AGE AND SEX STRUCTURE OF HARVESTED MOOSE RELATED TO SEASON MANIPULATION AND ACCESS

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Abstract : Harvests of moose in relation to opening dates of hunting seasons and access development were compared and analysed for data obtained in North Central Ontario from 1971 to 1981. Harvest structure changes occurring in road accessible and non-road accessible areas within one Wildlife Management Unit (WMU) over an eleven year period were examined. Early season harvests in two newly opened self-contained, static road networks over a nine year period following termination of logging are discussed. Significant changes occurred in the early season sex and total season age structure when season opening dates were progressively shifted from 22 September, 1973 to 18 October, 1980. With the exception of the early 22 September season opener, no significant total season sex ratio changes occurred as a result of shifting season opening dates. Significant differences in mean age and sex ratios were related to access. A general pattern of declining harvests occurs in areas where logging activities have terminated, road access remains static and unrestricted hunting is permitted.

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Ontario moose populations generally increased during the early 1960's. Factors favouring population expansion included an increase and dispersal of relatively small clearcuts during the 1950's, mild winters from 1959 to 1964, relatively few hunters and restricted road access by logging companies. Management strategies during this period were quite liberal consisting of either sex seasons extending from 15 September to 8 January each year (Cumming 1974a). Harvests peaked at approximately 14,500 with an estimated 60,000 hunters in 1965 (Cumming 1974b).

During the early 1970's many local moose populations were overexploited and by 1975 the Provincial population was estimated to have been reduced by 35% (Ontario Ministry of Natural Resources (O.M.N.R.) 1980).

A number of factors are believed to have contributed to the decline in the North Central Region (N.C.R.) of Ontario. These included:

1) Excessive harvests caused by: a) early season openings during the early 1970's, b) easy access due to road construction from accelerated timber harvests and c) increasing hunter numbers.

2) Severe winters in the region, particularly during winters 1969, 1971 and 1972 (Peterson and Allen 1974).

3) Habitat changes resulting from large scale clearcutting.

4) Predation resulting from a general increase in continental wolf _Canis lupus_ numbers in the 1970's (Mech, pers. comm. April 1977).

5) Suspected increasing year-round harvest by Treaty Indians.

Manipulation of season lengths and opening dates has been the principle strategy employed by the O.M.N.R. to regulate licenced harvests across Ontario during the period 1957-1981 (Cumming 1974b). Seasons in the N.C.R. traditionally opened in mid-to-late September in road accessible northern WMU's, while seasons within road accessible WMU's generally followed a few weeks later. In 1968, seasons were shortened by shifting the closing dates from 8 January to 15 December for Ontario residents and to 15 November for non-residents. In 1973, an exceptionally early 22 September opening date coincided with record hunter participation and a harvest nearly equalling that taken in 1965.

Since 1973, increased licence fees for non-residents, the introduction of resident only areas coupled with delayed season opening dates and a requirement in 1980 to share a moose has reduced the annual kill while still allowing full participation by those who wished to hunt.

Moose harvests in Ontario are closely associated with the creation and maintenance of road access from logging operations. The magnitude of the annual harvest is believed to fluctuate in direct relation to access conditions and season timing. In Ontario, the age and sex composition of moose shot in road accessible areas generally differs from that obtained from more lightly hunted roadless areas (Simkin 1964, Cook 1968). Crête et al. (1981) recently identified similar differences in sex and age structure between lightly and heavily harvested areas in Quebec.

This paper analyzes the effects of different hunting season opening dates on annual harvests within eight WMU's in N.C. Ontario and examines road access levels in relation to annual harvests.

METHOD

Ontario's present system of assessing the annual harvest includes the collection of age and sex data and location of kill (Addison and Timmermann 1974, Fraser 1976). A moose hunter crest introduced in 1967 (Cumming 1974a) and redesigned each year is offered annually as a reward in exchange for the lower jaw of hunter killed animals. Storage of

harvest data was greatly improved by the creation of a system of WMU's in 1973-74 and by standardized methods of collecting and checking data (Bisset 1982).

Provincially standard big game harvest information was collected for all non-residents and those residents who voluntarily submitted teeth or offered information concerning moose taken in 8 WMU's managed by the N.C. Region (Fig. 1). Data was referenced to individual 100 $km.^2$ universal transverse mercator grid cells within each WMU, entered and stored in a computer and in a standard data book. This biological information is generally available for the period 1971-81 inclusive and represents 55-65% of the annual licenced harvest as estimated from a Provincial mail survey of hunters (Barbowski 1972).

In order to examine the relationship between harvest and season opening, data were pooled for all WMU's having common season opening and closing dates. Temporal changes in harvest trends, sex composition, mean age and age structure were examined for the period 1971-80, during which hunting seasons opened as early as 22 September and as late as 18 October and generally closed 15 December. In addition, we identified the day of sex ratio change (no. of days after the commencement of the season that bulls cease to dominate in the harvest) for the period 1973-79 (Gollat et al., 1981), and crossover age for the period 1971-81 as described by Fraser (1976).

