AGE AND SEX STRUCTURE OF HUNTER HARVESTED MOOSE UNDER TWO HARVEST STRATEGIES IN NORTHCENTRAL ONTARIO

H.R. Timmermann[1,3] and R.S. Rempel[2]

[1] Ontario Ministry of Natural Resources, N.W. Region Science and Technology Section, R.R.#1, 25th Side Road, Thunder Bay, Ontario, Canada, P7C 4T9; [2] Ontario Ministry of Natural Resources, Centre for Northern Forest Ecosystem Research, 955 Oliver Road, Thunder Bay, Ontario, Canada, P7B 5E1

ABSTRACT: We examined moose age and sex structure from 38,870 moose harvest records voluntarily submitted by northcentral Ontario hunters for the period 1971-92, a sample representing ca. 60% of actual estimated harvest. Several parameters were compared between the unlimited non-selective (1971-82) and the limited selective harvest strategy (1983-92) periods, including adult sex ratio's, mean age ($\geq$ 1.5 yrs) and five arbitrary age classes. Mean adult sex ratio's in the harvest increased from 1.45 males:1 female to 2.34 males:1 female ($P < .0001$) following implementation of the selective harvest strategy. The decrease in mean age of bulls ($\geq$ 1.5 yrs) from 3.8 to 3.7 was not significant ($P = 0.245$), but the decrease in mean cow age from 4.3 to 3.9 was ($P = 0.0036$). Hunter submitted calf harvests were consistently higher (up to 100%) than those estimated from district mail surveys initiated in 1983. Two indices of population density (aerial census; animals seen by hunters) increased 11% and 36%, respectively, subsequent to implementation of selective harvest ($P < 0.0001$ and $P = 0.0019$). An age-sex structure profile contrasting pre- and post-selective harvest of a moose population is presented. The value of hunter-submitted kill data to facilitate management decisions is discussed.

ALCES VOL. 34(1): 21-30 (1998)

Key words: Age sex structure, *Alces*, demographic, harvest strategies, population parameters, voluntary kill survey.

Assessing hunter harvest is an essential component of any management system. Currently, kill registration is compulsory in the majority of jurisdictions that manage moose in North America (Timmermann and Buss 1995). However several jurisdictions, including Ontario, still rely on voluntary kill returns, and most provide an incentive to encourage a representative sample of annual harvest. In Ontario, voluntary kill reports are supplemented with a random sample mail survey of all licensed hunters (Barbowski 1972, Gollat and Timmermann 1987).

Recently, hunting statistics were used by both Quebec and Ontario to identify discreet populations showing similar characteristics and to develop regression models that can predict population parameters (Courtois and Crête 1993, Timmermann *et al.* 1993). Both hunter success and the percent calves harvested appear to correlate well with density estimates obtained from aerial surveys. Lykke and McTaggart Cowan (1968:5) reported that in Norway, a high percentage of bulls in an either sex

[3] Present address: R.R. # 2, Nolalu, Ontario, Canada POT 2KO

harvest indicated "a good moose population in relation to hunting pressure". The reverse occurs during a population decline. Fraser (1976) suggested an estimate of the proportion of the annual Ontario moose harvest can be assessed on the basis of age-related changes of animals shot. Addison and Timmermann (1974) however, cautioned managers that several biases and sources of variability limit meaningful comparisons from year to year. They believed these included small sample sizes often drawn from large geographic areas and differential vulnerability of moose to hunting.

A balanced social structure is important to "restore the rutting peak to the September period, shorten the rutting and calving period, raise reproductive success and allow the majority of adult cows to calve in May" (Bubenik and Timmermann 1982:86). Population structure and density are also important in inducing estrus and synchronizing rut periodicity (Timmermann 1992).

