SELECTIVE MOOSE HARVEST IN NORTH CENTRAL ONTARIO - A PROGRESS REPORT

H.R. Timmermann and H.A. Whitlaw

Ontario Ministry of Natural Resources, Thunder Bay, Ontario, P7B 5G6

ABSTRACT: Ontario introduced a province-wide sex and age selective harvest strategy for moose (*Alces alces*) in 1983. The program was designed to double the provincial moose population by the year 2000 by controlling the annual hunter harvest of bulls and cows in 67 Wildlife Management Units (WMU's). In north central Ontario the harvest sex/age ratio has averaged 54% bulls, 28% cows and 18% calves in 14 WMU's after eight years. A step-wise increase in the calf kill and corresponding decrease in the cow kill has occurred. There appears to be a trend towards a higher proportion of breeders and a lower proportion of yearlings and teens in both the adult bull and cow harvest. Demand for adult tags and success rates continues to increase in many WMU's as hunters report seeing more moose. Aerial inventories since 1983 suggest that populations in WMU's west of Lake Nipigon have generally reached or exceeded year 2000 targets while those to the east have failed to respond. Data for two WMU's, one representing a population response and the other, relative population stability are analyzed and discussed. Population densities in these WMU's are believed related, in part to differences in winter severity and land capability. Densities in both have declined slightly since 1988 as current mortality rates from all sources exceed annual recruitment. Adjacent jurisdictions (Isle Royale and northeastern Minnesota) display similar trends to several adjoining WMU's, regardless of density, hunter harvest or the presence or absence of white-tailed deer (*Odocoileus virginianus*). Increased winter tick (*Dermacentor albipictus*) mortality, triggered by short-term changes in weather patterns in the late 1980's, is believed responsible for synchronous population declines in northeastern Minnesota and on Isle Royale. It is possible that ticks were also involved in similar declines seen in WMU's 11B, 13 and 14, although the evidence is circumstantial. We recommend current WMU population and harvest targets be reviewed and adjusted to land capability; that lower and more flexible harvest rates be tailored to sustain local populations, and that further research on weather-related population changes be undertaken.

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Ontario has employed three distinct moose harvest strategies over the past three decades in an effort to balance harvests with natural mortality and herd recruitment. From 1955-1979, liberal, unlimited entry, either sex seasons were used (Timmermann and Gollat 1982). Passive harvest control measures in the form of adjustment of opening season dates and licence fee increases were introduced during the latter part of this time period in an effort to stabilize documented population declines (Gollat and Timmermann 1983a, Timmermann 1987). The second strategy was a party harvest system introduced in 1980 requiring two hunters to share one moose (Timmermann and Gollat 1984). The third and present strategy is selective harvest, introduced in 1983 to increase economic benefits and recreational opportunities and address enforcement problems and overharvests (Timmermann 1983).

The primary objective of the selective harvest program was to double the Ontario moose population from ±80,000 in 1983 to 160,000 by the year 2000 (Smith 1990). Population and harvest targets were assigned to each of 67 WMU's (OMNR 1982). Population target densities for most WMU's in north central Ontario were set at 0.39 moose/km^2 except for three northern WMU's where they were lower (ie. 0.11-0.15). Likewise, year 2000 sport harvest rates were arbitrarily established at 17.5% per year for all but four northern WMU's, where they varied between 12.3 and 15.0% (OMNR 1982). Harvest strategies were designed to protect a larger proportion of breeding cows and focus more hunting pressure on bulls and calves. The biological basis of selective harvest is the polygamous breeding capacity of bulls. Additionally, it is assumed that herd recruitment (R) will increase if the proportion of prime breeding females in the herd increases and that hunting mortality of calves is partially compensatory (Euler 1983a).

Aerial inventories are carried out in Ontario to estimate population size and trends, and determine the age and sex composition of moose populations. Inventories are conducted annually with the aim of sampling each road-accessible WMU within moose range at least once every three years (Bisset 1991). This information is used in setting annual harvest quotas and evaluating management strategies. Each WMU harvest quota is apportioned into a specific number of bulls, cows and calves. The applied 1983 ratio of 50:20:30 was refined to a baseline 60:20:20 in 1984, based on computer simulation (OMNR 1984, Gollat *et al.* 1985). Annual harvest quotas are set for each WMU based on the number of adult animals that can be taken and still allow the herd to increase or remain stable, depending on the degree of population target achievement. They are calculated based either on a percentage of adult cows in the population (ie. 5-8% of cows) or a harvest rate applied to the total pre-hunt population estimate (ie. 10-15%, Greenwood *et al.* 1984). The desired rate of increase based on the year 2000 population target also has a direct bearing on the annual harvest quota. Adult bull and cow harvest opportunities, hereafter referred to as the number of adult validation tags (AVT's), are allocated using a three-year moving average of success rates. Managers also aim for ±67 bulls/100 cows as a minimum post-hunt adult bull/cow population ratio in an attempt to increase populations and optimize harvests to year 2000 targets (Crête *et al.* 1981).

The selective harvest program introduced major changes in regulations and required hunters, for the first time, to identify and select the animal they were licensed to hunt by both sex and age. Qualifying residents wishing to hunt may purchase a basic moose licence and harvest a calf in any WMU during the open season. Those wishing to also hunt adult animals (≥1.5 years) have the option of applying for a bull or cow tag. Preference pooling was added in 1984 to give those unsuccessful in previous year's draw a greater chance of being selected. In addition, legalized party killing of calves and adults was reintroduced beginning in 1986 and 1988, respectively. The number of bull, cow and calf moose taken must not be more than the number of bull and cow validation tags and valid moose licences held by members of the party. Any party member may take the animal. See Methods for allocation information.

Changes in regulations have been communicated to hunters and management staff. In 1983, a pamphlet with nine questions and answers regarding selective harvest principles and regulations was mailed to all 1982 licence holders. This was followed in 1984 by a 22 page booklet (OMNR 1984) covering 19 items. Considerable emphasis was placed on communicating sex/age identification features and selective harvest philosophy and biology. Informational articles were published in trade magazines (Euler 1983b, Timmermann 1983). A moose identification quiz consisting of 62 colour slides and score sheet was prepared and distributed to field offices and a 21 minute film entitled 'Of Moose and Man' was produced in both 16mm and video formats. Field offices conducted community workshops/ seminars and special information meetings during the first two years. Local interviews on radio and T.V. as well as feature newspaper articles continue to play a significant role in communicating the program. A moose hunter fact sheet containing draw information has been produced on an annual basis since 1985. In addition, a moose hunter education manual produced in cooperation with the Ontario

Federation of Anglers and Hunters (OMNR 1990) provides detailed information on moose biology, ecology, management, hunting techniques, ethics and regulations.

A large data set containing both WMU harvest and population information has been amassed since the mid 1970's, both provincially and regionally. Some populations have changed noticeably in their estimated densities, often concurrent with changes in management strategy, while others have not. Winter severity, land capability, subsistance hunting, predation, parasites and incidental mortality can also impact populations. We believe there is value in attempting to isolate some of the potential factors that influence population growth. In this paper, we have narrowed this analysis to two WMU's - WMU 13 showing population growth and WMU 21B exhibiting population stability.

The purpose of this report is: 1) to compare hunting and harvest statistics in 14 WMU's (Fig. 1) with those of the two previously used harvest strategies, 2) to examine changes in selected population parameters as possible indicators of the impact of selective moose harvest on the herds of north central Ontario 1983-91, 3) to evaluate current population and harvest estimates with respect to year 2000 targets, 4) to compare in more detail two specific WMU's in an attempt to identify variables that may affect the growth of each population and to better understand how these variables contribute to observed differences in population densities and 5) to compare population density and composition estimates between adjacent non-hunted, lightly hunted and heavily hunted areas. This paper is updated and expanded from Timmermann and Gollat (1986).

METHODS

The effects of selective harvest on the sex and age composition of moose harvested by resident hunters were measured by comparing harvest data derived from voluntarily submitted jaw samples obtained from 14 WMU's in north central Ontario between 1977 and 1991. Sex and age data, as recorded on Big

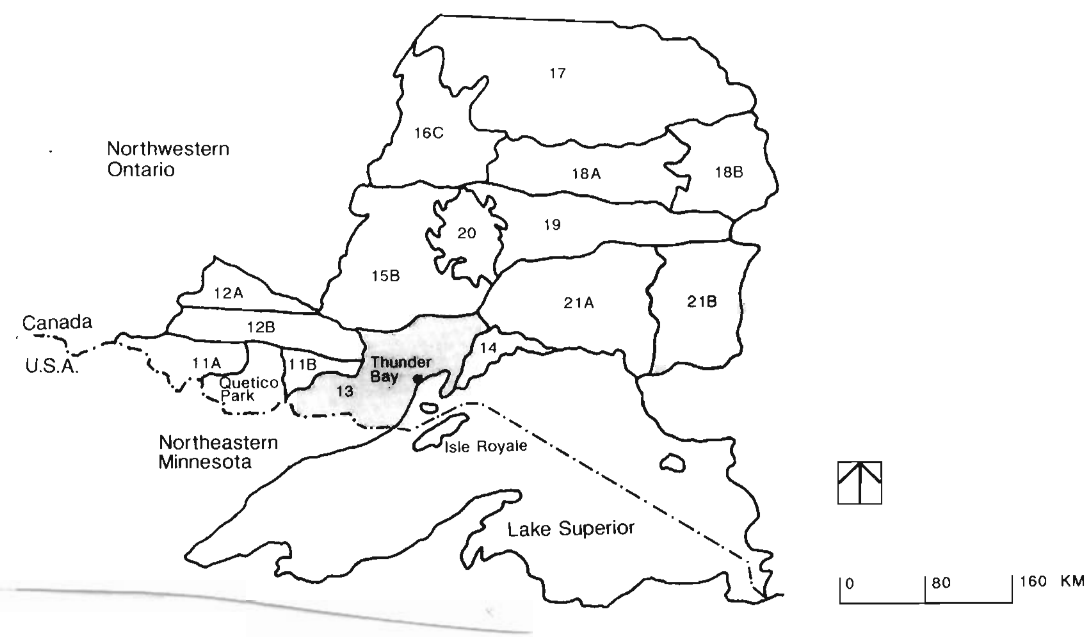

Fig. 1. Location of 14 WMU's used in selective harvest analysis, north central Ontario. (Note: Lake Nipigon is WMU 20).