For age analysis, 4 arbitrary age classes were used: yearling bulls and cows (1.5 yr.), bulls and cows ($\geq$ 1.5 yr.), prime bulls (5.5 - 10.5 yr.), and breeding cows ($\geq$ 2.5 yr.) after Bubenik and Timmermann (1982), Bubenik et al. (1975, 1977), and Simkin (1965). For mean age analysis, seasons opening 4 October or earlier and 11 October or later were subjectively designated as early and late respectively. Similarly for sex

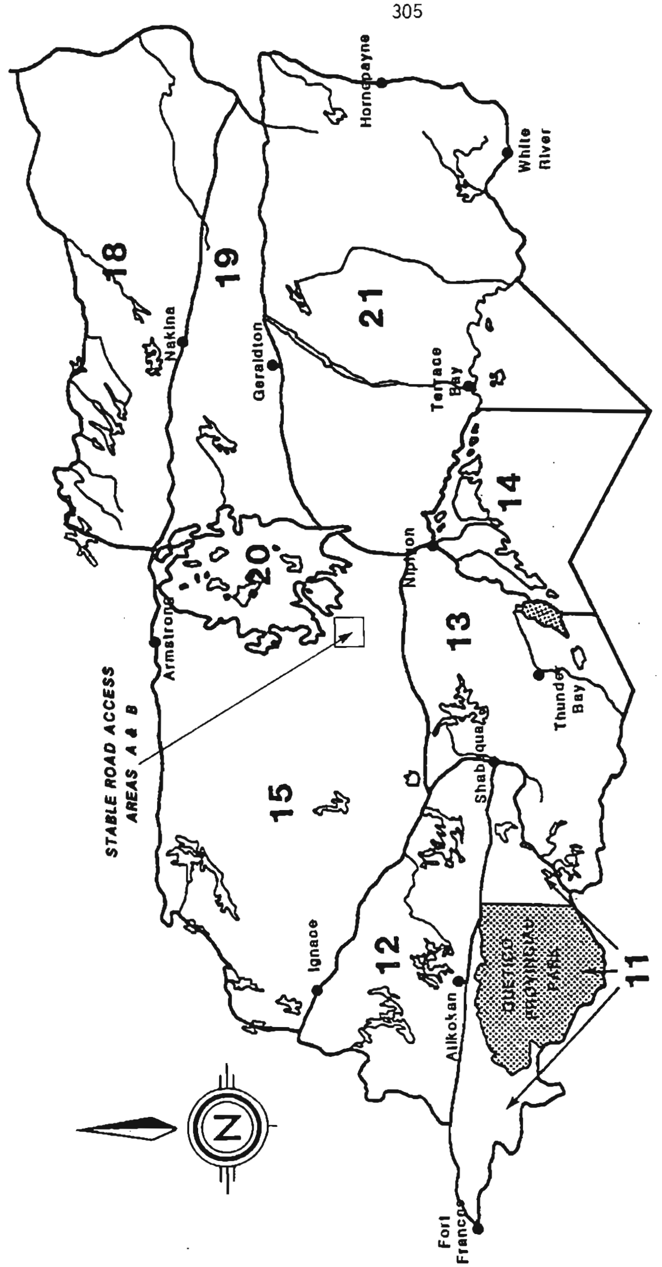

Fig. 1. Location of 8 WMU's and 2 stable road access study areas (A&B) N.C.Region, Ontario.

composition analysis, 4 arbitrary age classes as follows were used: calves of either sex (0.5 yr.), yearling bulls and cows, bulls and cows $\geq$ 1.5 yr., and bulls and cows $\geq$ 2.5 yr.

The relationship between access and harvest within WMU 15 was analysed for the period 1971-81. This unit (28,400 km.^{2} of land and water) contains 284 - 100 km.^{2} grid cells. Length of access roads was determined for each cell at 5 year intervals beginning in 1966. Data from 144 cells were grouped in one of three arbitrarily selected access categories: roadless (119 cells with $\leq$ 5 km. of road for the entire period 1966-81); stable road access (10 cells with $\leq$ 10 km. road 1966, increasing to 10+ km. 1971 and remaining stable to 1981); and increasing road access (15 cells with $\leq$ 10 km. road 1966, increasing to $\geq$ 11 km. 1971 and increasing by a magnitude of 25% or more in both 5 year periods beginning in 1971 and 1976). Harvest trends, sex composition and mean age were analysed in relation to access level for years 1971-81. In addition, early season harvests recorded for the first 14 days of each season (1966-74) were related to 2 stable road systems (Fig. 1) following termination of logging and initiation of hunting.

Regression analysis was used to determine trend over time relationships while a t-test was employed to test significance (generally at $P < 0.05$). Differences in sex ratios were examined by analysis of variance and the one-tailed binomial test. Sex ratio data tested by analysis of variance was first normalized using the arcsin transformation. In addition a non-parametric Kruskal-Wallis test (Sokal and Rohl, 1969) was also employed to recheck for sex ratio changes with variations in season opening date. Mean age differences were tested by analysis of variance.

We recognize that changes in the sex and age composition of the harvest could be influenced by a combination of variables including herd size, changes in hunting pressure and selection as well as those related to season opening dates and access. Examination of all contributing variables would however require an analysis of covariance which is beyond the scope of this paper.

RESULTS AND DISCUSSION

Season Date Shift vs. Harvest

Hunter and Harvest Trends

During the period 1973-80, the largest number of hunters and harvests occurred with seasons beginning in September (Table 1).

Table 1. Estimates of number of hunters and moose harvested for 8 WMU's, N. C. Region 1973 - 1980

Year	1973	1974	1975	1976	1977	1978	1979	1980[1]
Hunter #'s	26612	23163	20681	20666	20496	20859	20405	16948
Harvest	5213	4375	3815	3284	3291	3627	3706	2239
Earliest Opening Date (S.-Sept., O.-Oct.)	S.22	S.28	O.4	O.4	O.11	O.11	O.11	O.11
Closing Date (N.-Nov., D.-Dec.)	D.15	D.15	D.15	D.15	D.15	D.15	D.15	N.15

[1]two tags per moose required 15 - 31 Oct., one tag 1 - 15 Nov.

