EFFECTS OF SELECTIVE HARVEST ON MOOSE POPULATIONS OF THE BAS-SAINT-LAURENT REGION, QUÉBEC

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ABSTRACT: Selective hunting, based on the protection of a portion of cows, was implemented beginning in 1994 in Hunting Zone 2 located in the Bas-Saint-Laurent region of Québec. Using an aerial survey carried out in the winter of 1997, the impacts of this management measure on the moose population and its harvest by hunting were evaluated. Contrary to expectation, the winter moose density, estimated at 1.8 ± 0.3 moose / 10 km^2 ($\alpha = 0.10$), has remained unchanged since the previous survey carried out in 1991. However the structure of this population has changed. Bulls, which had represented 28.0% of the winter population in 1991 only represented 15.8% in 1997. In sharp contrast, the percentage of cows in winter increased from 41.4% to 51.8% between 1991 and 1997; this difference is significant (1-tailed Z test, $P < 0.001$). The percentage of bulls among adults fell from 40.3% to 23.4%, which is below the target value of 30%. Despite this imbalance in the sex ratio, the productivity of this population was excellent, with a winter ratio of 62 calves per 100 cows. Moreover, this ratio was not statistically different from that observed in 1991 (74 calves: 100 cows; $P > 0.05$). Productivity in the fall, prior to the hunting season, has remained stable since the introduction of selective hunting, with a ratio of 73 calves per 100 cows as compared to 68 calves per 100 cows. It was hypothesized that the better survival of cows allowed a greater number of them to achieve their full reproductive potential. The overall harvest rate seemed higher in the fall of 1996 (27%) than it was in the fall of 1990 (25%) even though the harvest of cows was cut in half. This increase in the harvest rate was not due to selective hunting, but rather to a 2-day extension of the hunting season which resulted in an additional harvest of 2.6%. The harvest rate for bulls, estimated at 57.5%, was very high and exceeded the initial forecasts in the management plan, which set this rate at 35%. This situation was attributed to the fact that the quotas placed on cows have resulted in a transfer of hunting pressure, mainly towards bulls and, to a lesser extent, towards calves. Nevertheless, selective harvest has improved the recruitment of calves and the population now has a growth rate that is superior to what it was prior to 1994 ($\lambda = 1.053$). However, sport hunting largely offsets this clear growth in the fall population. In conclusion, it is expected that the winter population of this hunting zone will increase more slowly than forecasted in the management plan. Moreover, the effects of selective hunting will be positive provided that the firearm-hunting season continues to be after the main rutting period of moose.

Key words: growth rate, harvest rate, hunting pressure, moose density, productivity, selective harvest, sex ratio

RÉSUMÉ: La chasse sélective avec protection d'une partie des femelles adultes a été implantée à compter de 1994 dans la zone de chasse 2, située dans la région du Bas-Saint-Laurent au Québec. On a pu évaluer au moyen d'un inventaire aérien, les impacts de la chasse sélective sur cette population d'orignaux et son exploitation par la chasse sportive. Contrairement aux résultats attendus, la densité hivernale, estimée à $1,8 \pm 0,3$ orignal / 10 km^2 ($\alpha = 0,10$), est demeurée inchangée depuis l'inventaire précédent effectué en 1991. La chasse sélective a néanmoins induit des changements importants dans la structure de cette population. Les mâles adultes qui représentaient 28% de la population hivernale en 1991 n'en composaient plus que 15,8% en 1997. À l'inverse, le pourcentage de femelles dans la population hivernale a augmenté, passant de 41,4% en 1991 à 51,8%