Ontario introduced a province-wide sex and age selective harvest strategy for moose in 1983 (Euler 1983, Timmermann and Gollat 1986). The prime objective of the selective harvest program, together with the moose habitat guidelines that were introduced at about the same time (OMNR 1988), was to double the Ontario moose population from ca. 80,000 in 1983 to 160,000 by the year 2000 (Smith 1990). Harvest strategies were designed to protect a larger proportion of breeding cows and focus more hunting pressure on bulls and calves. Under this system, population and adult harvest targets were established for each of 67 provincial Wildlife Management Units (WMUs) and a limited number of bull and cow adult validation tags (AVTs) are offered to hunters to achieve these targets (OMNR 1982). In northcentral Ontario the proportion of bull to cow AVTs approximated a ratio of 3:1 and declined from a total of 17,974 AVTs issued in 1983 to 9,561 in 1992 (Whitlaw *et al.* 1993). Calf harvest is not specifically controlled, as hunting mortality of calves is assumed to be partially compensatory. Thus all licensed hunters (ca. 100,000 in 1995) could legally take a calf in any WMU.

STUDY AREA AND METHODS

Ontario has attempted to assess the annual moose harvest by collecting age and sex data and location of kill since 1953 (Addison and Timmermann 1974, Fraser 1976, Timmermann and Gollat 1982). Hunters are rewarded with a moose hunter crest (introduced in 1967) and a cap in exchange for the lower jaw and hide of harvested animals (Cumming 1974). This collection was standardized in the late 1970's and expanded to include data on white-tailed deer (*Odocoileus virginianus*) and black bear (*Ursus americanus*).

Our data were collected from hunters who voluntarily submitted jaws or offered information concerning moose taken in 14 WMUs totaling 132,361km^2 of land managed by the former North Central Region (Timmermann and Whitlaw 1992). Samples represent ca. 60% (over a range of 50-75%) of the annual licensed harvest as estimated from a Provincial (Barbowski 1972) or District (Gollat and Timmermann 1987) mail survey of hunters. Samples came from moose killed by hunters during seasons beginning as early as 15 September and extending as late as 15 December, 1971-92.

We examined 228 sample sets by WMU and year (*N* = 88 pre-selective and 140 post-selective harvest) totaling 33,217 age-determined, and an additional 5,653 sex-determined animals. Annual harvest records over the 22 year period averaged 1,402 and 1,526 aged and sexed animals respectively. Calves and yearlings were aged by tooth eruption as described by Passmore *et al.* (1955), and incisors were sectioned and *cementum annuli* counted for older ($\geq$ 2.5 yr) animals (Sergeant and Pimlott 1959). The jaw/hide program was no longer supported province-wide after 1992, resulting in significantly reduced sample sizes. Unfortunately, very little attempt has been made to examine this long-term harvest structure data and determine its value as a management tool.

Our objective was to compare the sex and age structure in the harvest from the liberal non-selective period (1971-82) with the controlled selective harvest period (1983-92) to determine if age structure changed between periods. We then compared 2 indices of population density (aerial census; animals seen by hunters), before and after implementation of selective harvest, to determine if population density decreased after implementation of the selective harvest strategy.

A demographic profile of moose harvest by age class was created for male and female moose by summing total number of moose harvested in each age class from 0.5-13.5 years of age. The final age class included all moose 13.5 years and greater. Profiles were created for periods before and after implementation of Ontario's selective harvest strategy, i.e., 1971-82 and 1983-92.

A summary of moose harvest by sex/age class was created by calculating the mean number of animals harvested in each of 5 defined social classes for years 1971-92, where social class **0** = male and female moose less than 1.5 year; **1** = male yearlings of age 1.5; **2** = female yearlings of age 1.5; **3** = prime bulls 5.5-10.5 yrs.; and **4** = breeding females of age 2.5-13.5+ yrs. The social classes were originally described by Bubenik and Timmermann (1982) and later modified by Timmermann and Gollat (1982, 1986). The proportional harvest summary was then created by dividing the sum of each sex/age class by the sum of all moose identified as male or female, and then calculating the median proportion for each year among all WMUs. We also calculated the mean adult age of males and females ($\geq$ 1.5 yrs) to compare mean age between the pre- and post-selective harvest periods.