A more stable trend occurred with October opening dates while a significant reduction was achieved by a party hunting requirement introduced in 1980.

Temporal Distribution of Harvest

The proportion of the adult moose harvest for both sexes during the first 14 days of the open season is illustrated in Fig. 2. Seasons opening 30 September or later had typically high initial harvests of bulls and cows during the first three days, while a much more even harvest distribution was exhibited by seasons opening 22 and 28 September.

Sex Composition

Sex ratios among 3 age classes (.5 yr., 1.5 yr., $\geq$ 2.5 yr.) were examined for seasons in which the opening date began as early as 22 September and as late as 18 October (Table 2).

The sex ratio among calves generally did not differ from 50:50 ($P > 0.05$), while yearling bulls tended to be more numerous than yearling cows ($P < 0.05$). Bulls $\geq$ 2.5 yr. were always more numerous than cows which is similar to that reported elsewhere for adults ($\geq$ 1.5 yr.) by Pimlott (1959), Simkin (1965), Mercer (1974), Cumming (1974a), Fraser (1976,1978), Crête et al. (1981) and Paloheimo and Fraser (1981).

Bull Vulnerability

As season opening dates were delayed, a reduced imbalance of bulls and a corresponding earlier sex ratio change occurred (Table 3). Between 1973 and 1979, an average of 61.8% more bulls were harvested than cows prior to the sex ratio change date (max. 112.4% with a 22 September opener, min. 24.5% with an 11 October opener).

Table 2. Sex composition of calves (.5 yr.), yearlings (1.5 yr.) and ≥ 2.5 yr. moose as determined from jaws voluntarily provided by N. C. Ontario hunters, 1971 - 1980.

Year(s)	Season Opening	Total Calves N	Calves % Male	Total 1.5 yr. N	1.5 yr. % Male	Total ≥ 2.5 yr. N	≥ 2.5 yr. % Male
1973	Sept.22	162	50.6	213	65.3*	736	63.9*
74	28	230	48.3	402	53.0	1159	57.8*
73	29	45	40.0	50	74.0*	192	58.9*
72	30	167	61.1*	245	53.5	646	57.3*
71	Oct. 2	176	52.3	245	59.6*	622	54.5*
74,75, 76	4	535	54.6*	907	59.4*	2652	55.4*
77,78, 79,80	11	877	49.0	1629	60.3*	3303	52.3*
80	15	116	51.7	273	56.0*	485	54.2*
77,80	18	49	46.9	132	54.5	256	57.8*
	$\bar{x}_9$		50.5		59.5		56.7

* male > female at $P < 0.05$

Note: season closing dates are December 15 for all years except November 15, 1980.

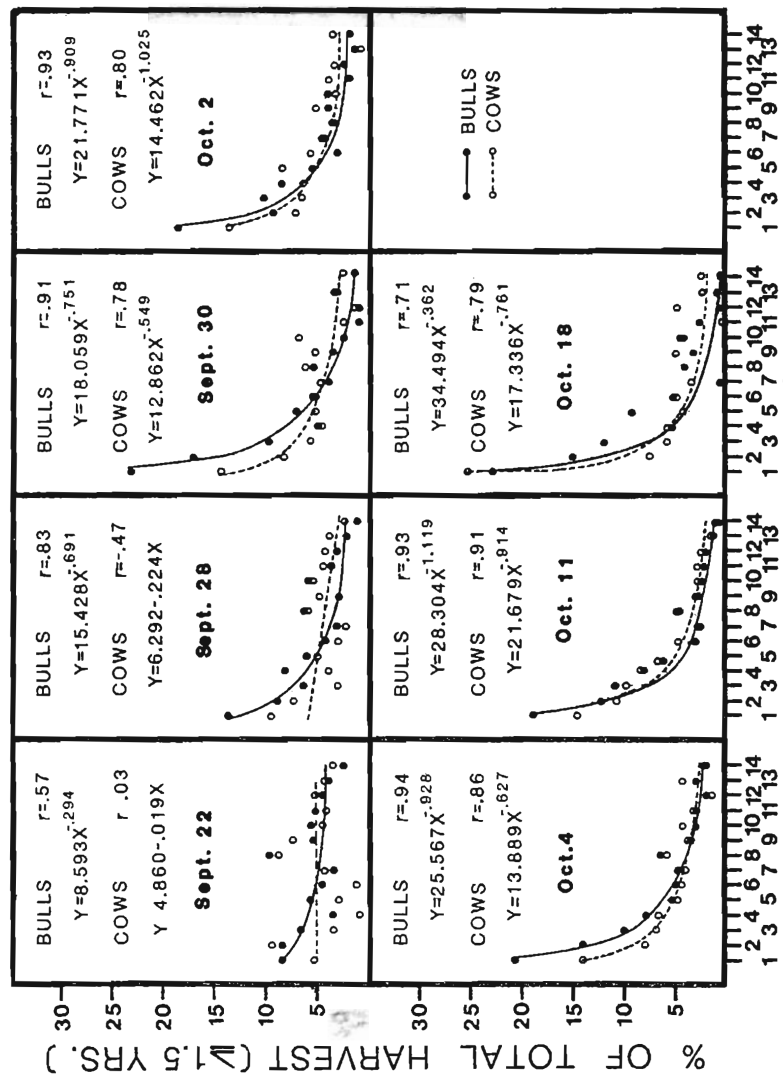

Fig. 2. Temporal distribution of first 14 day harvest related to shifting season opening dates, N.C.Region, Ontario.
Bulls are expressed as a percentage by day of the total seasons bull harvest≥1.5 yr.
Cows are expressed as a percentage by day of the total seasons cow harvest≥1.5 yr.