Game Harvest Cards (BGHC), were examined for each of the three distinct strategies employed during the sixteen hunting seasons involved. These include season manipulation 1977-79, the party harvest system 1980-82 and selective harvest 1983-91. Data were pooled and mean values for each strategy tested for statistical significance ($p<0.05$) using a one factor ANOVA and Scheffe's multicomparison test (Zar 1984). We acknowledge that differences between areas and years may exist, but data were pooled to increase sample size and examine the gross changes between the three harvest strategies. Five arbitrary age classes described by Timmermann and Gollat (1984) and modified from Bubenik and Timmermann (1982) were used to analyze harvest social structure. Trends in hunter numbers, total harvests, hunter days, moose sighted by hunters and hunter effort (successful hunt) were obtained from the annual, centrally conducted provincial mail survey (Barbowski 1972). These data span the time periods of the three different harvest strategies (1977-91).

Since 1983 the moose resource has been partitioned among four major users - viewers, subsistence hunters, resident sport hunters and the tourist industry (Bisset and Timmermann 1983). Within the harvestable portion of the population, the subsistence rights of treaty Indians are recognized first and the remainder proportioned provincially between the resident sport and tourist industry components on a 90/10 percent basis. Adult bull and cow harvest quotas are determined for each WMU to apportion sport hunting opportunities. Adult bull and cow tags are then calculated based on past success rates (Gollat and Timmermann 1983b) and are distributed by computer draw where the number of applicants exceeds the tag quota. This paper analyzes the resident gun sport harvest which represented 91% of the estimated annual provincial kill in 1990.

Resident gun hunter harvests specific to each WMU were determined from district conducted post-hunt mail surveys (Gollat and Timmermann 1987). Adult validation tag and harvest quotas for resident-draw gun hunters were retrieved from regional files and examined for trends in each of 14 WMU's, 1983-91. Hunter demand for adult tags (1985-91) was calculated by adding all Pool 1-Choice 1 and Pool 2-Choice 1 applicants, available from annual moose hunter fact sheets.

Population data were obtained from aerial inventories (Bisset 1991). Estimated moose densities were derived from observed plus those not sighted but believed to have been missed, based on a track aggregate method described by Bergerud and Manuel (1969). These estimated densities (observed+missed) were used in harvest quota calculations and although still considered conservative, we believe them to more accurately reflect total densities and population trends than using only observed moose. Density, sex ratio and recruitment estimates were calculated for each WMU, as well as for two logged, unhunted areas of WMU 13 and Quetico Provincial Park (Camp 236 and the McKenzie-Cache Lake area respectively) (OMNR 1982). Both density and harvest estimates were compared to year 2000 program targets. All surveys are described by their January calendar year because the bulk of surveys usually terminate by month's end. Density estimates for standard WMU population surveys were compared for two periods before and after the introduction of the selective harvest system using a Mann-Whitney U test. Population density estimates for WMU's east and west of Lake Nipigon (Fig. 1) were compared separately for the periods 1975-83 and 1984-92.

Additionally, more detailed data from two specific WMU's were analyzed - WMU 13, representing a population growth response and WMU 21B, representing relative population stability. We examined and compared Dec/Jan helicopter composition counts in more detail including percent calves, percent twin calves, and percent prime bulls, as well as differences in bull/cow tag and harvest quotas, mean adult (≥1.5 years) age and hunter success. Prime bulls were identified by antler class (Oswald 1982) and combined with all unantlered males also assumed to be of prime age. Estimates of annual adult mortality (Mn - natural mortality and Mh - hunting mortality) and rate of change (λ) were calculated using the relationship $\lambda=(1-M)/(1-R)$, were R=annual recruitment and M=total mortality (Mn + Mh) (Hatter and Bergerud 1991). We used the mean percentage of calves obtained from the most recent two population inventories to represent R, as well as the acutal population estimates and most current harvest rate for λ and Mh respectively.

Total snowfall records were obtained for the Thunder Bay airport from Environment Canada. Additional snow depth records from standard MNR snow course stations associated with WMU 13 (Courses 250-Thunder Bay, 257-Upsala and 258-White Fish) and WMU 21B (Courses 241-Manitouwadge and 341-Hornepayne) were evaluated (Bisset *et al.* 1989). Mean cumulative snow depth, mean maximum snow depth and mean number of weeks with snow were calculated from the initial year of data collection for each snow course to 1987.

Differences and limitations in land capability to produce year-round moose habitat, based on the productivity of characteristic landform features were compared. Dominant landforms and surface materials identified in the Northern Ontario Engineering Geology Terrain Study base maps (NOEGTS) (McQuay 1980 a,b,c; Mollard 1979 a,b,c; Mollard 1980) were divided into the following productivity classes: HIGH-deep glaciolacustrine soils and deep silty or clay till morainal soils; MEDIUM-deep, sandy till ground moraine, shallow silty or clay ground moraine and sandy till over bedrock, and LOW-any bedrock dominated landforms, outwash plains and organic terrain (Racey pers. comm. 1991). Using the site/soil characteristics (Sims *et al.* 1989) of Vegetation types (V-types) associated with general landforms features in Sims and Baldwin (1991), the three productivity classes were organized as follows: HIGH-V1, V2, V4-V15, V17, V19, V24-V26, V31, V32; MEDIUM-V1, V2, V16, V18, V20, V21, V27, V28, V33, V34, and LOW-V10, V11, V16, V18, V22, V23, V27-V29, V32, V34-V38. These divisions were subjectively interpreted with respect to year-round moose habitat requirements (Jackson *et al.* 1991) using the percentages of each productivity class estimated for WMU 13 and 21B.

Finally, we compare population density and composition estimates between adjacent non-hunted (Isle Royale), lightly hunted (northeastern Minnesota) and heavily hunted (WMU 13, 11B and 14) and discuss similarities and differences among various population parameters. Unpublished data were kindly provided by Dr. Rolf Peterson for Isle Royale and by Dr. Mark Lenarz for northeastern Minnesota.

RESULTS AND DISCUSSION

Harvest Statistics (Regional Overview)

Hunter numbers declined in 1984 but increased to late-1970 levels by the third year of selective harvest (Fig. 2). Regulation changes in 1984 including purchase of a licence as a prerequisite to enter the adult draw are believed responsible for the initial decline. Annual harvests approximate those experienced prior to the inception of the party harvest system. Recreational opportunities expressed in total hunter days have increased dramatically over the party harvest system, doubling those experienced during the 1980-1982 period (Fig. 2). Longer seasons and removal of the regulation to share one moose between two hunters contributed to the change. The average number of moose observed per hunter has generally increased since the period 1977-82 (Fig. 2), while fewer days effort were required by successful hunters to harvest

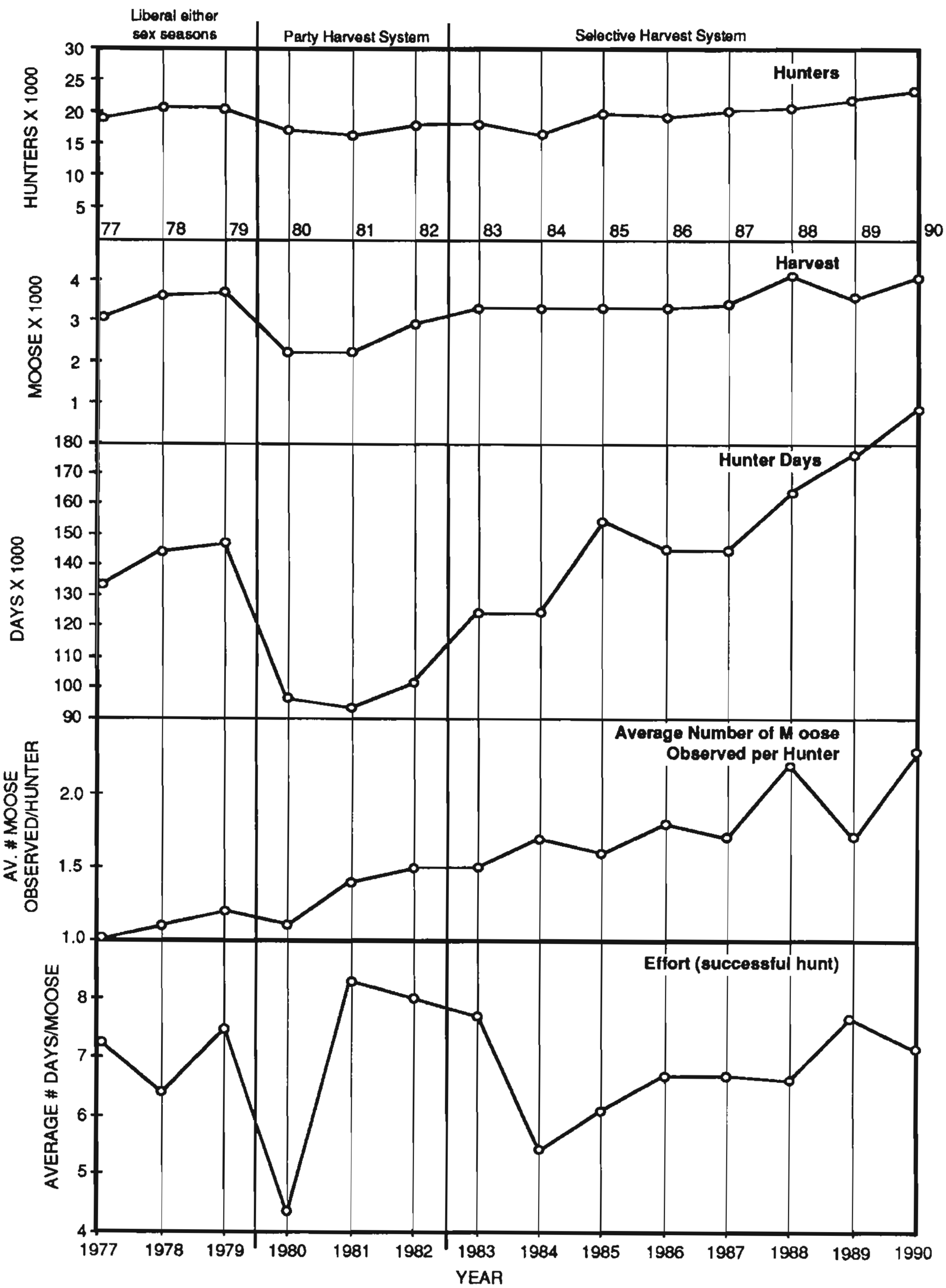

Fig. 2. Provincial hunter mail survey statistics for 14 WMU's, north central Ontario, 1977-90.

a moose from 1984 to 1988 compared to 1981-1983. Since 1985, the effort required has increased marginally from 6.1 to 7.2 days per moose but is still below the 1981-1983 effort of ±8 days. Curtailed seasons, coupled with the requirement of two hunters to share one moose between 1980 and 1982 are believed partially responsible for increasing overall populations and reducing effort.