en 1997. Ces différences sont statistiquement significatives (test Z unilatéral, $P < 0,001$). Le pourcentage de mâles chez les adultes a diminué de 40,3% à 23,4% et il est sous l'objectif établi initialement à 30%. Malgré ce déséquilibre dans le rapport des sexes, la productivité est demeurée excellente avec un rapport de 62 faons par 100 femelles à l'hiver. Ce rapport n'est pas statistiquement différent de celui observé en 1991 (74 faons par 100 femelles; $P > 0,05$). La productivité à l'automne, avant chasse, est demeurée stable depuis la mise en place de la chasse sélective avec 73 faons par 100 femelles en 1996 en comparaison avec 68 faons par 100 femelles en 1990. On avance comme hypothèse que la meilleure survie des femelles aurait permis à un plus grand nombre d'entre-elles d'atteindre leur plein potentiel reproducteur. Le taux d'exploitation global par la chasse sportive semble plus élevé à l'automne 1996 (27%) qu'à l'automne 1990 (25%) même si la récolte des femelles a été réduite de moitié. Cette hausse n'est pas due à la chasse sélective, mais à un prolongement de 2 jours de la saison de chasse qui a résulté en une exploitation additionnelle de 2,6% des orignaux. Le taux d'exploitation des mâles adultes, estimé à 57,5%, est très élevé et dépasse le niveau anticipé au départ de 35%. On attribue cette situation au fait que le contingentement des femelles adultes a amené un transfert de la pression de chasse vers les mâles adultes et, dans une moindre mesure, vers les faons. Cependant, on évalue que la chasse sélective a eu pour effet d'augmenter le recrutement des faons à l'automne et cette population d'orignaux présente maintenant un taux d'accroissement supérieur à ce qu'il était avant 1994 ($\lambda = 1,053$). Toutefois, cet accroissement apparent a été en bonne partie absorbée par la chasse sportive. En conclusion, on estime que les effets de la chasse sélective sur cette population seront positifs en autant que la saison de chasse à l'arme à feu soit maintenue après la principale période d'accouplement des orignaux.

Mots-clés: chasse sélective, densité, pression de chasse, productivité, rapport des sexes, taux d'accroissement, taux d'exploitation

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Selective harvest is a management method applied in several North American jurisdictions to increase moose populations (Stewart 1985, Timmermann 1987, Courtois and Lamontagne 1991). The general approach is to reduce the exploitation of certain segments of a population in order to stimulate population growth. In Québec, selective harvest, oriented towards the protection of adult cow moose, was implemented in 1994 by the Ministère de l'Environnement et de la Faune (MEF) as part of the moose management plan for 1994 - 1998 (MLCP 1993). At the provincial scale, this plan was intended to meet 3 main objectives, which were to maintain or increase moose populations, maintain recreation opportunities, and improve the quality of the hunt.

In Hunting Zone 2, situated in southeastern Québec, the sustained increase of the harvest and number of hunters between 1989 and 1993 indicated that the moose population might be exploited to its maximum. An aerial survey with double sampling, conducted in the winter of 1991, provided a density estimate of 1.8 ± 0.3 moose / 10 km^2 ($\alpha = 0.10$) and indicated a harvest rate of 24.8% by sport hunting (Lamoureux and Parisé 1997). At this rate, permissible harvest quotas could be reached and the population could be expected to decline if the harvest surpassed 600 moose per year. During the previous period, hunters could harvest any moose without consideration of the age or sex of the animal. The bow-hunting season covered 9 days and the firearm-hunting season 7 days. The harvest limit was set to 1 moose per 3 hunters. No restrictions were imposed on the number of hunters allowed to hunt in the zone. The average age of adult moose harvested was

very low: 2.8 years for bulls and 3.3 years for cows.

To allow this population to increase, a selective harvest based on the protection of adult cows was established in 1994. The objective was to reduce the harvest rate of cows to 10% by allocating a limited number of special permits for this category of animals. With this approach it was anticipated that the overall harvest rate would not exceed 20% and that the population would increase 6 - 8% yearly to attain a density of 2.6 moose / 10 km² by the winter of 1998.

Other changes were introduced to the hunting regulations to improve the quality of the hunt. The firearm-hunting season was extended by 2 days to provide a total of 9 days and the harvest limit was reduced to 1 moose per 2 hunters. It was expected that the extension of the hunting season would have little impact on the total harvest because only a small proportion of moose are taken during the last few days of the firearm season (MLCP 1985). Moreover, similar to Courtois and Lamontagne (1991), it was expected that changes in the harvest limit would only re-distribute the moose harvested among hunters and would not affect the total number of moose taken.

In the winter of 1997, the MEF conducted another aerial survey in Hunting Zone 2 to evaluate the impacts of the selective harvest program on the density and structure of the moose population. In this paper, the results of the 2 aerial surveys are presented and the impacts of the selective harvest program on the sport hunt and this moose population are discussed.