Table 3. Number of moose harvested prior to sex ratio change date WMU's 11, 12, 13, 15, 19 and 21 - 1973-1979

Year	Season Opening Date	Sex Ratio Change Date	Sex Ratio Change Day[1]	# Bulls	# Cows	% More Bulls	% Bull[2]	% Cow[3]
1973	Sept. 22	Oct.4	13	720	339	112.4	79.8	22.8
74	28	7	10	584	338	72.8	67.2	17.8
75	Oct. 4	12	9	574	327	75.5	70.0	17.0
76	4	11	8	619	409	51.3	70.2	17.6
77	11	15	5	487	341	42.8	57.4	9.9
78	11	15	5	542	354	53.1	57.1	1.9
79	11	14	4	447	359	24.5	37.3	4.1

1. no. of days after season opening
2. percent of season total ≥ 1.5 yr. bull harvest to sex ratio change date
3. percent of season total ≥ 1.5 yr. cow harvest to sex ratio change date

In 1973, with a 22 September opening date, the sex ratio change took place on 4 October or day 13 of the season. During this period, 79.8% of the total season's ≥ 1.5 yr. bull harvest occurred. This represents a 57.0% higher rate of removal for bulls than cows, suggesting a vulnerability period which extends well beyond 4 October. From 1977 - 1979 seasons opened on 11 October and sex ratio changes occurred only 4 to 5 days after the opening date (ie. 15, 15 and 14 October respectively), suggesting that the active rut period may have been nearly over. The average percent of total bull harvest to sex ratio change during this period was 50.6%, substantially lower than in 1973.

Between 1974 and 1976, season opening dates fell between the two extremes discussed above. Sex ratio change days, percent of bull harvest

and bull removal rates are intermediate to the earlier (1973) and later season opening years (1977-79). These analyses suggest a male vulnerability period which begins prior to 22 September and extends to 15-20 October.

The proportion of bulls ≥ 1.5 yr. in the harvest after day 1 and cumulative to days 7 and 14, decreased significantly ($P < 0.05$) when seasons were opened progressively later (Fig. 3). The slope of the regression for sex ratio data cumulative to season end however, suggests little relationship exists between percent bulls in the harvest and shifting opening dates ($P > 0.10$). A more detailed examination using the non-parametric Kruskal-Wallis test supports ($P > 0.05$) this initial observation. A similar test using parametric single classification analysis of variance suggests that significant ($P < 0.05$) differences in sex ratio do exist between different season opening dates. A recalculation using the original data minus the 22 September opener however, generates results similar to the regression analysis and Kruskal-Wallis test. Based on these findings it appears that with the exception of the early 22 September opener occurring in 1973, total season sex ratios within the NC Region have not varied significantly with season opening during the period 1971 to 1980. As reflected in Fig. 3, early season sex ratios which are always heavily weighted towards bulls, appear to be highly influenced by season opening dates. However, as any age/sex seasons progress, the harvest of cows relative to bulls increases due in part to reduced bull vulnerability and availability. Conversely, a greater proportional availability of cows exists as seasons progress resulting in a relatively stable total season sex ratio.

Crête (1982) and (pers. comm. September 1982) reported delayed season opening dates significantly influenced sex ratios of Quebec moose