Harvest Composition

The composition of the 1983-90 harvest has changed from that of the previous two harvest strategies (Table 1). Under selective harvest, bulls, cows and calves averaged 54, 28 and 18 percent of the reported harvest over eight years. This compares to 50/38/12 for the party harvest system and 48/38/14 for pre-1980 liberal either sex seasons. During selective harvest, the proportion of harvested bulls was significantly higher than recorded for the liberal either sex season strategy and also higher, yet not significantly, than the party harvest system (F=6.563, df=13, p=0.0133, Table 1). Conversely, the cow harvest was lower than realized during the party harvest system or the either sex season (F=28.959, df=13, p=0.0001). This change is believed to have resulted from a direct manipulation of adult tag quotas to achieve the targeted adult harvest ratio. To date the overall mean calf harvest has changed significantly in the targeted direction (F=5.778, df=13, p=0.0193, Table 1). This overall step-wise harvest increase from 11.9 to 21.1% between 1983 and 1990 suggests populations and/or hunters are responding, in part, to selective harvest strategies in many WMU's and that compliance by hunters was high.

Selective harvest has generally effected an increase (F=13.330, df=13, p=0.0011) in the proportion of prime bulls and a decrease in teen bulls in the kill since termination of the party harvest system (F=7.041, df=13, p=0.0107, Table 1). Although not significant (F=1.970, df=13, p=0.1857), similar trends were noted for breeding and yearling cows, respectively. Earlier season opening dates, a weekend season opener since 1983 and a suspected higher proportion of breeding cows and prime bulls in the population resulting from reduced harvests between 1980-1982, are believed responsible.

Harvest Control

Total annual adult harvest quotas (bulls + cows) fluctuated between 2073 and 2289 bulls and cows ($\bar{x}_9$ = 2185) collectively for 14 WMU's 1983-91 (Table 2). Individual harvest quotas however have been increased in 8 and reduced in 6 WMU's in response to higher hunter success rates and population changes. During the 8-year period of 1984-91, adult harvests (19,344) exceeded quotas (17,450) by 11% (Table 2, Appendix 3). In addition, an estimated 3,675 calves (0.19 x 19,344) were taken. Over-quota adult harvests in 1988 were as high as 483 or 23%, while in other years quotas and actual harvests approached parity.

The total number of adult bull and cow hunting opportunities (# available adult validation tags) has been reduced from 17,974 in 1983 to 9,561 in 1992, a 47% decrease (Appendix 1). Reductions occurred in 10 and increases in 4 WMU's, in response to changes in hunter success rates. Bull tags declined from about 12,500 to 7,200 while cow tags declined from about 5,400 to 2,400 (Fig. 3). All but one WMU has experienced increased hunter demand for adult tags (range 1-360%, Appendix 2). Overall hunter demand has increased by 31%, from 15,066 in 1985 to 19,659 in 1991. Demand for bull tags increased one third from about 9,000 to 12,000 while cow tags increased 25% from about 6,000 to 7,500 (Fig. 3).

Regional Population Trends and Density

The most currently used (1992) population estimates derived from aerial inventories place the regional population at nearly 26,000

Table 1. Sex and age composition of voluntarily registered hunter harvested moose, combined for 14 WMU's in north central Ontario and extending over three distinct management periods, from 1977 to 1990. A) unlimited, non selective, B) party harvest system, C) selective harvest.

		PERCENT TOTAL				PERCENT BULLS			PERCENT COWS		
Strategy	Year	n	Bulls	Cows	Calves	NB	Teen (1)	Prime (2)	NC	Yearlings	Breeders (3)
A	1977	2067	47.1	39.2	13.7	856	78.6	18.5	701	44.9	55.1
	1978	2122	50.2	35.7	14.1	899	76.8	19.4	648	31.9	68.1
	1979	2409	45.8	39.4	14.7	949	80.8	16.9	800	28.6	71.4
	x		***47.7**	***38.1**	**14.2**		***78.7**	***18.3**		**35.1**	**64.9**
B	1980	1295	49.8	38.0	12.2	549	82.3	13.5	429	38.9	61.1
	1981	1680	52.0	37.7	10.2	769	82.7	14.3	551	34.5	65.5
	1982	2284	48.4	39.6	12.0	941	84.4	13.7	764	36.0	64.0
	x		**50.1**	**38.4****	***11.5**		***83.1****	***13.8****		**36.5**	**63.5**
C	1983	1996	56.8	31.3	11.9	972	79.0	17.4	546	34.1	65.9
	1984	1942	54.9	30.8	14.3	899	81.3	16.1	497	31.4	68.6
	1985	2068	50.3	31.3	18.3	846	77.2	20.1	523	31.5	68.5
	1986	2132	54.3	28.3	17.4	944	78.6	19.2	496	31.2	68.8
	1987	1981	57.0	25.0	18.0	887	80.2	18.5	358	31.3	68.7
	1988	2619	49.3	26.4	23.8	1054	80.6	16.5	564	33.7	66.3
	1989	1788	52.3	26.8	20.7	780	81.3	17.6	399	30.6	69.4
	1990	2115	54.3	24.1	21.1	807	77.7	19.5	358	28.8	71.2
	x		***53.7**	***28.0****	***18.2**		**79.5****	**18.1****		**31.6**	**68.4**
F value			6.563 (p=0.0133)	28.959 (p=0.0001)	5.778 (p=0.0193)		7.041 (p=0.0107)	13.330 (p=0.0011)		1.970 (A=B=C)	1.970 (A=B=C)

(1) Teen = 1.5 - 4.5 yrs (2) Prime = 5.5 - 10.5 yrs (3) Breeders = ≥2.5 yrs
TOTAL N = No. of animals registered NB = No. of aged bulls NC = No. of aged cows
Significant differences tested using an ANOVA and Scheffe's test are indicated by matching asterices at a 95% significance level (F values given in table).

Table 2. Adult bull and cow moose harvest quotas (Q) and estimated harvests (H) for resident hunters in 14 WMU's north central Ontario, 1983-91. Estimated harvests calculated from District Mail Surveys.

WMU	1983		1984		1985		1986		1987		1988		1989		1990		1991		Year 2000
	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Q	H	Harvest Target**
11A	23		23	40	42	39	42	53	47	46	47	68	48	44	47	52	47	56	175
11B	50		50	48	43	60	43	73	56	75	56	90	56	80	56	105	56	90	100
12A	93		93	114	99	122	99	101	94	91	94	139	94	114	77	126	94	128	235
12B	158	322*	158	274	196	228	196	225	166	188	166	204	191	184	191	226	191	240	365
13	397	575*	397	463	407	497	407	567	385	495	385	629	588	543	588	595	588	541	765
14	62	80*	62	48	65	57	67	66	67	49	67	48	67	49	67	41	65	35	80
15B	436	346*	436	381	458	438	453	466	363	421	365	424	354	408	354	470	354	398	1020
16C	53		53	39	71	51	71	54	75	43	70	56	70	39	54	30	70	35	190
17	77		77	30	93	24	93	26	97	24	97	29	97	41	97	37	97	31	315
18A	62		62	40	38	46	38	51	32	34	32	50	30	34	30	34	30	29	385
18B	7		7	9	33	17	38	22	41	32	44	46	44	27	44	35	44	39	205
19	128	201*	128	132	105	150	105	150	95	126	76	103	76	98	76	85	68	65	700
21A	345		313	371	313	444	313	349	285	346	285	320	285	289	285	355	214	201	930
21B	325	413*	317	323	304	428	317	360	289	315	289	350	289	409	191	330	196	259	875
Total	2216	1937	2176	2312	2267	2601	2282	2563	2092	2285	2073	2556	2289	2359	2157	2521	2114	2147	6340
Over/Under (+/-) Harvest	(+) 431	(+)29%	(+)136	(+)6%	(+)334	(+)15%	(+)281	(+)12%	(+)193	(+)9%	(+)483	(+)23%	(+)70	(+)3%	(+)364	(+)17%	(+)33	(+)2%	

* Harvests based on district post hunt questionnaires for bull and cow resident gun hunters only - only six WMU's completed in 1983

** Includes adult and calf gun and archery harvest target plus an additional 8% Tourist Industry component or about two thirds of the year 2000 target of 39,000 (Table 3). Population density estimates for 10 of 14 WMU's where four or more aerial inventories have been completed since the mid 1970's are illustrated in Figure 4a. Populations in WMU's west of Lake Nipigon (Fig. 1) approach or exceed year 2000 targets, while those WMU's east of Lake Nipigon and north of Lake Superior are generally well below target densities. The exception is WMU 14 which shows a substantial population decline since the mid 1980's. Several factors including mortalities related to winter tick (Samuel and Welch 1991) and an eruption of white-tailed deer carrying the "brainworm" *Parelaphostrongylus tenuis* (Karns 1967, Whitlaw, unpub. data), as well as improved hunter access and predation, are believed to have contributed to the decline.