STUDY AREA

Hunting Zone 2 is located in the Bas-Saint-Laurent region of southeastern Québec (Fig. 1). The total surface area is 16,231 km². The region is diverse and includes large areas of fir - yellow birch, maple - yellow birch, and fir - white spruce forests. These mixed forests are dominated by hardwoods in the west and by conifers in the east. The main tree species are balsam fir (*Abies balsamea*), white spruce (*Picea glauca*), trembling aspen (*Populus tremuloides*), eastern white cedar (*Thuja*

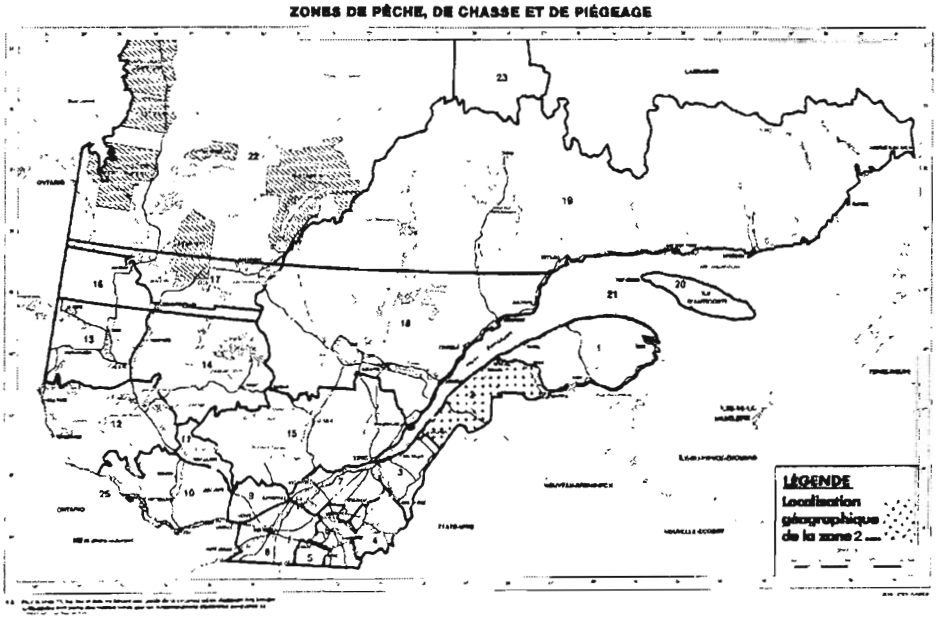

Fig. 1. Location of Hunting Zone 2 in the Bas-Saint-Laurent region of southeastern Québec. [*Localisation de la zone de chasse 2 au sud-est du Québec dans la région du Bas-Saint-Laurent.*]

occidentalis) and yellow birch (*Betula alleghaniensis*).

In this hunting zone, moose hunting can be practised in 3 different types of areas: (1) an area without limits on the number of hunters (both free zone and ZECS [areas managed by hunters associations]) which covers 14,779 km², or 91% of the zone; (2) an area with limits on the number of hunters (wildlife reserves and outfitters areas) which covers 1,260 km², or 7.8% of the zone; and (3) an area with no moose hunting which covers 192 km², or 1.2% of the zone. Thus, moose hunting occurs on 98.8% of the total surface area of this zone. An extensive network of logging roads makes the area very accessible to sport hunting. Hunting regulations in Québec require all harvested moose to be brought to a registration station authorized by the MEF, where the age (adult, calf) and sex of each moose are recorded.

The specific area examined in this study covers the entire zone, with the exception of wildlife reserves and areas where hunting is banned. Within the area considered, moose habitat spreads over 10,496 km². This habitat is good quality for moose because of the young age of the forest regrowth and numerous cut blocks. Black bears are the only potential predators of moose in the area. Wolves are not present in this region, the last one having been exterminated by man at the beginning of the century (Martin 1980).

METHODS

An aerial survey of Hunting Zone 2 was conducted with double sampling (Rivest *et al.* 1990) between 8 January and 14 February 1991, with the intent of obtaining a precision of estimations of 20% at a probability level (α) of 0.10. The inventory sector covered 10,980 km², which was slightly larger than the area of potential moose habitat in the zone (10,496 km²). This sector was composed of 2 strata, each divided into plots of 60 km²: an area of low density covering 6,420 km² (107 plots) and the other of moderate density covering 4,560 km² (76 plots) (Lamoureux and Parisé 1997). Altogether, 81 plots of 60 km² were surveyed at the time of this first inventory, giving an overall sampling rate of 44.3%. In the low stratum, 25 plots were inventoried for a sampling rate of 23.4%, while in the moderate stratum, 56 plots were inventoried for a sampling rate of 73.7%. The inventory was conducted with Bell 206B helicopters, according to MEF standards (Courtois 1991a). At first, all 81 plots were flown over to locate track networks and mark their boundaries on 1: 50,000 topographic maps. In a second phase, 25 plots were flown over to count, age, and sex the moose present in the track networks. Altogether, 214 moose were sexed at the time of this inventory.