Population density, estimated from standard aerial surveys and number of moose seen alive by hunters (Bisset 1991a, Timmmerman *et al.* 1993, Table 1: 49-50) were used to test for differences in moose density before and after selective harvest.

All data differed significantly from a normal distribution, so all but one comparison of harvest data (before and after implementation of selective harvest) was made using Mann-Whitney U non-parametric tests; comparisons of aerial survey data were made with ANOVA following log transformation of the moose density estimates. Analysis of proportions was restricted to yearly records where number of female moose was > 10.

RESULTS AND DISCUSSION

Harvest age distribution

The relative distribution of age classes within Ontario's moose harvest (Fig. 1; Table 1) changed following implementation of selective harvest in 1983. The jaw/hide data do not allow us to directly compare the total reported number of animals killed (Table 1) between the pre- and post-selective harvest periods because we don't know if sampling rate was constant between 1971-92. However, the relative distribution of age classes should not be biased by moderate changes in sampling intensity, which we estimate dropped from 60-40% between the pre- and post-selective harvest periods.

Relative to other age classes, the reported annual harvest increased more for calves (219 - 309) than for the other combined age classes (1,246 - 1,254) following selective harvest (Table 1). The relative proportion of adult females in the harvest

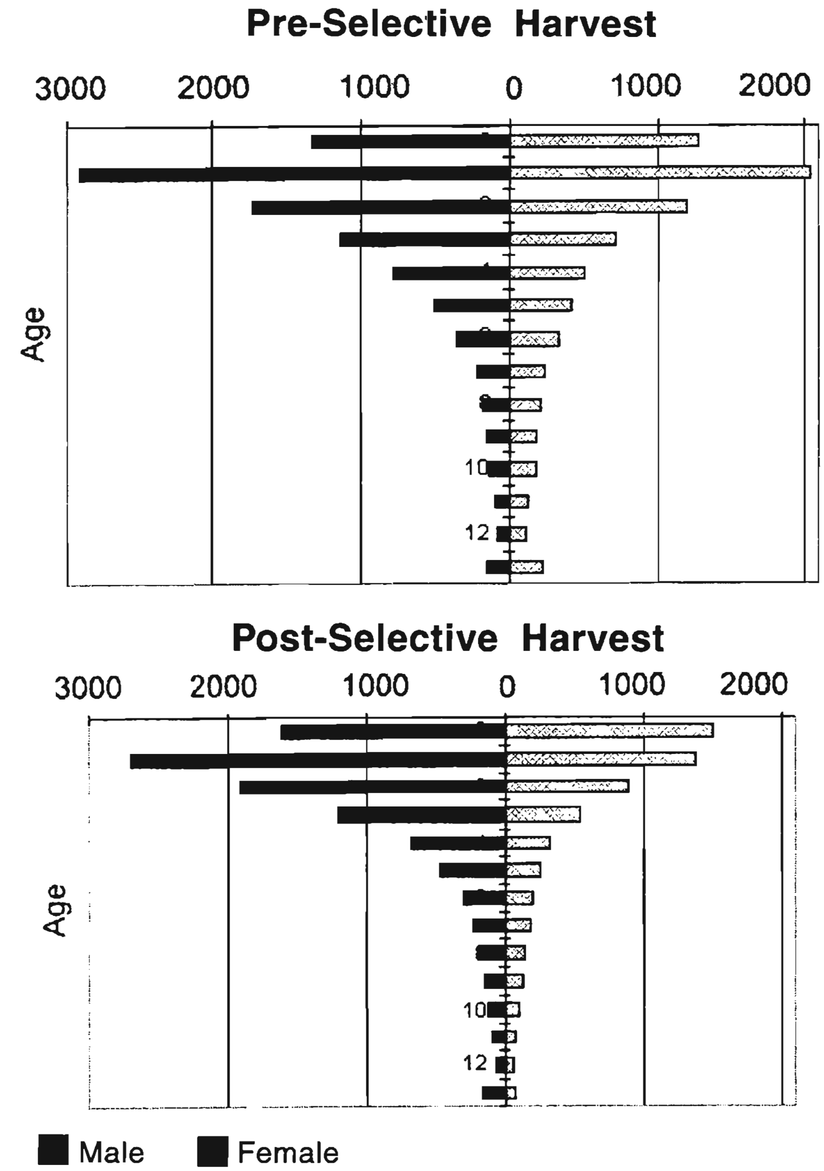

Fig. 1. Profile of age distribution in harvest of male and female moose for pre-selective harvest (1972 - 82) and post-selective harvest (1983 - 92) periods, northcentral Ontario. Values are proportion of total harvest for each age class, averaged across wildlife management units and years.

decreased (Table 2) in the selective harvest period. Overall, the shift in demographic pattern was greater for females than males (Fig. 1). This reflects the change in harvest strategy whereby all licensed hunters could legally kill a calf in any WMU but adult cow harvests were restricted to a reduced WMU specific quota (Timmermann and Whitlaw 1992). The most pronounced decrease was for age classes 1.5-3.5. In contrast with females, the age profile of the male harvest changed relatively little except for a similar increase in calves after implementation of selective harvest (Fig. 1; Table1).

