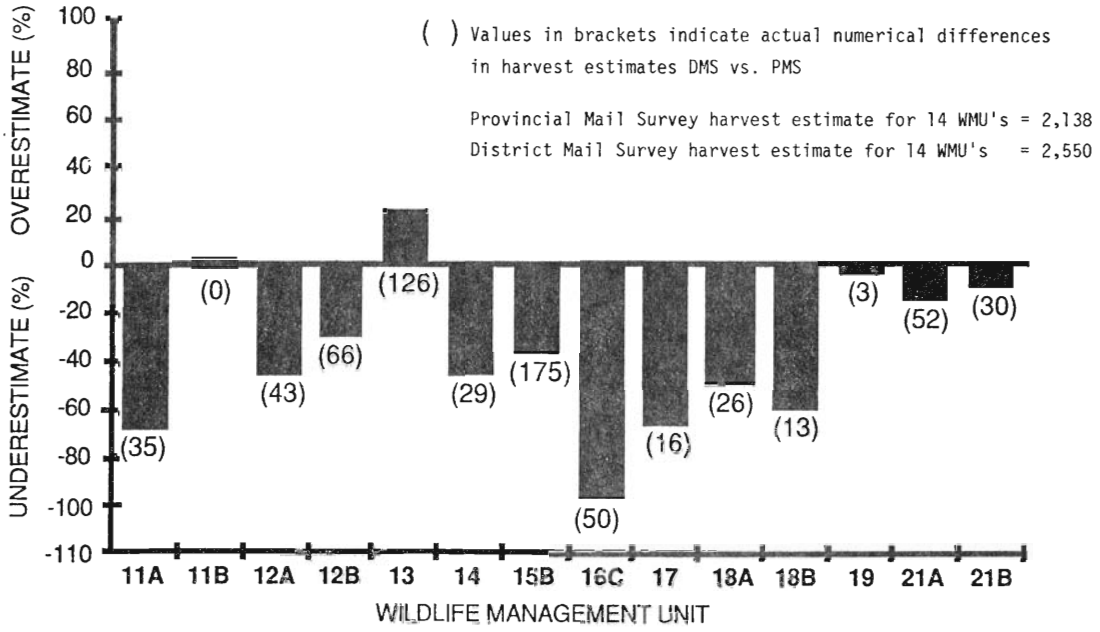


Figure 3. Variation in 1986 Provincial Mail Survey estimated moose harvests relative to estimates predicted by District Mail Surveys conducted in the Ontario Ministry of Natural Resources NC Region.

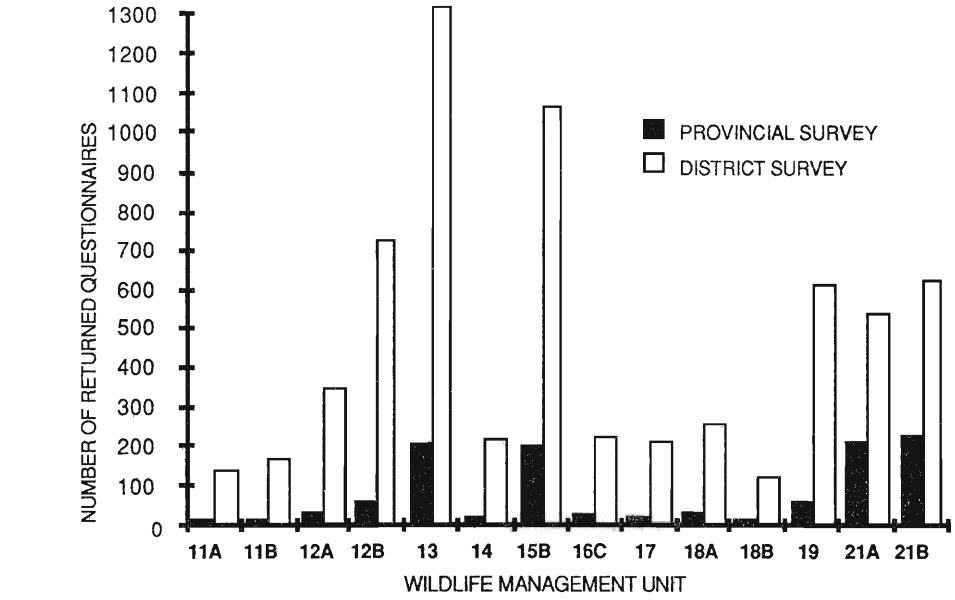


Figure 4. Number of returned questionnaires used to estimate 1986 hunter harvests from Provincial and District Mail Surveys conducted in the Ontario Ministry of Natural Resources NC Region.

Timmermann (1975) also suggests that hunters responding to mailed questionnaires are subject to memory bias which increases with later post-hunt mailings. Differences in PMS and DMS harvest estimates may, in fact, partially reflect this source of respondent bias.

Survey Costs

Total 1986 DMS costs for 6,400 returned questionnaires are estimated at $14,780.00 or an average of $2.31 per response (Table 6). A marginally lower estimate of $2.00-$2.25 is given by Barbowski (1987, pers. comm.) for the PMS.

Unit mailing costs of the completed (two mailouts) 1986 DMS relative to the initial mailout are illustrated by Fig. 5. Cost variability reflects differing WMU return rates. When based strictly on mailing costs, an average initial return rate of 68.8% was achieved at a mean unit cost of $0.88. A follow-up mailing increased overall postal costs to $0.99, however, a substantially higher return rate (84.3%) was realized. Addition of labour and printing costs increased overall first and second mailing cost estimates to $1.75-$2.00 and $2.50-$2.75 respectively. We believe these additional costs are well justified considering the importance of high sample and return rates.