Over time, there was no significant change in pooled moose population densities before ($p=0.346$, $r^2=0.03$) or after ($p=0.620$, $r^2=0.01$) the introduction of the selective harvest system (Fig. 4b). Mean population densities for WMU's west of Lake Nipigon however were higher than those east of Lake Nipigon both before ($p=0.0003$) and after ($p=0.001$) the implementation of selective harvest (Fig. 4c).

Mean adult sex ratios in the population have varied from 48 to 76 bulls/100 cows and densities from 0.12 to 0.42 per km^2 among 5 hunted WMU's over 17 surveys (Table 4).

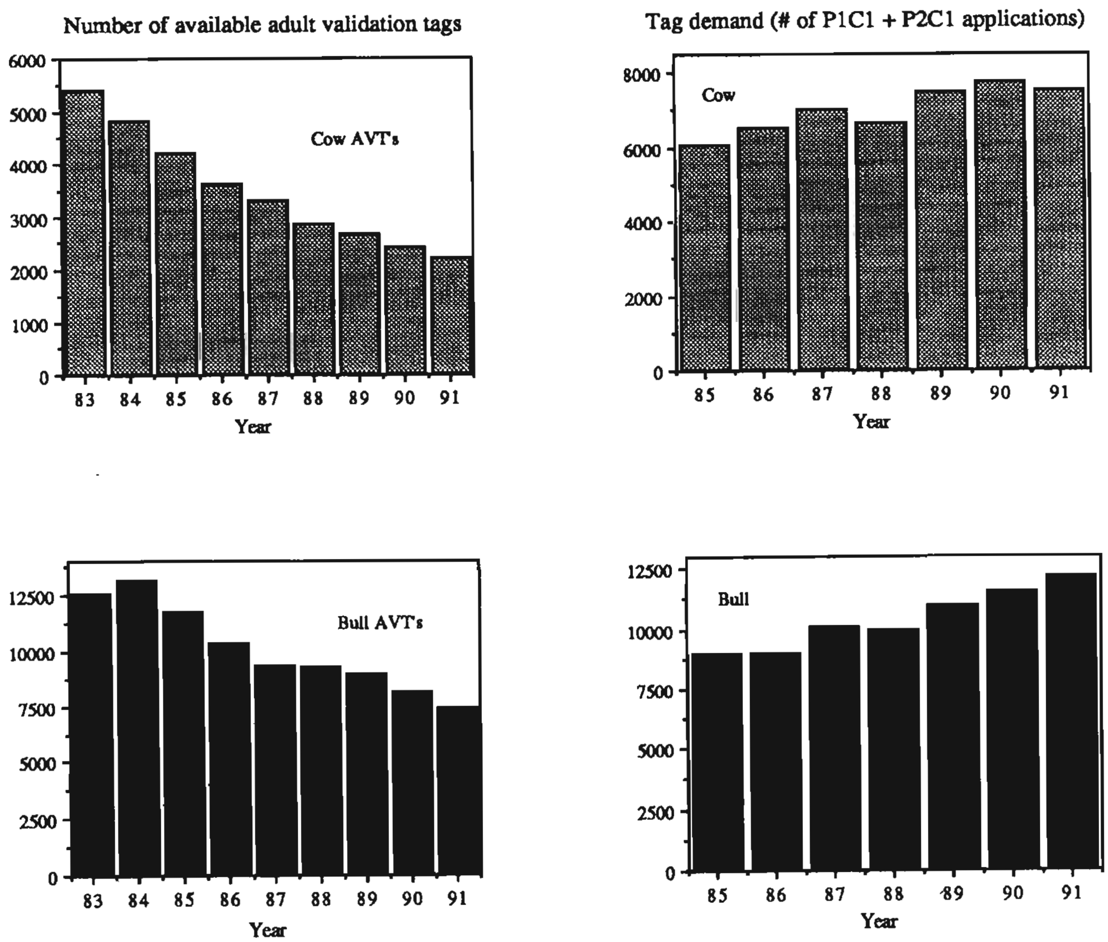

Fig. 3. Number of adult bull and cow tags available (1983-91) and corresponding tag demand (1985-91) for 14 WMU's, north central Ontario.

Table 3. Current population, density and harvest estimates, and year 2000 targets for 14 WMU's, north central Ontario.

WMU	[1]Land Area (km^2)	Population: [2]Current	Population: [3]Year 2000 target	Density ($/km^2$): [2]Current	Density ($/km^2$): [3]Year 2000 target	Harvest: [4]Current	Harvest: [5]Rate(%)	Harvest: [3]Year 2000 target	Harvest: [5]Rate(%)	[6]% of Year 2000 harvest target
11A	2,589	1,097±440 (91)	1010	0.42	0.39	66	5.7	177	17.5	37.3
11B	1,489	530±221 (90)	581	0.36	0.39	110	17.2	102	17.5	107.8
12A	3,435	1,068±263 (90)	1,340	0.31	0.39	152	12.5	235	17.5	64.7
12B	5,354	2,463±406 (92)	2,088	0.46	0.39	246	9.1	365	17.5	67.4
13	11,213	4,013±1133 (92)	4,373	0.36	0.39	707	15.0	765	17.5	92.4
14	1,186	325±159 (92)	463	0.27	0.39	55	14.5	81	17.5	67.9
15B	14,946	5,440±918 (91)	5,844	0.36	0.39	521	8.7	1,023	17.5	50.9
16C	8,671	1,134±354 (90)	1,447	0.13	0.15	50	4.2	181	12.5	27.6
17	27,968	1,875±598 (84)	2,965	0.07	0.11	43	2.2	365	12.3	11.8
18A	7,817	657±149 (92)	2,580	0.08	0.33	47	6.7	387	15.0	12.1
18B	10,990	1,079±369 (85)	1,649	0.10	0.15	43	3.8	206	12.5	20.9
19	10,268	1,330±349 (90)	4,015	0.13	0.39	114	7.9	700	17.5	16.3
21A	13,640	2,454±486 (90)	5,320	0.18	0.39	386	13.6	931	17.5	41.5
21B	12,795	2,179±1597 (91)	4,990	0.17	0.39	436	16.7	873	17.5	49.9
TOTAL		25,651	38,665							

[1] Bisset (1991) - The land area for WMU 16C does not include Wabakimi Park (975 km^2)

[2] Most recent population estimate (Survey year ie. 92 is the winter of 1991/92)

[3] OMNR (1982)

[4] Current total harvest mean (1988-90), bulls and cows (DMS) + 20% additional calves for resident gun hunters

[5] Pre-harvest rate (%) = (harvest estimate)/(population estimate + harvest estimate)

[6] A conservative estimate that does not include approximately 3% archery harvest quota and approximately 10% Tourist Industry harvest quota for the Region.

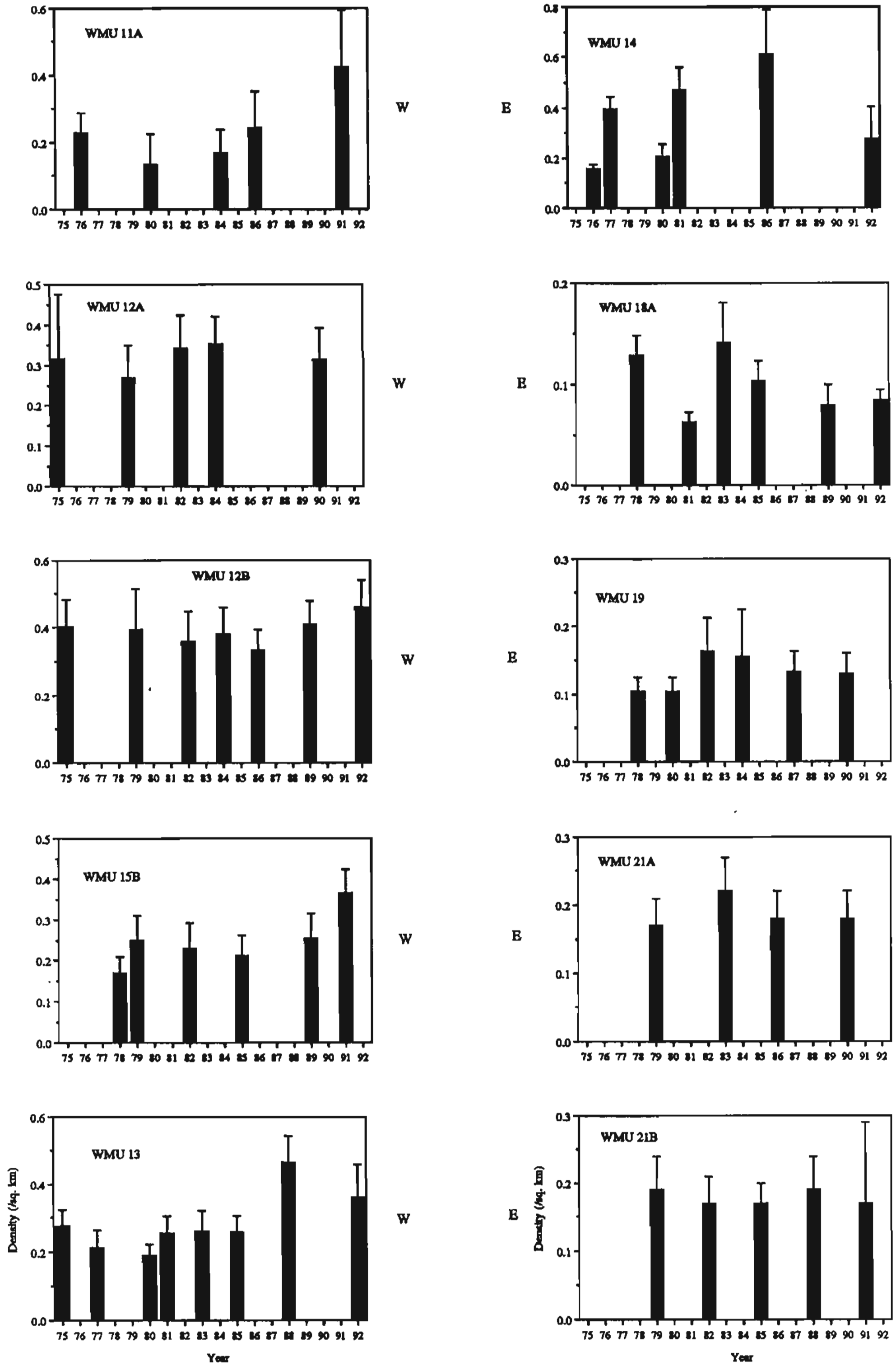

Fig. 4a. Population density estimates (estimate/land area) for 10 WMU's based on provincial standards for moose population inventory (Bisset 1991). Capped bars represent 95% confidence intervals for the estimated population mean. W & E designate WMU's west and east of Lake Nipigon.