We believe the jaw/hide return program is the most appropriate method of determining the age structure of the harvest. In particular, voluntary submitted harvest

Table 1. Age structure of reported moose harvest by age class. Values are total number of animals killed by age class, as voluntarily submitted by northcentral Ontario hunters, for the 12 yr. pre-selective harvest period (1971-82), and 10 yr. post-selective harvest period (1983-92).

Age Class	Harvest Period			
	Pre-selective		Post-selective	
	Male	Female	Male	Female
0.5	1341	1288	1600	1489
1.5	2913	2042	2706	1383
2.5	1736	1195	1907	883
3.5	1134	726	1205	542
4.5	784	503	682	313
5.5	504	411	475	255
6.5	351	336	303	196
7.5	231	239	237	174
8.5	187	214	190	139
9.5	154	184	140	116
10.5	137	177	120	98
11.5	100	121	85	72
12.5	80	117	58	45
13.5+	158	222	158	61
Subtotal	9810	7775	9866	5766
TOTAL	17,585		15,632	
Annual Average	1,465		1,563	

records are believed to yield an unbiased determination of a calf profile. The incentive to provide biological data is largely based on hunters desire to obtain a crest or hat, or to participate in population management. We assume the age of the harvested moose is not likely to influence whether hunters submit a return, and this program provides a random sample across all age-classes.

An accurate assessment of calf harvest has always been difficult. The provincial mail survey samples all licensed hunters (ca.100,000) using a 5% province-wide sampling intensity. The district mail survey introduced in 1984 is based on a WMU sample of AVT holders. Although sampling rates are generally high (ca. 50%) and return rates approach 75 % or more (Gollat and Timmermann 1987), few districts attempt to sample the calf-only licensed hunters who can legally harvest a calf in any WMU. Hence, traditional hunter harvest records from the voluntary jaw/hide program reported here remain the principle method of assessing annual calf harvests. Unfortunately, in the early 1990's the jaw/hide program has been de-emphasized, and by 1993-94 the reduced voluntary returns can no longer be used to monitor changes in harvest structure.

Mean age

The increase in proportion of the 0.5 age class resulted in a decreased mean age of adult (≥ 1.5 yr.) females, with mean age declining from 4.3 to 3.9 yrs. in the selective harvest period ($P = 0.0036$, z = -2.91, df = 222). The mean age of adult males in the pre-selective harvest period (3.8 yr.) was not different from mean age of males (3.7 yr.) in the post-selective harvest period ($P = 0.254$, z = -1.139, df = 226).