A second aerial inventory was conducted between 14 January and 8 February 1997 by stratified random sampling (Snedecor and Cochran 1971), with the intent of obtaining the same precision level as the preceding survey (i.e., ± 20%, α = 0.10). The stratification employed for this inventory was the same as that used in the winter 1991 survey (Lamoureux and Pelletier 1997). A total of 80 plots of 60 km² were inventoried, giving an overall sampling rate of 43.7%. In the low stratum, 26 plots out of the 107 were flown over, for a sampling rate of 23.4%, while in the moderate stratum, 54 plots out of 76 were flown over, for a sampling rate of 71.1%. Helicopters (Hughes 500-D and Bell 206-L) were used to conduct the inventory. Characteristics of moose censused, as well as any mortalities, were recorded for all survey plots. Altogether, 546 moose were sexed at the time of this second inventory.

To better compare the results of the 2 surveys, 70% of the plots inventoried in

1997 were chosen randomly from among those previously surveyed in the winter of 1991 and the remaining 30% from those not censused during the first survey (Table 1). According to Courtois *et al.* (1994), this strategy allows better detection of density changes between 2 aerial surveys, while minimizing the risk of bias.

The estimates of moose population density obtained from these 2 aerial surveys were corrected for visibility bias, which was estimated to be 52% in the Bas-Saint-Laurent region (Courtois 1991b). The fall population size was calculated by adding the recorded sport harvest in the fall preceding the aerial survey to the estimated winter population size. The harvest rate was calculated by dividing the sport harvest by the fall population size, and multiplying the result by 100. The sex ratio, the proportions of adult bulls, and the calf recruitment rate were determined from the structure of the estimated fall population. The apparent growth rate of the population (λ) was calculated as: λ = (100 - harvest rate) / (100 - % calves in the fall). As such, this parameter does not account for natural mortality, migration, or immigration. Ages of harvested moose were determined by counting *cementum annuli* in sectioned incisors, following the technique of Ouellet (1977). In the present study, the adult class includes moose $\geq$ 1.5 years of age. Aerial survey data were processed with INVENT.ORI software, version 4.0 (Leblanc *et al.* 1996). Statistical comparisons between proportions of bulls, cows, and calves, as well as ratios of bulls / 100 cows and calves / 100 cows, were made with 1-tailed *Z* tests. Comparison of hunting success, expressed as the number of moose harvested by 100 hunters before (1989 - 1993) and after (1994 - 1997) the introduction of the selective harvest program, was made by a *t*-test.

RESULTS

Selective Harvest

Between 1989 and 1993, the harvest in Hunting Zone 2 progressively increased to 660 moose (Fig. 2). The number of hunters also increased from 5,693 in 1989 to 7,124 in 1993, which represents an annual increase of 5.8%. Hunting success remained stable at about 9 %. The increase in the harvest during this period was probably attributable to the large number of hunters frequenting the zone, which was the largest of all the years compared.

Table 1. Characteristics of the aerial survey conducted in winter 1997 in Hunting Zone 2 (habitat area = 10,496 km²). [*Caractéristiques de l'échantillonnage pour l'inventaire aérien de l'orignal réalisé dans la zone de chasse 2 à l'hiver 1997 (superficie d'habitat = 10 496 km².*]

Stratum *Strate*	Total no. of plots *Parcelles totales*	Plots surveyed[1] *Parcelles inventoriées*[1]	Plots surveyed in 1991 and 1997 *Parcelles inventoriées en 1991 et 1997*	Sampling Effort (%) *Taux de Sondage (%)*
Low *Faible*	107	26	18	24.3
Medium *Moyenne*	76	54	38	71.1
Total	183	80	56	43.7

[1]Using the Neyman optimal allocation method (Snedecor and Cochran 1971) [*Allocation optimale de Neyman (Snedecor et Cochran 1971)*]