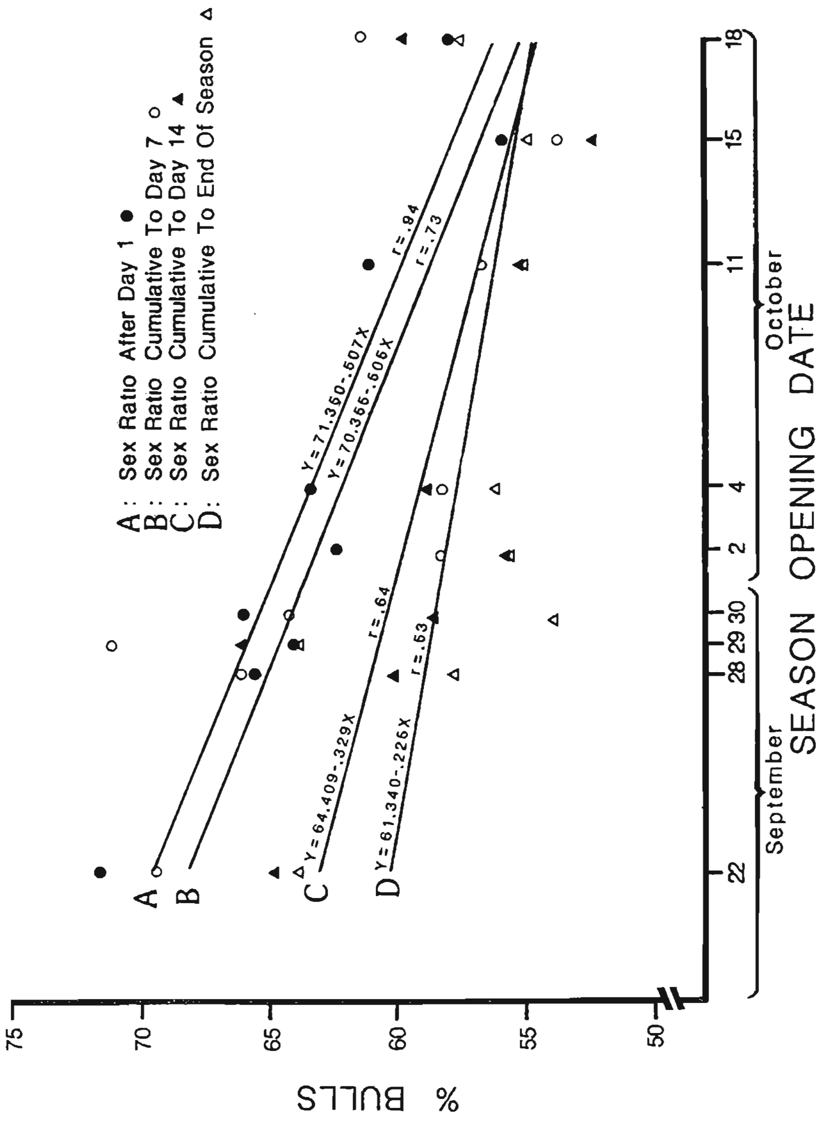

Fig. 3. Relationship between season opening date and percent bulls in the ≥ 1.5 yr. harvest for 4 time periods (A-D) within each season, N.C.Region, Ontario.

Table 4. Variation in mean age ($\bar{x}$) of harvested moose ≥ 1.5 yr. by opening date of hunting season, N. C. Region Ontario 1971 - 1980.

	Season Opening Date	Year	Male Age N	$\bar{x}$	s	Female Age N	$\bar{x}$	s
Early	Sept. 22	1973	547	4.3	(±3.2)	332	4.5	(±3.7)
	28	74	796	4.6	(±3.5)	583	4.6	(±3.6)
	29	73	165	4.2	(±3.4)	100	4.4	(±3.7)
	30	72	389	3.7	(±2.9)	390	4.0	(±3.4)
	Oct. 2	71	388	3.5	(±3.6)	303	3.9	(±3.2)
	4	74	21	3.8	(±1.7)	11	4.1	(±3.3)
	4	75	841	4.1	(±3.1)	589	4.3	(±3.4)
	4	76	860	4.1	(±3.0)	690	4.4	(±3.8)
	$\bar{x}_8$			4.1			4.3	
Late	Oct. 11	1977	758	3.6	(±2.8)	630	4.6	(±3.5)
	11	78	871	3.7	(±2.9)	678	4.4	(±3.4)
	11	79	926	3.4	(±2.5)	786	4.6	(±3.5)
	11	80	19	3.8	(±2.8)	20	3.9	(±2.6)
	15	80	360	3.4	(±3.0)	302	3.9	(±3.3)
	18	77	57	3.6	(±2.0)	54	3.5	(±3.0)
	18	80	139	3.3	(±2.6)	93	4.1	(±3.6)
	$\bar{x}_7$			3.5			4.1	

harvests. He found sex ratios to approximate 60% males for seasons beginning prior to 1 October and decreasing to 50-55% after 10 October. The disparity between our findings and those of Crete may have been due to differences in season length, number of opening date changes and moose densities (ie. approx. 0.10 - 0.15 km.^{2} vs. N.C. Region's 0.20 - 0.25 km.^{2}).

Mean Age

The mean age of both bulls and cows $\geq$ 1.5 yr. was significantly older ($P < 0.05$) during seasons opening 4 October or earlier than during seasons opening 11 October or later (Table 4). This age differential may have been in part due to excessive harvests of older animals during the early seasons of 1973 and 1974 resulting in a deficit of older age classes in later years. More probable however, is a combination of the aforementioned and those factors related to changes in vulnerability associated with delayed season timing as noted by Peterson (1955), Crête et al. (1981) and Paloheimo and Fraser (1981).

The mean age of cows was significantly older than bulls during seasons which had early ($P < 0.025$) and late ($P < 0.005$) season openings, again reflecting the greater vulnerability of bulls (Fraser 1976). Fraser (1978) noted that if hunting pressure remains relatively heavy and is biased toward bulls, then the bull harvest should be composed of younger age classes than the female harvest. Hunter selectivity may play a role in skewing harvest sex ratios. We feel however that during this time period little conscious selection by hunters took place, particularly in view of the existence of a legal party killing provision and relatively low success rates.

Bull and Cow Age Class Trends

Harvests of both bull and cow yearlings increased by similar rates ($P < 0.01$) under different season opening dates (26%, 22 September opener to 40%, 18 October opener Fig. 4). The proportion of prime bulls decreased from approximately 20% to 13% ($P < 0.05$) while breeding cows likewise decreased from 74% to 61% ($P < 0.01$) during the same period. These analyses suggest that in Ontario a delay in season opening date decreased the vulnerability of prime bulls and cows. Conversely, yearling bulls and cows, a vulnerable age class (Pimlott 1959, Simkin 1965) became more vulnerable. This may be related to delayed spermiogenesis in yearling bulls as described by Bubenik and Timmermann (1982). If such a direct relationship exists, the biological advantage of opening any sex/age seasons later are obvious ie. a higher yearling component and a lower harvest of prime bulls and breeding cows.