Harvest density and sex ratio

The temporal trend in sex ratios and density of males versus females harvested again illustrates the influence of the selective harvest strategy by restricting the harvest ratio of cows: bulls on the harvest profile (Fig. 1, Table 1). Before selective harvest, the difference between male and female harvest density (number killed per unit area) was relatively constant. After selective harvest this difference increased, causing the male to female sex ratio to increase sharply from 1.45 males/female to 2.34 males/female ($P < 0.0001$, z = -7.854, df = 222). Such a proportional reduction in cow harvest and a "high bull percentage" supports the belief by Cumming (1974) and Lykke and McTaggart Cowan (1968:5) of an overall reduction of hunting pressure and a "good moose population" respectively.

Age and sex structure

The proportion of calves in the harvest increased from 0.125 to 0.162, while proportions of yearling bulls decreased from 0.148 to 0.132, and yearling cows from 0.096 to 0.064 (Table 3). In a non-selective harvest system, yearlings are generally over represented and calves under represented in the kill (Pimlott 1959, Simkin 1965). It appears Ontario's selective harvest system reduced the over representation of yearlings but increased the proportional harvest of calves killed by hunters. The decreased percentage of yearlings may in part reflect a real reduction of hunting pressure as suggested by Cumming (1974) or a reduced availability of yearlings. The proportion of breeding cows in the harvest (≥ 2.5 yrs.) decreased from 0.218 to 0.141 ($P < 0.0001$, z = -8.608, df = 195, Table 3). The proportion of prime bulls (0.0801) remained unchanged ($P = 0.454$, z = 0.749, df = 195). The protection of prime breeding animals, especially cow moose, to enhance calf production and direct hunting pressure toward animals in the herd with the lowest reproductive potential, such as young bulls and calves, is a key component of Ontario's selective harvest program (Timmermann 1987). The unusually high harvest of breeding cows and bulls from 1973-74 (Table 2) was a consequence of an early season opening date, and these results illustrate the sensitivity of harvest age structure to timing of season opening (Timmermann and Gollat 1982).

Population density indices

Two indices of population density differed before and after implementation of selective harvest. Overall pooled density estimates from aerial surveys increased from 0.19 to 0.21 ($P < 0.0001$, $F = 15.0$, df = 60), and number of moose seen alive per hunter increased from 1.34 to 1.82 ($P = 0.0019$, z = -3.11, df = 60). Although this does not represent a thorough evaluation of the success of the selective harvest strategy, and does not consider all the variables necessary to address success of the program, the analysis does fail to demonstrate that the selective harvest strategy was detrimental to the population, and indicates that the population increased subsequent to implementation of the harvest strategy.

MANAGEMENT IMPLICATIONS

Hunter submitted harvest information was valuable in assessing the consequences

Table 2. Trends in harvest age/sex structure[1], before (1971-82) and after (1983-92) implementation of the selective harvest strategy in northcentral Ontario. Values are mean numbers of reported animals in each social class, with relative proportion[2] in parentheses.