Table 4. Observed adult sex ratios and calf-cow ratios as determined from rotary wing aerial surveys conducted post-hunt during December and January in north central Ontario.

				Most Recent Survey			
Area/WMU	Mean Bulls/100 Cows (Range)	N_t	No. of Years	Survey Year	Density (/km²)	Ca/100 Cows[1]	% Calves (N_y)
[2]Camp 236	83(54-126)	843	7	91/92	0.82	33	17.8(107)
[2]McKenzie-Cache Lake	73(43-101)	1338	13	87/88	2.42	38	16.6(145)
WMU 12B	66(57-79)	1345	4	91/92	0.46	37	17.1(420)
WMU 13	48(37-63)	1214	4	91/92	0.36	37	21.0(398)
WMU 15B	69(62-76)	827	3	90/91	0.36	23	12.6(425)
WMU 19	76(64-92)	558	3	89/90	0.13	39	18.7(212)
WMU 21B	58(49-68)	648	3	90/91	0.17	41	20.5(217)

[1] Ratio includes all cows ≥1.5 yrs [2] Unhunted logged control area
N_t = total number of observations for all years N_y = total number of moose observed for the most recent survey

Ratios and densities in two unhunted, recently logged control areas in the Thunder Bay area are higher (73 to 83 bulls/100 cows and 0.82 - 2.42 moose/km²). Managers are targeting 67/100 as a minimum adult bull/cow ratio to ensure the majority of cows are successfully bred. Current bull/cow ratios are below this arbitrary threshold in both WMU 13 and 21B. We have no evidence to suggest that these adult sex ratios are affecting pregnancy rates (Timmermann 1992).

Harvest Target Assessment

The proportions of recent harvests are based on current population estimates and a three year (1988-90) mean harvest (Table 3). Current moose harvests in most WMU's are well below year 2000 targets. Mean harvests (1988-90) were 25% below target in four WMU's, between 25-70% of target in eight WMU's and near or at target levels in only two WMU's (Table 3). Harvest rates vary from lows of 2.2 and 3.8% of the population

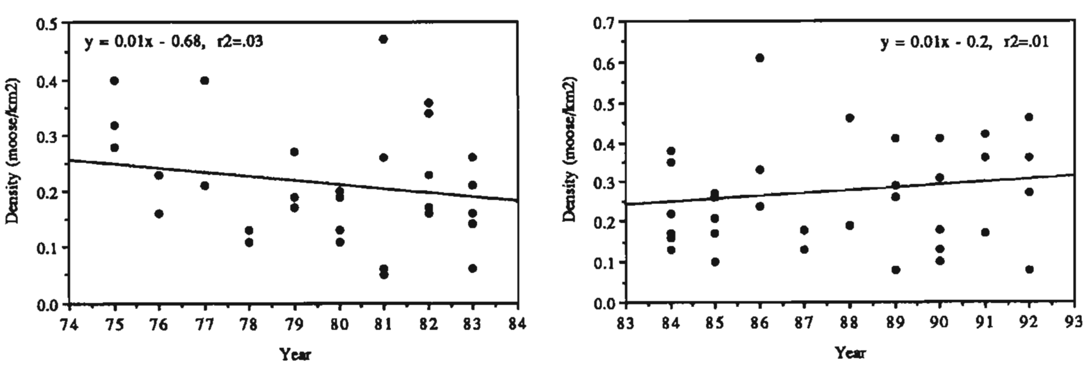

Fig. 4b. Moose density estimates for 30 and 34 WMU surveys before (left) and after (right) introduction of a selective harvest system in north central Ontario.

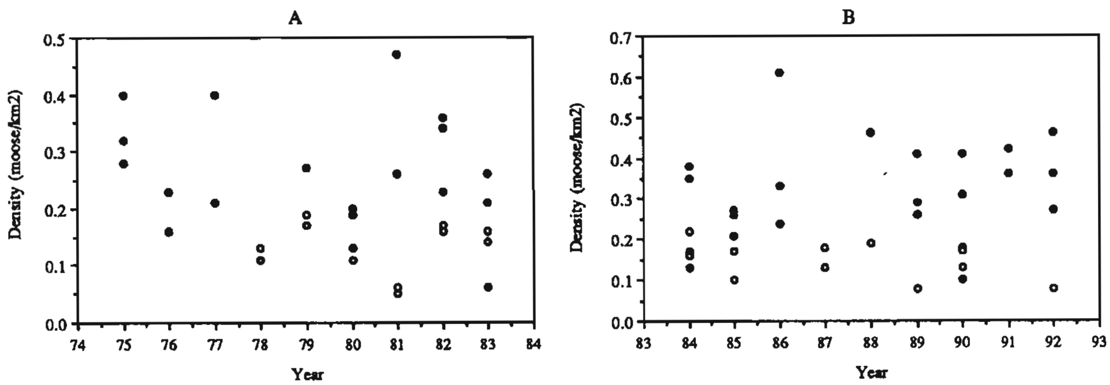

Fig 4c. Moose denstiy estimates for WMU surveys east (open circle) and west (closed circle) of Lake Nipigon, before (A) and after (B) introduction of a selective harvest system.

for remote WMU's 17 and 18B to highs of 17.2 and 16.7% for road accessible WMU's 11B and 21B, the latter being too high, we believe, to sustain current populations. Initiated in 1985, fewer AVT's are being issued in an attempt to reduce overall annual harvest rates and stabilize or increase populations in specific WMU's (Appendix 1).

WMU 13 vs. 21B COMPARISON

Population Parameters

Density estimates, based on aerial surveys, have increased significantly in WMU 13 ($p=0.0265$) since 1985, yet WMU 21B has demonstrated little change since 1979 ($p=0.5055$, Fig. 4a), although the confidence intervals for several surveys are wide. Both WMU's are comparable in size yet inventory data based on the most recent population estimates (1988/89, 90/91 and 91/92) suggest that WMU 13 supports more than double the population (0.36-0.46 vs 0.16-0.18 moose/km^2, Table 5). The presence of white-tailed deer which provide an alternate prey to wolves (*Canis lupus*) (Bergerud 1992) and a more productive land base in WMU 13 (see Land Capability section) are believed largely responsible. Population sex and age parameters are similar (ie. a 2:1 ratio favouring cows and a mean of approximately 40 percent prime bulls in the male component, Table 5). Recruitment indices (51 and 37 vs 57 and 41 calves/100 cows and about 26 and 21 percent calves for each survey) are also remarkably similar. A higher twinning rate in WMU 13 observed during the 1987/88 survey may reflect differences in calf survival.

Population Change

Recent inventory data suggest populations in both WMU's have declined slightly since 1988 (Table 5). If we assume these estimates reflect true population values then, the annual finite rate of change (λ) for WMU 13 was 0.94 and 0.96 for WMU 21B. Likewise, the combined estimates of total annual mortality (Mn + Mh) were 29.98% (14.98 + 15.0) and 28.4% (11.7 + 16.7) respectively, based on the relationship $Mn = 1 - [\lambda(1-R)/(1-Mh)]$ reported by Hatter and Bergerud (1991). These combined losses exceed the 8 month mean recruitment (R) of calves (23.3 and 23.4%, Table 5) by 6.7 and 5.0% respectively. We suggest that populations in either WMU cannot sustain recent harvest rates (Table 3), without a corresponding reduction in natural mortality.

Harvest Levels and Composition

Adult bull and cow harvest quotas have consistently been set higher in WMU 13 ($\bar{x}_9$=460, range 385-588) than in 21B ($\bar{x}_9$=280, range 191-325, Table 2, Fig. 5). Mean bull harvests since 1984 have generally been 42% higher in WMU 13 ($\bar{x}_8$=351, range 294-408 vs

Table 5. A comparison of population and harvest data for WMU 13, representing a population growth response and WMU 21B, representing population stability.