Access vs. Harvest

Harvest Trends in 3 Access Categories

WMU 15 moose densities estimated from aerial surveys indicate a stable population of approximately 0.25/km.^{2} since 1975. This WMU accommodated an average of 5,500 hunters (range 4,000 - 8,300) who harvested approximately 1,000 moose per year (1973 - 79) primarily from road accessed areas. More moose per unit area were shot from areas of both stable and increasing road access areas ($P < 0.01$) than roadless areas (Table 5). There were no differences ($P > 0.05$) in harvests per unit area between stable and increasing access areas.

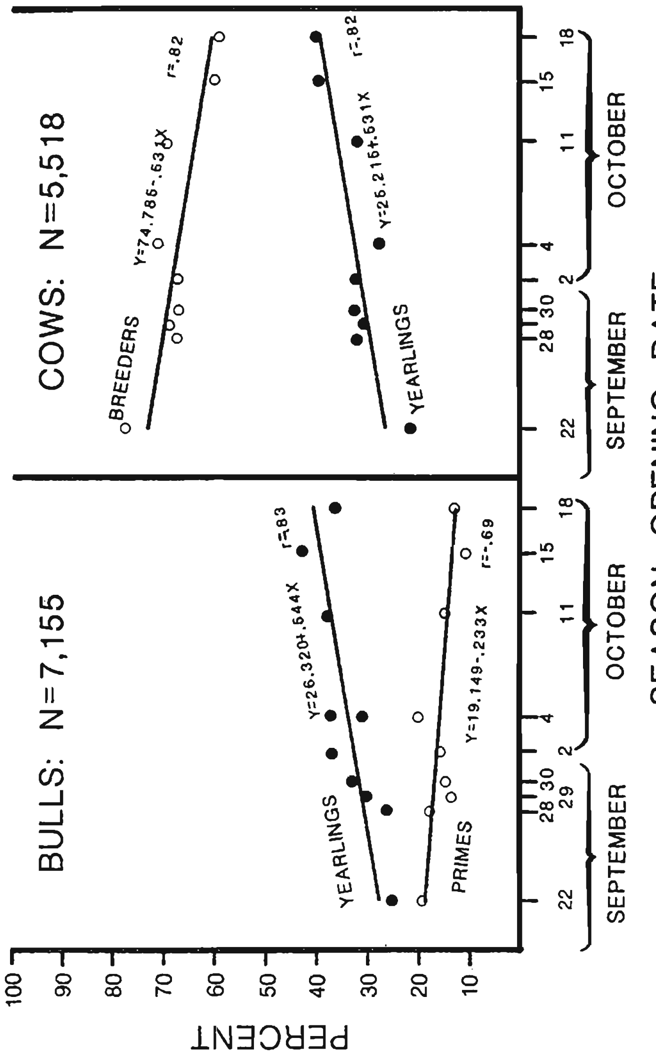

Fig. 4. Relationship between 9 progressively later season opening dates and percent of two age classifications among bull and cow moose in the harvest, N.C.Region, Ontario.

Table 5. WMU 15 Moose Harvest Data for 3 Access Categories Expressed as Mean Values for the 11 Year Period, 1971 - 1981

	Road Access Category		
	Roadless	Stable	Increasing
# 100 km^2 cells examined	119	10	15
N	1185	350	427
Mean # of moose harvested per 100 km^2 cell	0.9	3.2	2.9
Sex ratio crossover age (Fraser 1976)	none apparent	5.5 yr.	9.5 yr.
Mean % calves in total harvest	13.1	12.4	10.6
Mean % yearlings in the ≥ 1.5 yr. harvest	25.0	27.7	22.5
Mean % bulls in the ≥ 1.5 yr. harvest	55.1	55.1	54.4
Mean bull age (≥ 1.5 yr.)	4.2	3.6	4.0
Mean cow age (≥ 1.5 yr.)	4.7	4.7	5.0

The harvest of bulls relative to cows as indicated by sex ratio crossover age (Fraser 1976), appeared to be greater in stable than in increasing access areas while no distinct pattern was apparent for roadless areas. This suggests a higher measure of hunting mortality on bulls associated with a continuous period of access and sustained hunting pressure.

No significant differences ($P > 0.05$) were apparent in the mean percent of calves among access categories. The percentage of yearlings in the harvest was significantly ($P < 0.05$) greater in stable than in increasing access areas. Bulls $\geq$ 1.5 yr. were consistently more numerous than cows ($P < 0.05$) but no differences between access categories were evident ($P > 0.05$).

Bulls shot in roadless areas were older than in stable road access areas ($P < 0.05$) but were not significantly different ($P > 0.05$) from those taken in increasing road access areas as reported by Simkin (1964). Bulls shot in increasing road access areas were marginally older than those from stable road access areas ($P < 0.02$). The mean age of cows was similar for all 3 access categories but was significantly older than bulls ($P < 0.05$).

Both roadless and stable road access areas experienced a declining harvest trend (Fig. 5), while harvests rose significantly in increasing road access areas ($P < 0.05$). This latter trend is similar to that documented elsewhere in Ontario and Quebec by Fraser (1976, 1978) and Crête et al. (1981) respectively.

The proliferation of roads in WMU 15 (Table 6) has in effect maintained a higher than expected annual harvest while delayed seasons have reduced the period of male vulnerability as well as roadless fly-in hunting opportunities.