Year	Age/sex class				
	0	1	2	3	4
1971	67.5(0.162)	64.0(0.162)	41.0(0.096)	29.5(0.074)	87.0(0.221)
1972	55.0(0.161)	41.7(0.129)	37.3(0.118)	22.0(0.059)	75.7(0.251)
1973	59.7(0.129)	41.7(0.108)	23.3(0.058)	39.3(0.108)	94.0(0.246)
1974	53.7(0.129)	49.3(0.114)	41.0(0.092)	38.7(0.090)	99.0(0.242)
1975	26.7(0.115)	28.4(0.128)	18.1(0.082)	22.8(0.105)	48.0(0.218)
1976	33.1(0.145)	29.6(0.121)	22.1(0.088)	22.2(0.094)	53.8(0.222)
1977	30.2(0.123)	34.1(0.162)	25.0(0.106)	16.8(0.081)	49.6(0.210)
1978	33.3(0.146)	37.7(0.160)	23.0(0.097)	19.3(0.075)	48.9(0.205)
1979	39.4(0.136)	40.7(0.152)	25.4(0.076)	17.8(0.067)	63.4(0.236)
1980	17.6(0.119)	24.2(0.168)	18.6(0.121)	8.9(0.057)	29.1(0.188)
1981	19.1(0.111)	31.1(0.163)	21.1(0.114)	11.8(0.069)	37.9(0.222)
1982	19.6(0.118)	25.4(0.157)	19.6(0.111)	9.2(0.061)	34.9(0.203)
1983	17.1(0.101)	22.4(0.161)	16.9(0.100)	12.1(0.088)	25.6(0.166)
1984	19.8(0.129)	20.9(0.120)	11.1(0.063)	10.4(0.077)	24.4(0.179)
1985	27.1(0.163)	21.7(0.127)	11.8(0.082)	12.6(0.086)	26.1(0.156)
1986	26.4(0.179)	24.4(0.149)	11.1(0.074)	12.9(0.072)	24.4(0.147)
1987	25.4(0.147)	21.9(0.136)	8.0(0.055)	11.7(0.077)	17.6(0.124)
1988	36.4(0.201)	26.8(0.155)	13.6(0.079)	12.4(0.072)	26.7(0.138)
1989	21.9(0.173)	18.4(0.138)	8.7(0.059)	9.8(0.074)	19.8(0.144)
1990	22.4(0.133)	16.4(0.100)	7.4(0.047)	11.2(0.064)	18.2(0.111)
1991	19.1(0.197)	12.6(0.135)	6.0(0.038)	5.6(0.052)	15.1(0.105)
1992	11.9(0.147)	7.9(0.103)	4.3(0.051)	6.0(0.069)	8.9(0.098)

[1]Social class 0 = male and female moose < 1.5 year; 1 = male yearlings of age 1.5; 2 = female yearlings of age 1.5; 3 = prime bulls aged 5.5 - 10.5; and 4 = breeding females of age 2.5 - 13.5+.

[2]Yearly proportions are median values for all WMUs, where proportion was calculated if total number of females within the WMU was > 10.

of implementing a selective harvest program. Volunteer reporting rate declined from ca. 60% of reported kill before, to ca. 40%, after the program was no longer fully supported province-wide. The age and sex structure of northcentral Ontario's moose harvest appears to have been altered significantly since the introduction of a controlled selective harvest strategy in 1983. Our analysis suggests that an increase in hunting pressure on calves and a consequent increased calf harvest has significantly lowered the mean age of adult females in the kill. Several factors may

Table 3. Analysis of harvest age/sex structure[1], before and after implementation of the selective harvest strategy, in 14 wildlife management units from North Central Region of Ontario (1971 - 92).

Age/Sex Class	Harvest Period		Z[3]	*P*	df
	Pre[2]	Post			
0	0.125	0.162	4.288	<0.0001	195
1	0.148	0.132	-2.397	0.0165	195
2	0.096	0.064	-5.266	<0.0001	195
3	0.078	0.072	0.749	0.4540	195
4	0.218	0.141	-8.608	<0.0001	195

[1] Social class 0 = male and female moose < 1.5 year; 1 = male yearlings of age 1.5; 2 = female yearlings of age 1.5; 3 = prime bulls aged 5.5 - 10.5; and 4 = breeding females of age 2.5 - 13.5+.

[2] Yearly relative proportions were calculated only for WMUs where number of females for that year was > 10.

[3] Z statistics, and associated probability, are for Mann-Whitney U test of hypothesis that the pre- and post-selective harvest period proportions do not differ. Five separate tests were performed, so to maintain an "experimentwise" error rate of 0.05 in the statistical comparisons, differences were not considered to be significant (at alpha=0.05) for *P* values > 0.01.

account for a younger female mean age after 1983. Significant growth occurred between 1982 and 1991 adding a higher proportion of younger-aged individuals to the population (Timmermann and Whitlaw 1992, Timmermann and Buss 1995). During the pre-selective period (1971-82) major logging-road expansion opened new access to large, formerly inaccessible areas (Timmermann and Gollat 1982). These remote lightly hunted areas generally yield an older mean age structure compared to moose harvested in more road accessible areas according to Simkin (1964). A decline in road building occurred 1983-91 as provincial moose habitat guidelines were applied to provide good moose habitat while at the same time and on the same area, ensuring a continuous and predictable wood supply (OMNR 1988). Lastly, even though the selective harvest strategy reduced the overall legal female harvest, later opening seasons also reduced breeding cow vulnerability associated with the rut (Pimlott 1959, Simkin 1965, Timmermann and Gollat 1982). Conversely, younger females became proportionally more vulnerable to the controlled quota harvest.