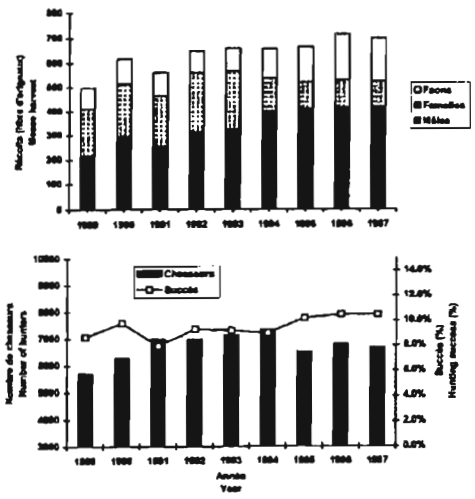

Fig. 2. Moose annual harvest, number of hunters, and hunting success in Zone 2 before (1989-1993) and after (1994-1997) implementation of the selective harvest strategy. [*Récolte annuelle d'orignaux, nombre de chasseurs, et taux de succès dans la zone de chasse 2 avant (1989-1993) et après (1994-1997) l'application de la chasse sélective.*]

Since the introduction of the selective harvest in 1994, moose taken outside reserves continued to increase an average of 2% yearly, although expected to decline after quotas were applied to the harvest of adult cows. The harvest increased from 656 moose in 1994 to 696 in 1997, which represents an increase in harvest rate from 0.62 moose / 10 km² to 0.66 moose / 10 km² of habitat. In 1997, adult bulls comprised a greater percentage of the harvest than in previous years. Their importance in the harvest increased from 47% in 1994 to 59% in 1997. The number of hunters frequenting Zone 2 diminished by 9.1% after the beginning of the selective harvest. After reaching a peak of 7,327 hunting permits sold in 1994, sales declined to 6,658 permits in 1997. Hunting success, which oscillated around 9% before 1994, increased to 10.5% by the fall of 1997. Nevertheless, this increase is not significant (t = 2,24, 7 df, P = 0.06). The success of those holding special permits allowing hunting of adult cows almost doubled, increasing from 15.8% in 1994 to 30.8% in 1997 (Fig. 3). This required the MEF to annually readjust the number of special permits issued to prevent the cow harvest from exceeding the objective of 10% cows per year in this hunting zone. The number of special permits issued thus decreased from 880 permits in the fall of 1994 to 350 in the fall of 1997. These changes resulted in a trend towards a net increase in the number of adult cows in the population.

The average age of bull moose harvested declined from older age classes to 2.4 years (SE = 0.21, n = 55) in 1997, while that of cows increased to 3.6 years (SE = 0.32, n = 50) the same year (Fig. 4).

Population Characteristics and Harvest Rates

In 1991, the winter population of Zone 2 was estimated at 1,871 ± 389 moose while in 1997 it was 1,925 ± 305 individuals. Density in the winter of 1997 was 1.8 ± 0.3 moose / 10 km² (α = 0.10), which is the same as the 1.8 ± 0.4 moose / 10 km² (α = 0.10) measured in the winter of 1991, indicating that the population had not changed between the 2 surveys. The precision objectives were reached, with a relative error of 20.8% in 1991 and 15.8% in 1997, which meets the generally recognized standards for this type of survey (Gasaway and Dubois

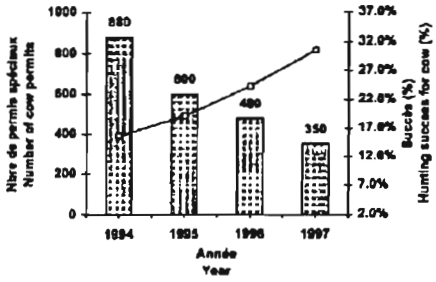

Fig. 3. Hunting success for adult cow moose in Zone 2. [*Succès de chasse à la femelle orignal dans la zone 2.*]

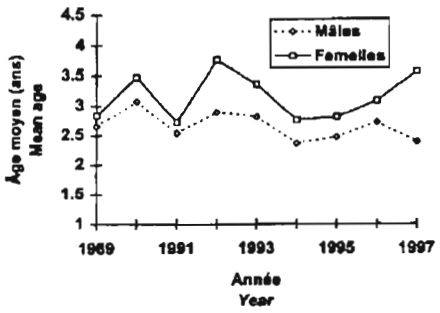

Fig. 4. Mean age of bulls and cows harvested in Hunting Zone 2. [*Âge moyen des orignaux mâles et femelles récoltés à la chasse.*]