Table 6. Road access changes WMU 15, 1966 - 1981

Year	# Roadless 100 km.^{2} cells	# Stable or Increasing Road Access Cells	Est. km. of All Weather Roads
1966	201	83	1700
1971	174	110	2500
1976	139	145	3300
1981	121	163	4200

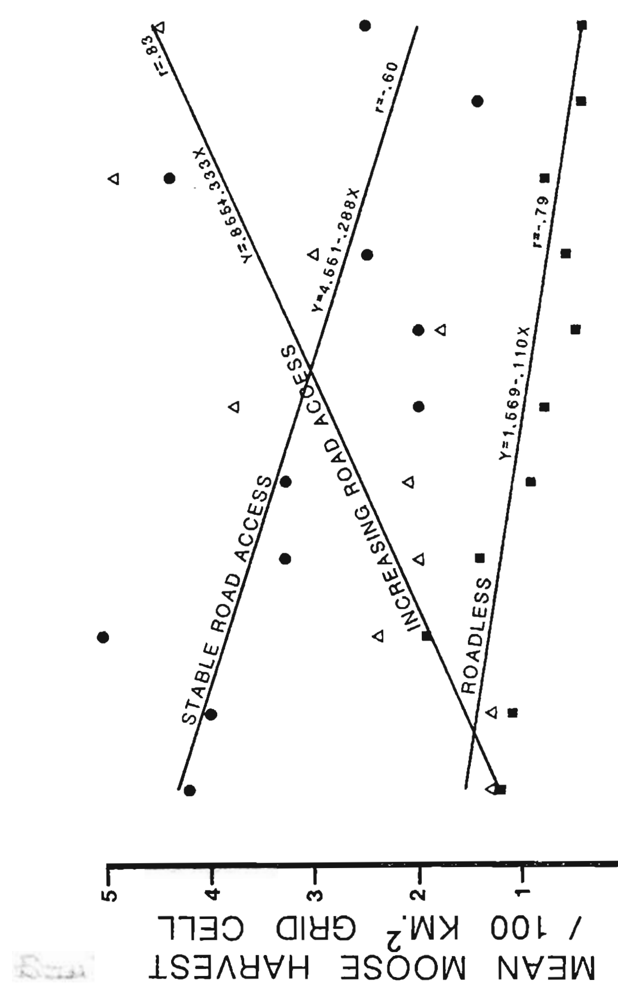

Fig. 5. Comparison of average annual number of moose harvested/100 km.^{2} grid cell within 3 distinct access categories in WMU 15, N.C. Region, Ontario 1971 - 1981.

Harvest Trends in Stable Road Access Areas

Locations of hunter killed moose in Ontario are closely associated with road and water access routes similar to those described by Judd (1972) in Minnesota and Bider and Pimlott (1973) in Quebec. The pattern of documented kill locations in two self-contained stable road systems for the nine year period 1966 - 1974 is illustrated by Fig. 6. Both areas (designated A and B) were initially opened to public vehicular traffic and hunting in 1966, following completion of logging and road building operations. With the exception of a 22 September 1973 opener in area A, seasons during the nine year period generally opened on or around 1 October.

Annual harvests in both areas decreased significantly ($P < 0.05$) over the nine year period (Fig. 7). We believe this to be the general pattern or trend in most hunted recently logged, road accessible areas. Moose are extremely vulnerable immediately after removal of standing timber and local populations are severly depressed for a period of 8 or 10 years following logging and initiation of hunting. Populations generally increase thereafter as regeneration provides escape cover and harvest vulnerability is reduced.

Crête (pers. comm. September 1982) regards the reduction of moose density after initiation of hunting in a newly accessed area, followed by a later stabilization of density at a lower level, as a normal sequence of events.