Euler (1983) believed increased hunting pressure on calves would not cause an excessive calf harvest as hunting mortality is assumed to be additive on adults and partially compensatory on calves. Bergerud (1981) cautioned that wolves (*Canis lupus*) limit the carrying capacity for moose and that such predation is additive. In addition black bears (*Ursus americanus*) have been identified as important predators of moose calves in several areas of North America (Wilton 1983, Stewart *et al.* 1985, Franzmann and Schwartz 1986, Crête and Jolicoeur 1987). The question then becomes - at what point does combined mortality on calves impact future growth potential? "If the calf harvest becomes too high, then steps to change hunting pressure on calves can be taken" (Euler 1983:157). Given the evidence presented in this paper, we suggest managers in other regions of Ontario should more closely examine calf harvest and overall population trends. In addition, further analysis is required to determine the long-term consequences of following policy objectives (OMNR 1980) currently guiding the selective harvest program. A subsequent paper will examine this data by projecting survivorship of a cohort and discussing alternate harvest strategies on population growth.

In the past Ontario moose managers have focused on meeting population targets (Bisset 1991b, Heydon *et al.* 1992) and less effort was placed on examining changes in harvest structure following a major harvest strategy change. We believe our analysis has demonstrated the value of hunter-submitted kill records to help evaluate changes in population structure. In future, managers need to assess all sources of data, including harvest data and, as recommended by Euler (1983) following principles of adaptive management, to consider modifying or refining policy to reflect monitoring evaluations.

ACKNOWLEDGEMENTS

Our appreciation is extended to Wayne MacCallum, Ministry of Natural Resources, Thunder Bay who assisted with data input, Ruth Berzel, NWR Science and Technology Section for preparing tables, the Ontario Federation of Anglers and Hunters (Zone B) who provided travel funding to the senior author to attend the 4th International Moose Symposium/33rd N. AM. Moose Conf. Workshop, and all hunters who submitted data to the various Ministry of Natural Resources offices and check stations.

REFERENCES

ADDISON, R.K. and H.R. TIMMERMANN. 1974. Some practical problems in the analysis of the population dynamics of a moose herd. Proc. N. Am. Moose Conf. Workshop 10:76-106.

BARBOWSKI, J. 1972. Mail surveys of moose hunters in Ontario. Proc. N. Am. Moose Conf. Workshop 8:326-339.

BERGERUD, A.T. 1981. The decline of moose in Ontario - a different view. Alces 17:30-43.

BISSET, A.R. 1991a. Standards and guidelines for moose population inventory in Ontario. Ont. Min. Nat. Resour., Wildl. Br., Toronto. 37pp.

_______. 1991b. The moose population of Ontario revisited - a review of survey data., 1975-1991. Ont. Min. Nat. Resour., Toronto. 20 pp.

BUBENIK, A.B. and H.R. TIMMERMANN. 1982. Spermatogenesis in the Taiga-moose of North Central Ontario. Alces 18:54-93.

COURTOIS, R. and M. CRÊTE. 1993. Predicting moose population parameters from hunting statistics. Alces 29:75-90.

CRÊTE, M. and H. JOLICOEUR. 1987. Impact of wolf and black bear removal on cow:calf ratio and moose density in southwestern Quebec. Alces 23:61-87.

CUMMING, H.G. 1974. Annual yield, sex and age of moose in Ontario as indices to the effects of hunting. Naturaliste can. 101:539-558.

EULER, D. 1983. Selective harvest, compensatory mortality and moose in Ontario. Alces 19:148-161.