1987, Courtois 1991a). The density in the moderate stratum was estimated at 2.9 ± 0.4 moose / 10 km² in 1991 and 3.3 ± 0.8 moose / 10 km² in 1997. The density in the low stratum was estimated at 1.0 ± 0.6 moose / 10 km² in 1991 and 0.8 ± 0.5 moose / 10 km² in 1997. Despite the fact that the winter population remained unchanged between 1991 and 1997, the estimated fall population increased by 6% from 2,488 moose in the fall of 1990 to 2,638 moose in the fall of 1996. These population estimates do not take into account possible immigration of moose from the Rimouski Wildlife Reserve which has a density of 7.4 moose / 10 km² (Lamoureux and Parisé 1995), as well as New-Brunswick and Maine which have, in localized areas close to the border with Québec, densities on the order of 2.5 moose / 10 km² and 6 moose / 10 km², respectively (R. Courtois, MEF, *pers. comm.*). However, this factor probably has little effect on the demography of moose in Zone 2 because the region of potential migration is limited to a 5-km band along the edges of these territories of high density (Labonté *et al.* 1998).

The winter structure of this moose population changed between the 2 aerial surveys. In 1991, the population was composed of 28.0% adult bulls, 41.4% adult cows, and 30.6% calves, while in 1997 it was 15.8% adult bulls, 51.8% adult cows, and 32.4% calves (Table 2). The observed differences in the proportions of bulls and cows between the 2 surveys are highly

Table 2. Comparison of the structure of the moose winter population estimated from the aerial surveys conducted in 1991 (214 moose sexed) and in 1997 (546 moose sexed). One-tailed *Z* test. [*Comparaison de la structure de la population hivernale d'orignaux observée au cours des inventaires aériens réalisés dans la zone de chasse 2 à l'hiver 1991 (214 orignaux sexés) et à l'hiver 1997 (546 orignaux sexés). Test Z unilatéral.*]

	1991	1997	*Z* value *Valeur de Z*	*P*
Bulls *Mâles* (%)	28.0 ± 6.1[1]	15.8 ± 1.7	3.19	<0.001
Cows *Femelles* (%)	41.4 ± 5.0	51.8 ± 2.1	3.18	<0.001
Calves *Faons* (%)	30.6 ± 6.2	32.4 ± 2.1	0.45	0.67
Percentage of adult bulls *% de mâles chez les adultes*	40.3 ± 6.8	23.4 ± 2.4	3.86	<0.001
Bulls/100 cows *Mâles/100 femelles*	67.5 ± 19.2	30.6 ± 4.0	3.11	0.001
Calves/100 cows *Faons/100 femelles*	73.9 ± 20.5	62.4 ± 6.0	0.89	0.81
Calves/100 cows in fall *Faons/100 femelles à l'automne*	68.0 ± 18.9	72.8 ± 7.0	0.39	0.65

[1]90% confidence interval *[intervalle de confiance à 90%]*

significant (1-tailed Z test, $P < 0.001$) (Table 2). In the winter of 1991, there were 67 bulls / 100 cows in this moose population, which indicated a ratio of 82 bulls / 100 cows in the preceding fall of 1990. By the winter of 1997, the ratio had declined to 30 bulls / 100 cows, indicating a ratio of 64 bulls / 100 cows in the fall of 1996. Bulls, which made up 40.3% of the adult segment of the population in the winter of 1991, did not represent more than 23.4% of the adults in the winter of 1997. Both the ratio of bulls / 100 cows and the percentage of adult bulls declined significantly (1-tailed Z test, $P < 0.001$) between the first and second survey. The estimated productivity in the winter of 1997 reached 62 calves / 100 cows, which is not significantly different ($Z = 0.89$, $P = 0.81$) from the estimated productivity in the winter of 1991 (74 calves / 100 cows). The recruitment rate of calves in the fall, estimated at 73 calves / 100 cows in 1997, is not significantly different from what it was in 1991, at 68 calves / 100 cows ($Z = 0.39$, $P = 0.65$).