SUMMARY AND CONCLUSIONS

Variations in season opening dates and increased road access have

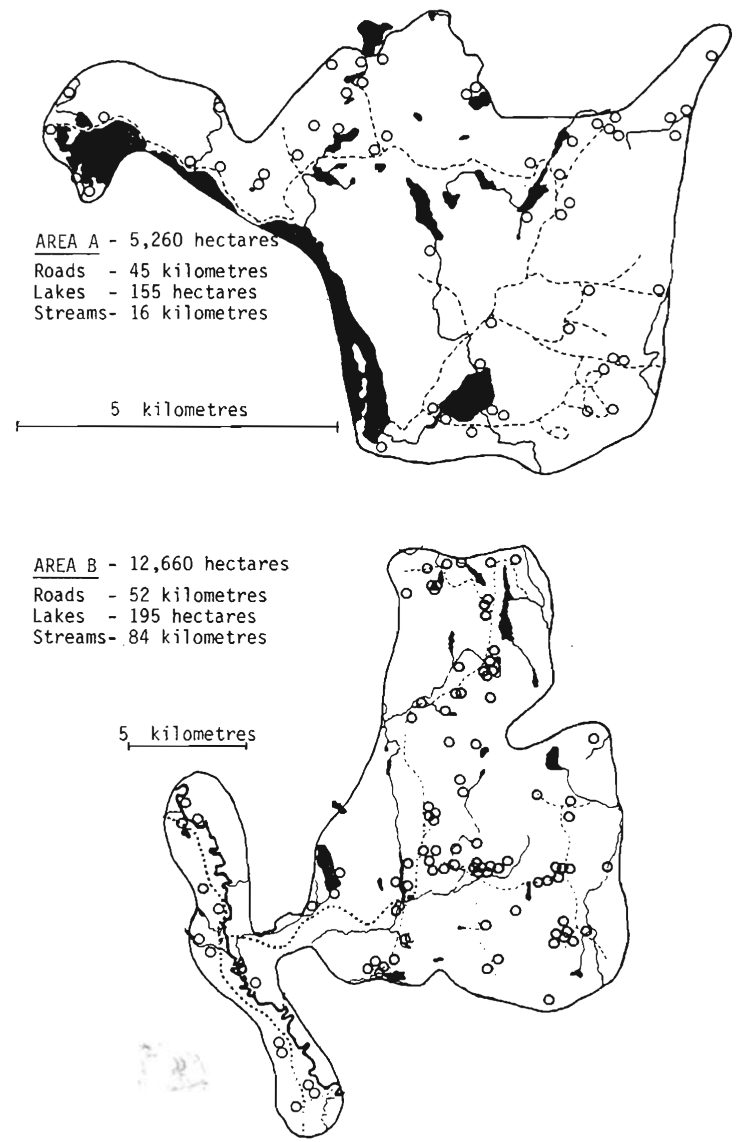

Fig. 6. Moose hunter kill locations within two stable, self-contained road systems, N.C.Region, Ontario 1966 - 1971.

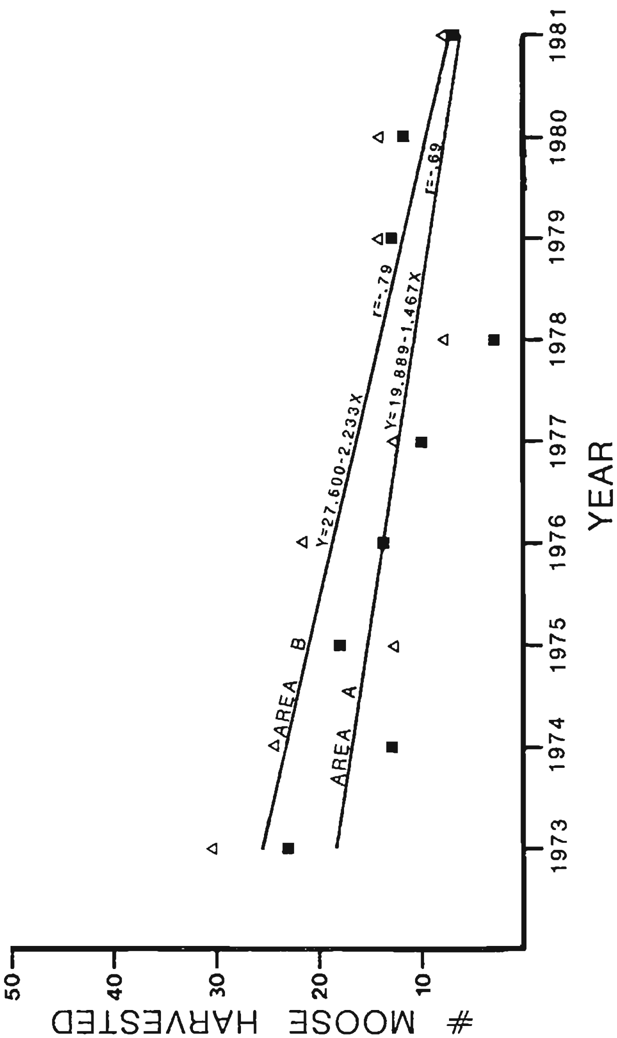

Fig. 7. Annual harvests of moose from 2 stable road accessible areas following initiation of hunting, N. C. Region, Ontario.

influenced both the magnitude and age structure of the harvest. Meaningful analysis of harvest age and sex must consider all such influencing factors.

Two distinct harvest patterns were related to season opening dates. Generally those opening in October exibited a high initial harvest followed by a rapid decline, whereas those opening earlier displayed a more even kill distribution. The behaviour of moose during the annual rut makes them especially vulnerable. The first 14 days of each season produces 65 - 75% of the annual harvest. Season timing then becomes an important factor in dictating the age structure of the kill and must be considered in population management. Prime breeding bulls and cows are particularly vulnerable during hunting seasons which overlap the rut period. Managers should carefully consider formulating selective harvest strategies which control the harvest of prime breeders while maximizing that of the non-breeding component. In this study, males were quite vulnerable from at least 22 September to mid-October. Bulls $\geq$ 1.5 yr. appear to be more vulnerable than cows to hunting mortality in all seasons and access combinations.

Early season sex ratios during the period 1971-80 were highly influenced by season opening date. However, except for the 22 September opening in 1973, total season sex ratios have remained relatively stable. A combination of factors including expanding road acess, variation in season length, sex related vulnerability and availability may have played a role in masking season related sex ratio changes.

Shifting seasons later and terminating them earlier has proportionately reduced roadless and stable access road harvests while hunter kills in newly road accessed areas have continued to increase. Expanding logging operations and road access has resulted in a disproportionately high level of kill in these areas when compared to stable or roadless access situations. In such areas, moose remain particularly vulnerable to hunters irrespective of season timing or rut vulnerability.

Generally in areas where logging activities have terminated and road access remains static, annual harvests decline over time. Populations recover or increase after a period (8 - 10 yr.) when new growth reduces vulnerability, however harvests thereafter generally remain at a level below potential. We therefore suggest, if moose populations and harvests are to be optimized, greater emphasis must be directed in long-term planning of access roads and logging activities. Establishing a permanent road system and then scheduling a scattered distribution of cutting over time will yield a highly beneficial mixture of food and cover.

Management strategies employed in Ontario during the period 1971-81 were not specific enough to control either local over-harvests or allow expanded harvests in specific areas. Other techniques which reduce hunter efficiency, control road access or limit kills in specific social classes are required to maintain a sustained harvest level without reducing the population.

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