FRANZMANN, A.W. and C.C. SCHWARTZ. 1986. Black bear predation on moose calves in highly productive versus marginal moose habitats on the Kenai Peninsula, Alaska. Alces 22:139-153.

FRASER, D. 1976. An estimate of hunting mortality based on age and sex structure of the harvest. Proc. N. Am. Moose

Conf.Workshop 12:236-273.

GOLLAT, R. and H.R. TIMMERMANN. 1987. Evaluating Ontario moose harvests using a postcard questionnaire. Alces 23:157-180.

HEYDON, C., D. EULER, H. SMITH, and A. BISSET. 1992. Modelling the selective moose harvest program in Ontario. Alces 28:111-122.

LYKKE, J. and I. Mc TAGGART COWAN. 1968. Moose management and population dynamics on the Scandinavian peninsula, with special reference to Norway. Proc. N. Am. Moose Conf. Workshop 5:1-22.

(OMNR) ONTARIO MINISTRY OF NATURAL RESOURCES. 1980. Moose management policy. Wildl. Branch, Toronto. 6pp.

_______. 1982. Northwestern Ontario strategic land use plan. Ont. Min. Nat. Resour., Toronto. 71pp.

_______. 1988. Timber management guidelines for the provision of moose habitat. Ont. Min. Nat. Resour., Toronto. 33pp.

PASSMORE, R.C., R.L. PETERSON, and A.T. CRINGAN. 1955. A study of the mandibular tooth wear as an index to age in moose. Appendix A: Pages 223-238 *in* R.L. Peterson, North American Moose. Univ. of Toronto Press, Toronto. 280pp.

PIMLOTT, D.H. 1959. Reproduction and productivity of Newfoundland moose. J. Wildl. Manage. 18:563-581.

SERGEANT, D.E. and D.H. PIMLOTT. 1959. Age determination in moose from sectioned incisor teeth. J. Wildl. Manage. 23: 315-321.

SIMKIN, D.W. 1964. Some differences in ages of moose shot in heavily hunted and lightly hunted areas. Ont. Fish Wildl. Rev. 3:8-13.

_______. 1965. Reproduction and productivity of moose in Northwestern Ontario. J. Wildl. Manage. 29:740-750.

_______. 1974. Reproduction and productivity of moose. Naturaliste can. 101:517-526.

SMITH, H. 1990. Managing a moose population. Pages 25-29 *in* M. Buss and R. Truman (eds.) The Moose in Ontario, Book 1. Ont. Min. Nat. Resour., Wildl. Branch, Toronto. 78pp.

STEWART, R.R., E.H. KOWAL, R. BEAULIEU, and T.W. ROCK. 1985. The impact of black bear removal on moose calf survival in east-central Saskatchewan. Alces 21:403-418.

TIMMERMANN, H.R. 1987. Moose harvest strategies in North America. Swedish Wildl. Res. Suppl. 1:565-579.

_______. 1992. Moose sociobiology and implications for harvest. Alces 28:59-78.

_______ and R. GOLLAT. 1982. Age and sex structure of harvested moose related to season manipulation and access. Alces 18:301-328.

_______ and _______. 1986. Selective moose harvest in Northcentral Ontario-a progress report. Alces 22:395-418.

_______ and M.E. BUSS. 1995. The status and management of moose in North America-early 1990's. Alces 31:1-14.

_______ and H. WHITLAW. 1992. Selective moose harvest in North Central Ontario. Alces 28:137-164.

_______, _______, and A.R. RODGERS. 1993. Testing the sensitivity of moose harvest data to changes in aerial population estimates in Ontario. Alces 29: 47-53.

WHITLAW, H., H.R. TIMMERMANN, P. PERNSKY, and A.R. BISSET. 1993. Northwest region moose population and harvest profile. Ont. Min. Nat. Resour., Northwest Region Science and Technology Tech. Rep. No. 75. 129pp.

WILTON, M. 1983. Black bear predation on young cervids— a summary. Alces 19:136-147.