CONCLUSIONS

A short, simple mail-back questionnaire was developed to estimate Ontario's moose harvests. In the North Central Region kill estimates derived from the DMS were completed within two months post-hunt, thus facilitating their use in preparing AVT quotas for the upcoming season.

Table 6. Estimated 1986 District Mail Survey costs in the Ontario Ministry of Natural Resources NC Region.

District	# Returned Questionnaires	Postage Cost ($)	Labour Cost ($)	Printing Cost ($)	Total Survey Cost ($)	Cost/Returned Questionnaire ($)
Atikokan	1,176	1,065.00	1,650.00	120.00	2,835.00	2.41
Geraldton	1,158	1,065.00	1,500.00	140.00	2,705.00	2.34
Nipigon	427	390.00	600.00	50.00	1,040.00	2.44
Terrace Bay	1,162	1,060.00	1,650.00	120.00	2,830.00	2.44
Thunder Bay	2,477	2,390.00	2,790.00	190.00	5,370.00	2.17
Total	**6,400**	**5,970.00**	**8,190.00**	**620.00**	**14,780.00**	
NCR Average						**2.31**

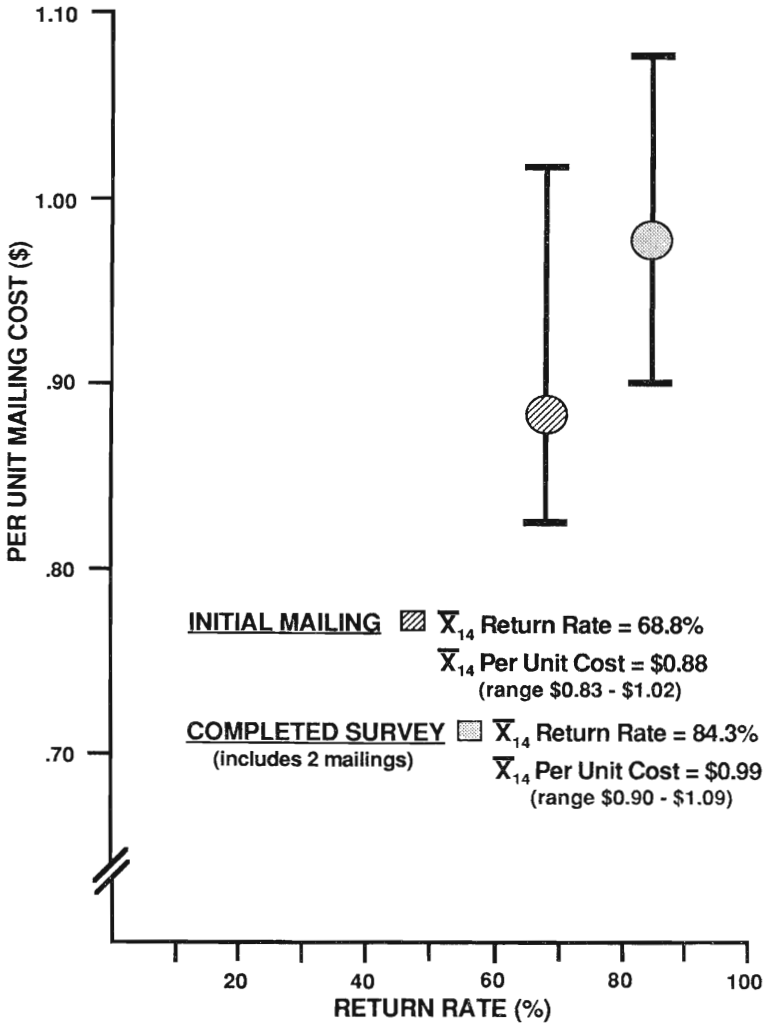


Figure 5. Average 1986 return rate and mailing cost per returned questionnaire after initial and follow-up mailings respectively as determined from a District Mail Survey of 14 wildlife management units in the Ontario Ministry of Natural Resources NC Region.

Response rates generally averaged >80% when both prepaid return postage and a second follow-up mailing to non-respondents was employed. Responses averaged 64% in the absence of a second reminder and prepaid return postage. These findings parallel those by Erdos and Morgan (1970) who suggested using a multiple mailing and simple question design to obtain a high rate of response.

Single mailing response rates were also found to be higher when prepaid return postage was provided, further demonstrating the value of this incentive towards improving questionnaire returns.

Non-respondent bias correction factors have been successfully used on a regional basis in Ontario's Algonquin Region (Strickland 1987). In the NCR, however, some inconsistency was detected in non-response bias when applied on a WMU basis. Bias corrected harvest estimates after one and two mailings respectively were generally quite variable. We therefore suggest that single mailing bias corrected results are suspect at low return levels and may be subject to significant error.

Considering its relative ineffectiveness at compensating for low hunter response rates and the significant increase in workload required to perform the calculation, we recommend terminating the use of the non-response bias correction factor. We emphasize, however, that every effort should be made to ensure sufficiently high response rates to compensate for the potential effects of hunter non-response bias.

DMS results in 1985 yielded an overall 16.2% higher kill estimate than the more comprehensive PMS which employs a lower overall sample rate. Individual WMU discrepancies, however, varied by as much as 94.3%. We assume the higher sampling intensity DMS (5.7x) more

accurately reflects the true WMU kill. This information is also much more timely (i.e., two months post-hunt vs. 8-12 months for the PMS).

The average DMS cost per response projected at $2.31 after two mailings is higher than would result from a single mailing. We believe, however, that the additional costs involved to significantly increase response rates from ±65% to ±85% is both cost effective and justified.

Continuation of the DMS in its present form is recommended. We should, however, strive to ensure a ±90% response rate to reduce potential hunter non-response bias.

ACKNOWLEDGEMENTS

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