POPULATION PARAMETER[1]	WMU 13 (N)		WMU 21B (N)	
Size (km^2) - Land (water)	11,213 (2112)		12,795 (705)	
Year of Survey	1987/88	1991/92	1987/88	1990/91
Estimated population	5,199	4013	2430	2,179
Density (/km^2)	0.46	0.36	0.19	0.17
Total Observations	533	398	221	217
Bulls/100 cows	49	45	48	58
% Prime bulls	51	27	17	62
Ca/100 cows	51	37	57	41
% Calves	25.7	21.0	26.2	20.5
% Twin calves	19.4	3.8	11.5	2.8
λ (1988-92)	.94		.96	
HARVEST PARAMETER[2]				
x_8 # Bull AVT's (range)	1635(1415-1881)		1541(730-2295)	
x_8 Bull harvest (range)	351(294-408)		248(214-298)	
x_{7a} Mean age of bulls (≥1.5 years)	3.32±0.02		3.85±0.02	
x_8 % Bulls total	51.8(3756)		53.0(2067)	
x_8 % Teen bulls	84.2(1748)		74.6(845)	
x_8 % Prime bulls	14.2(1748)		21.8(845)	
x_8 % Success Bull AVT holders (range)	24(18-27)		19(14-31)	
x_{7b} Demand (range)	2110(1699-2537)		1891(1605-2125)	
x_6 Effort (days/bull shot) (range)	43.1(41.9-45.6)		53.4(32.2-66.2)	
x_8 Cow AVT's (range)	594(410-801)		526(220-775)	
x_8 Cow harvest (range)	190(150-232)		99(45-130)	
x_{7a} Mean age of cows (≥1.5 years)	3.85±0.11		4.41±0.19	
x_8 % Cows total	28.5(3756)		31.7(2067)	
x_8 % Yearling cows	32.8(946)		34.7(501)	
x_8 % Breeding cows	67.2(946)		65.3(501)	
x_8 % Success Cow AVT holders (range)	36(24-45)		27(12-49)	
x_{7b} Demand (range)	1299(1144-1483)		1304(1272-1395)	
x_6 Effort (days/cow shot) (range)	26.2(20.2-33.0)		35.8(20.9-61.0)	
x_8 % Calves total	19.4(3756)		14.6(2067)	
x_8 B/C Tag ratio	2.9/1		3.6/1	
x_8 B/C Harvest ratio	1.9/1		2.4/1	
x_6 No. moose seen/day	0.39		0.14	

[1] Rotary-wing inventory/composition surveys conducted in January 1988 and January 1992 on 53 plots in WMU 13 and January 1988 and January 1991 on 56 plots in WMU 21B. All plots are randomly selected and 2.5 x 10 km (25 km^2) in area.

[2] Parameters are mean values for the following years: x_8 = 1984-91, x_{7a} = 1984-90, x_{7b} = 1985-91 and x_6 = 1986-91.

248, range 214-298, Appendix 3, Table 5). Although harvested bulls in total represented 51.8 and 53.0 percent respectively in WMU 13 and 21B, their age structure varied considerably (84.2% vs 74.6% teen and 14.2% vs 21.8% prime, Table 5). Additionally, the mean age of adult bulls ($\geq$1.5 yrs) was 3.32 vs 3.85 years (Table 5), suggesting lower bull recruitment or vulnerability in 21B. Bull/cow tag ratios (2.9 and 3.6/1) produced a lower harvest ratio of bull/cow in the WMU 13 harvest (1.9 vs 2.4/1, Table 5). Mean cow harvests since 1984 have been 92% higher in WMU 13 ($\bar{x}_8$=190, range 150-232) than in WMU 21B ($\bar{x}_8$=99, range 45-130, Appendix 3, Table 5). The proportion of cows in the total harvest was lower (28.5% vs 31.7%) although the percentages of yearling cows (32.8% vs 34.7%) and breeders (67.2% vs 65.3%, Table 5) were similar. A significantly younger mean age of adult (¯1.5 yrs) cows (3.85 yrs vs 4.41 yrs, Table 5), a higher percent of calves in the harvest (19.4% vs 14.6%) as well as a higher percent of twins (16% vs 3%) all suggest a higher recruitment rate in WMU 13.

Annual reported jaw samples are believed to be sensitive to population density, but are tempered by changes to available adult bull and cow AVT's and variable moose vulnerability. Similar trends were observed in harvest data (Fig. 5) as in density estimates (Fig. 4a). Harvested bulls, cows and calves increased in WMU 13 from 1980-88, then declined to 1991, whereas little change was evident in WMU 21B except a reduction in harvested cows, believed linked to fewer AVT's issued, beginning in 1989.

Winter Severity

Deep snow, when moose are at high densities, may impact some moose populations by reducing recruitment and adult survival (Rolley and Keith 1980; Gasaway *et al.* 1983). Prolonged deep snow winters which reduce moose mobility may increase the incidence of malnutrition and vulnerability to wolf predation (Peterson and Allen 1974; Gasaway *et al.* 1983; Larsen *et al.* 1989). A cursory examination of total seasonal snowfall since 1976 reveals 11 of 16 winters fell below the 30 year mean (1960-90) of 213 cm in the Thunder Bay area, within WMU 13. Ten of these, including a record low of 111.7 cm, occurred since 1979-80, coincidental with added party and selective harvest restrictions. Snow depth records from standard snow stations (Passmore 1953) scattered across north central Ontario also verify reduced snow depths and milder winters during the 1980's.

More specifically, analysis of snow course data identified differences in winter severity between WMU's 13 and 21B (Table 6). WMU 21B has a deeper range of mean cumulative snow depths (SDI) in both weeks 16 and 32 (range 428-441cm and 1239-1295cm), than does WMU 13 (range 260-317cm and 722-940cm). WMU 21B also has a deeper mean maximum snow depth (83.6cm vs. 58.5-68.1cm), and on average, has more weeks with snow (24.0 vs 19.2-21.3; Table 6). This analysis suggests the influence of snow depth and duration, on forage quality and moose, is greater in WMU 21B than in 13.

Land Capability

WMU 13 appears to be more productive than 21B based on differences in land capability to produce year-round moose habitat (Table 7). Over half (53.0%) of WMU 13's land base is classified High or Medium, compared to 26.7% in 21B. We expect the High productivity classes to provide a relatively even abundance of summer feeding, early and late winter habitat requirements for moose. The Medium class would have essentially the same abundance, with V34 (Black spruce/Labrador Tea/Feathermoss/Sphagnum) providing thermoregulatory values, whereas the Low class would fulfill primarily thermoregulation requirements. We believe good year-round moose habitat requires a balanced mix of all three productivity classes.

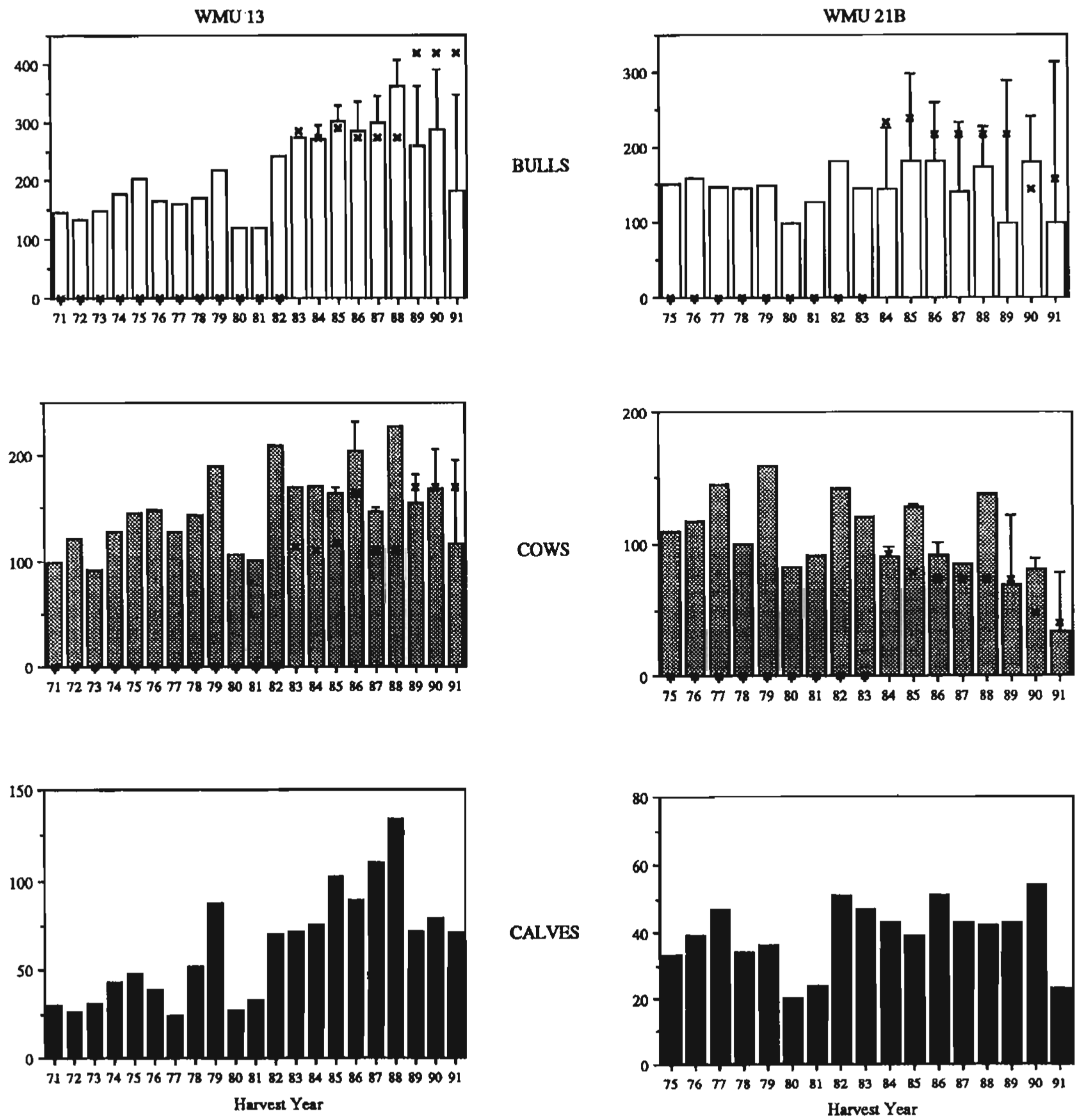

Fig. 5. A comparison of bull, cow and calf harvests voluntarily reported by hunters for WMU's 13 and 21B, 1971-91 (bars). Estimated total adult harvests (capped bars) and quotas (x) are displayed beginning in 1983 and 1984 respectively.

Two limitations affect this analysis: 1) the Forest Ecosystem Classification System for Northwestern Ontario (Sims *et al.* 1989) does not apply to early successional stages and 2) the moose habitat interpretations have not yet been field tested. We suggest however, that WMU 13 has a greater potential to produce year-round moose habitat than does WMU 21B, especially since the latter appears limited by its high proportion of low productivity areas (Table 7).

Data from these two WMU's, one representing a population growth response and the other representing population stability during the 1980's suggest population densities are related, in part, to differences in winter severity and land capability. Other mortality factors, including predator removal, subsistence harvests, other non-hunting losses and excessive sport harvests may also contribute to

Table 6. Mean cumulative snow depths, mean maximum snow depth and mean number of weeks with snow for WMU's 13 and 21B, NCR - (1954-1986).

Snow Course Station (Course number)	Cumulative Snow Depth - Wk 16 (cm)	Cumulative Snow Depth - Wk 32 (cm)	Number of Years Sampled	Mean Maximum Snow Depth (cm)	Mean Number of Weeks with Snow
WMU 13					
Thunder Bay (250)	260	722	34	58.5	19.2
White Fish (258)	317	864	13	65.5	20.3
Upsala* (257)	343	940	24	68.1	21.3
WMU 21B					
Manitouwadge (241)	441	1239	29	83.6	24.0
Hornepayne (341)	428	1295	33	•	•

* Upsala snow course station is immediately west of the western boundary of WMU 13

differences in densities, and are being investigated.

REGIONAL POPULATION COMPARISONS

Population Trends in Adjacent Jurisdictions

Population trends (1983-92) appear remarkably similar between adjacent jurisdictions (Isle Royale, northeastern Minnesota and selected WMU's of north central Ontario). Mean densities and percent calves generally increased in a step wise manner; peaking in 1988-89 and then declined into the early 1990's, although confidence intervals generally overlapped (Fig. 6). A similar pattern was apparent in WMU 13 harvest data (Fig. 5).

Meterological data from Thunder Bay (Fig. 7) and adjacent northeastern Minnesota (Peterson and Lankester 1991) confirm that 1987 and 1988 were unusually mild [ie. record low snowfall (112 and 114 cm), longer snowfree days (237 and 238), greater summer precipitation (41.5 and 42.8 cm) and mean temperatures (14.7 and 14.8ƒC) well above long term values]. In contrast, weather conditions in 1989 were much more severe (219 cm, 201 days, 34.6 cm and 12.5ƒC respectively).

Peterson (pers. comm. 1992) attributed the Isle Royale moose population decline (about 25%, 1988-90, Fig. 6) to the influence of winter ticks which he believed greatly

Table 7. A comparison of productivity classes based on differences and limitations in land capability to produce year-round moose habitat, WMU 13 vs 21B.

WMU	Land Area (km^2)	Productivity Class - land area (km^2) & (%) High	Medium	Low
13	11,213	4,093	1,850	5,270
		(36.5)	(16.5)	(47.0)
21B	12,795	2,521	896	9,379
		(19.7)	(7.0)	(73.3)

increased following the warm early springs of 1987 and 1988. About one third of all moose observed in February 1989 had hairless patches - a 10-fold increase over the usual level. Likewise, Lenarz (pers. comm. 1992) believes the moose decline (0.54 - 0.30 /km^2, Fig. 6) in northeastern Minnesota 1989-91 was tick related. He reported 46% of moose observed in March 1991 had observable hairloss (Lenarz 1992). As a result of lower densities, the planned 1991 season was cancelled. Recent surveys suggest populations are again increasing in both jurisdictions (Fig. 6) with a corresponding reduction in observed tick related hair loss. Wilton (pers. comm. 1992) suggested a major tick related moose die-off occurred in Ontario's Algonquin Provincial Park during the spring of 1992. In excess of 40 carcasses were reported found during annual spring cow-calf surveys, conducted since 1981 (Wilton and Garner 1991). The previous high was 21 carcasses, observed in 1988.

Drew and Samuel (1985, 1986) reported a close relationship between weather, moose and larval winter ticks. They found survival of engorged female ticks under field conditions was related to early snow melt in spring and believe environmental conditions, especially temperature, determine the numbers of larval winter ticks available for infesting moose the following autumn. McLaughlin and Addison (1986) reported captive moose, with extensive premature hair-loss, had less pericardial and abdominal visceral fat than moose with little or no hair-loss. This suggests that these moose could be more susceptible to predation and disease and, in severe cases, could result in catabolic shock and death. Wild moose may be similiarly affected.

Tick outbreaks causing significant moose mortality were reported across large portions of the North American moose range in the 1930's and early 1940's (Peterson 1955). Tick related dieoffs were documented in Nova Scotia (1930-35), New Brunswick (early 1930's), Ontario (1933-39), Alberta (1932-35), western Canadian national parks (1943)

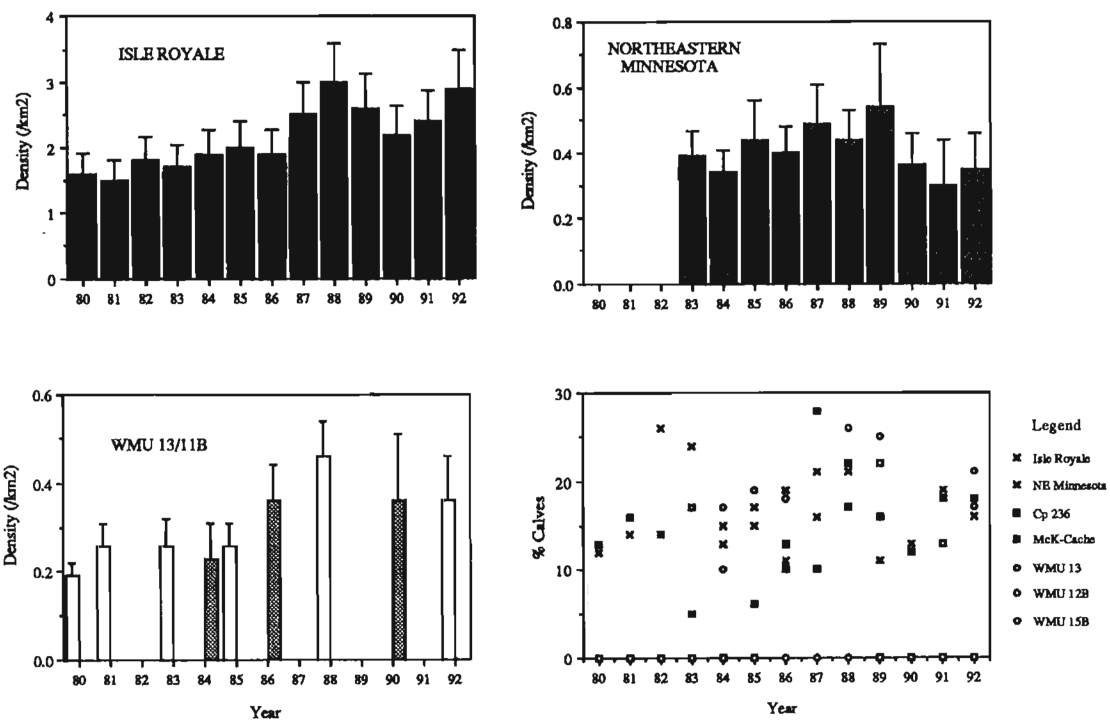

Fig. 6. Density and percent calf estimates for adjacent jurisdictions/WMU's based on December and January aerial surveys.

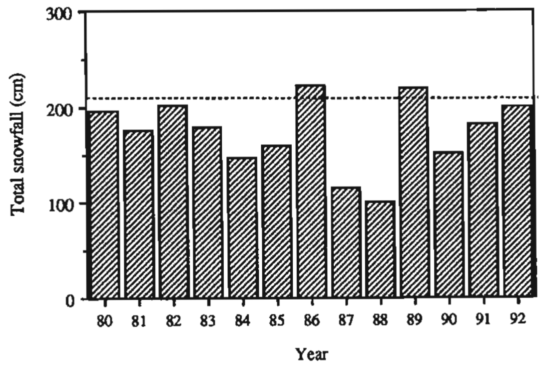

Fig. 7. Total annual snowfall for Thunder Bay, Ontario 1980-92. (--- indicates 30 year mean of 212 cm).

and in British Columbia (early 1940's). The heaviest tick infestations were coincidental with high moose densites (Peterson 1955). Several jurisdictions closed their moose season due to decreased moose populations (ie. Saskatchewan in 1946, Manitoba in 1945 and Ontario in 1949). Cowan (1951) concluded that ticks are "the most harmful of all moose parasites and probably causes more losses than all other parasites and diseases combined".

Dieoffs of moose on Isle Royale (Peterson and Page 1983) coincided with those reported elsewhere by Peterson (1955). The first occured in the mid 1930's and reduced the population from 1000-3000 to a "relatively low level" (Murie 1934; Peterson and Page 1983). The second, reported by Krefting (1974), occured in the late 1940's. Malnutrition, due to a reduced forage base was suggested as the principal causal agent in both, but could ticks have been implicated? To our knowledge reports of abrupt moose dieoffs directly linked to food shortage are uncommon and poorly documented (Cumming 1987; Bergerud 1981). In addition to Isle Royale, insufficient food has been suggested as the principal cause of winter mortality only on the Kenai penninsula, AK, in 1922-23 (Spencer and Chatelain 1953).

We believe a relationship exists between weather and tick induced moose mortality in northeastern Minnesota and on Isle Royale, regardless of hunting pressure or the presence of white-tailed deer. Ticks may have also been responsible for declines in adjacent WMU's 11B, 13 and 14, although no evaluations have been made. Isle Royale has no hunting, no deer and a very high (±3/km^2) moose population (Fig. 6). Nearby northeast Minnesota has a 'light" moose harvest every second year (Lenarz pers. comm. 1992), a rapidly increasing deer population, fluctuating from 2.8-6.4/km^2 (Dexter 1991) and a moderate (±0.35/km^2) (Fig. 6) moose density. Current moose densities in adjacent WMU 13,11B and 14 are similar, deer densities much lower and annual moose harvest rates much higher (ie. 14.5 to 17.2%, Table 3). Morris (1959) noted that often the major, common mortality factors may not be as important in influencing population fluctuations as those variable factors that operate inconsistently.

SUMMARY AND CONCLUSIONS

Program Overview

A majority of hunters appear to support the selective harvest system, including its modifications such as the legalization of party hunting in 1988 and the addition of a group application in 1992 to help improve tag distribution. After nine years, both hunter numbers and overall harvests in north central Ontario approximate those experienced prior to the inception of the party harvest system (ie. late 1970's). As well, recreational opportunities and the average number of moose observed per hunter have both increased since 1983. Harvest composition has changed in the expected direction from the previous two harvest strategies - the proportions of bulls and calves harvested has increased significantly, while the cow harvest is significantly lower.

Aerial inventories since 1983 suggest that moose populations west of Lake Nipigon have generally reached or exceed year 2000 targets, while those to the east have generally failed to grow. Mean adult winter population sex ratios in 5 WMU's have varied from 53 to 76 bulls/100 cows, bracketing the minimum target of 67/100 set by managers. Recruitment in these 5 WMU's varied from 23 to 51 calves/100 cows, based on recent surveys. During the 8 year period 1984-1991, adult harvests (19,344) exceeded quotas (17,450) by 11%. In addition, an estimated 3,675 calves were also taken. Total adult bull and cow tags (AVT's) have been reduced 47% from 17,974 in 1983 to 9,585 in 1992. Reductions occurred in 10 and increases in 4 WMU's, largely in response to increasing success rates. Overall demand for adult tags has increased 31% between 1985 and 1991.

WMU 13 vs. 21B Comparison

Data from two WMU's, one representing a population increase and the other relative population stability suggest population densities are related, in part, to differences in winter severity and land capability. Other mortality factors, including predator removal, subsistence harvests, non-hunting losses and excessive sport harvests may also contribute to differences in densities, and are being further investigated. Recent inventory data suggest populations in both WMU's have declined slightly since 1988 (λ=0.94 and 0.96 respectively). Estimates of total mortality from all causes (29.98 and 28.4%) exceed the 8 month mean recruitments of 23.3 and 23.4% respectively.

We conclude that populations in either WMU cannot sustain recent harvest rates of 15.0 and 16.7% without a corresponding reduction in natural mortality levels. We believe overall population and harvest targets are unrealistically high and non-sustainable in many WMU's, given the multitude of natural and human influenced mortality factors over which managers have little or no control. Furthermore, our ability to measure changes and adjust hunter harvests in a timely manner in all WMU's are limited by shrinking budgets and changing priorities. In future, consideration should be given to narrowing the focus to a few representative WMU's and determine key factors which cause significant population changes.

We recommend that current population and harvest targets need to be reviewed and adjusted to land capability and that lower and more flexible harvest rates be tailored to achieve these targets. Concurrently, the expectations of all consumptive users must be lowered. Improved mortality estimates from all causes and an expanded hunter education/communications effort are a prerequisite in maintaining program support and credibility, as well as evaluating population dynamics.

Regional Population Comparisons

Adjacent jurisdictions (Isle Royale, northeastern Minnesota and selected WMU's) show similar population trends, regardless of density, hunter harvest or the presence/absence of deer. We suggest short-term changes in weather patterns in the late 1980's are linked to changes in populations, where densities are $^{-}0.30/km^2$. Winter ticks are believed to have been associated with synchronous population reductions in northeastern Minnesota and on Isle Royale. Evidence to suggest similar tick related mortality, although circumstantial, is not available for WMU's 11B, 13 and 14. We recommend that further research on weather-related population changes of both moose and ticks is justified.

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Appendix 1: Number of adult bull and cow tags available in the resident gun draw for 14 WMU's in north central Ontario, 1983-92

WMU	1983 B	1983 C	1984 B	1984 C	1985 B	1985 C	1986 B	1986 C	1987 B	1987 C	1988 B	1988 C	1989 B	1989 C	1990 B	1990 C	1991 B	1991 C	1992 B	1992 C
11A	111	44	115	40	100	60	100	70	110	70	110	70	110	50	110	50	120	60	120	60
11B	235	102	250	100	205	95	145	65	165	80	165	80	150	65	115	65	115	65	115	65
12A	431	197	475	175	355	155	285	110	285	110	285	110	285	90	285	90	285	70	285	70
12B	739	285	770	280	750	190	675	160	635	150	500	150	500	150	500	170	500	170	500	170
13	1881	801	1880	700	1690	560	1415	780	1415	410	1600	500	1600	500	1600	500	1600	500	1600	500
14	180	81	200	75	200	60	200	70	200	70	200	70	200	70	200	70	200	70	90	20
15B	2190	947	2450	950	2490	830	2420	800	1480	505	1480	505	1270	465	1270	405	1350	405	1350	405
16C	220	119	250	100	255	110	270	105	270	120	270	120	270	120	270	120	270	120	270	120
17	413	208	465	185	560	260	560	220	560	270	560	270	560	270	560	270	560	270	560	270
18A	479	210	500	200	335	95	310	45	265	45	265	45	195	45	195	25	170	30	170	30
18B	64	12	80	20	200	60	160	65	185	100	185	100	185	100	185	100	230	140	230	140
19	850	374	815	285	665	200	515	160	425	90	265	65	265	65	210	65	185	55	185	55
21A	2470	1032	2605	945	2000	800	1585	440	1585	440	1585	290	1585	290	1585	255	1070	130	1070	130
21B	2320	979	2295	775	1940	735	1755	540	1755	540	1755	475	1755	395	1069	220	730	115	630	115
Total	12 583	5 391	13 150	4 830	11 745	4 210	10 395	3 630	9 335	3 300	9 225	2 850	8 930	2 675	8 154	2 405	7 385	2 200	7 175	2 386

Appendix 2: Demand (P1C1 + P2C1) for bull and cow adult validation tags in the resident gun draw for 14 WMU's in north central Ontario, 1985 - 91.

	1985		1986		1987		1988		1989		1990		1991	
WMU	B	C	B	C	B	C	B	C	B	C	B	C	B	C
11A	105	64	107	55	131	90	127	92	159	100	156	117	206	117
11B	147	100	160	125	243	167	225	133	247	165	316	203	357	214
12A	250	170	263	184	306	171	290	161	387	221	468	287	464	253
12B	841	565	765	544	818	557	819	489	876	583	887	603	956	586
13	1699	1144	1760	1172	1985	1191	2170	1274	2307	1483	2313	1425	2537	1404
14	120	108	119	125	141	148	89	132	108	132	113	139	98	132
15B	1379	882	1317	923	1544	1127	1483	1066	1640	1109	1819	1296	1904	1235
16C	170	101	147	110	185	119	165	112	171	122	160	122	152	90
17	131	78	132	83	112	75	159	96	178	137	196	137	175	137
18A	231	153	174	131	228	209	253	207	274	235	282	200	326	214
18B	42	22	79	49	134	76	149	99	166	95	157	96	174	119
19	833	509	818	555	873	532	857	489	902	488	886	451	743	365
21A	1445	1013	1528	1203	1506	1246	1368	1021	1552	1243	1725	1307	1935	1246
21B	1605	1159	1631	1278	1872	1312	1832	1272	2070	1352	2108	1362	2125	1395
Total	8 998	6 068	9 000	6 537	10 078	7 020	9 986	6 643	11 037	7 465	11 586	7 745	12 152	7 507

Appendix 3: Estimated resident gun harvest* 1984-1991, north central Ontario. Estimates are obtained from District Mail Survey

	1984			1985			1986			1987			1988			1989			1990			1991		
WMU	B	C	Ca	B	C	Ca	B	C	Ca	B	C	Ca	B	C	Ca	B	C	Ca	B	C	Ca	B	C	Ca
11A	34	6	6	29	10	3	33	20	4	35	11	0	42	26	5	27	17	1	36	16	5	44	12	3
11B	32	16	12	44	16	12	51	22	11	49	26	6	56	34	9	61	19	9	66	39	1	54	36	5
12A	74	40	9	76	46	11	66	35	7	63	28	14	92	47	8	81	33	6	78	48	6	101	27	5
12B	174	100	32	160	68	28	165	60	34	140	48	22	136	68	17	126	58	12	153	73	9	154	86	4
13	294	169	89	328	169	80	335	232	42	345	150	50	408	221	57	362	181	36	390	205	37	347	194	48
14	35	13	3	34	24	13	42	24	13	27	22	4	33	15	8	20	29	5	27	14	8	24	11	5
15B	238	143	42	231	207	35	317	149	38	307	114	18	296	128	23	276	132	19	323	147	8	267	131	21
16C	27	12	6	34	17	5	37	17	4	28	15	6	34	22	6	26	13	2	19	11	3	27	8	4
17	22	8	0	14	10	3	19	7	1	15	9	1	20	9	5	30	11	5	18	19	7	17	14	1
18A	22	18	5	19	27	7	37	14	9	29	5	4	33	17	9	26	8	1	30	4	2	21	8	0
18B	7	2	0	12	5	1	17	5	4	21	11	0	33	13	4	22	5	1	28	7	0	24	15	5
19	98	34	7	94	56	16	104	46	10	98	28	6	78	25	5	79	19	3	63	22	0	42	23	2
21A	245	126	6	230	214	79	244	105	54	238	108	2	232	88	36	195	94	20	257	98	55	159	42	10
21B	225	98	17	298	130	47	259	101	24	232	83	18	227	123	25	288	121	13	241	89	28	214	45	11
TOTAL**	2312 (2546)			2601 (2941)			2563 (2818)			2285 (2436)			2556 (2773)			2359 (2492)			2521 (2690)			2147 (2271)		

* Calf harvest is underrepresented due to the large number of applicants for adult validation tags (AVT's) who are unsuccessful in the draw and thus receive no AVT's. Unsuccessful applicants in the draw (hunters who possess only a general moose licence) are not sampled in the mail surveys (either District or Provincial). Estimated Harvest = [(No. animals reported tagged)/(No. valid returns)] * (Total no. AVT's issued)

** Total estimated ADULT TAG resident gun harvest (adult harvest + estimated calf harvest for AVT holders only)