The harvest rate by sport hunting was estimated at 27% in the fall of 1996. This was slightly higher than that estimated in the fall of 1990, which was 24.8% (Table 3). Bulls are very strongly pursued and their harvest rate increased from 36.1% in the fall of 1990 to 57.5% in the fall of 1996. Cow harvest declined from 22.1% to 10.4% between 1990 and 1996, and the harvest of calves increased from 15.3% to 23.0% during this same period. The overall adult harvest rate did not change; it was 28.4% in the fall of 1990 compared to 28.8% in the

Table 3. Moose winter populations estimated from the 1991 and 1997 aerial surveys, fall harvest, and harvest rate in the preceding autumn in Hunting Zone 2. [*Population hivernale d'orignaux estimée lors des inventaires aériens de 1991 et 1997, récolte sportive et taux d'exploitation à l'automne précédent dans la zone 2.*]

	1991				1997			
	Winter population *Population hivernale*		Fall harvest[2] *Récolte à l'automne*[2]	Harvest rate[3] (%) *Taux d'exploitation*[3] *(%)*	Winter population *Population hivernale*		Fall harvest *Récolte à l'automne*	Harvest rate (%) *Taux d'exploitation (%)*
	Moose *Orignaux*	C.I.[1]% *I.C.*[1]*%*			Moose *Orignaux*	C.I.% *I.C.%*		
Bulls *Mâles*	522	21.8	295	36.1	304	10.8	411	57.5
Cows *Femelles*	775	11.9	219	22.1	997	4.0	116	10.4
Calves *Faons*	574	20.2	103	15.3	624	6.4	186	23.0
Total	1871	20.8	617	24.8	1925	15.8	713	27.0

[1]Confidence interval as a % of the estimated population ($\alpha = 0.10$) [*Intervalle de confiance en % de la population estimée ($\alpha = 0,10$)*]

[2]Fall preceding the aerial survey [*À l'automne précédent l'inventaire aérien*]

[3]Harvest rate (%) = fall harvest + (winter population + harvest) x 100 [*Taux d'exploitation (%) = récolte sportive + (population hivernale + récolte) x 100*]

fall of 1996.

DISCUSSION

With the introduction of the selective harvest program, it was expected that the total harvest would decline because hunters could not harvest enough additional moose to replace the adult cows that were saved, thereby inducing growth of this population. Opposite to the results expected, there was a substantial increase in the harvest of bulls and calves, so that the total harvest actually increased slightly despite a reduction of the adult cow harvest by half. These results differ from those observed elsewhere in Québec, as well as in other jurisdictions where selective harvest programs have been introduced. In Québec, the selective harvest program has led to a decrease in the total harvest, varying from 7 - 40%, depending on the hunting zone (Courtois and Lamontagne 1999). In Ontario, the total harvest did not surpass the level reached when no restrictions were applied (Timmermann and Rempel 1998). Timmermann and Rempel (1998) observed an increase in the calf harvest and a decrease in the adult cow harvest, but a stable adult bull harvest after the establishment of a selective harvest program based on the protection of adults of both sexes. In Saskatchewan, the introduction of selective harvesting in 1977, based on increased protection of cows, has led to a decrease in the total harvest (Stewart 1985). The harvest of calves increased, bull harvest remained stable, and the cow harvest declined. A decrease in total harvest was also observed on the Kenai Peninsula, in Alaska (Schwartz *et al.* 1992), and in British Columbia (Child and Aitken 1989) after the establishment of a selective harvest. However, in these last 2 cases, the selective harvest was implemented after a hunting period for bulls only, with the objective of re-establishing the sex ratio and increasing productivity, which makes these results not very comparable with the present study.

Selective harvest influenced several parameters of the Bas-Saint-Laurent moose population. First, the percentage of adult cows in the winter population increased. Next, the percentage of adult bulls in winter declined to a level under the threshold of 30% proposed in the management plan (MLCP 1993) and which was suggested to maintain good productivity (Courtois *et al.* 1994). Despite this unbalanced sex ratio, no significant change in the calves: cows ratios, measured in winter or the fall, was observed in this population. In other hunting zones in Québec, Courtois and Lamontagne (1999) also observed a decrease in the percentage of adult bulls. This decrease was not generally significant and did not have an impact on the productivity of these other populations. The observed percentage of adult bulls is also within the range reported by Timmermann and Whitlaw (1992) in Ontario, which varied from 53 - 76 bulls per 100 cows. No change in productivity was noted in Ontario (Timmermann and Whitlaw 1992) or in Alaska (Schwartz *et al.* 1992) under these circumstances.

The cow harvest rate declined so much that their overall survival probably improved. This hypothesis is corroborated by the increase in the age of the adult cows harvested (Fig. 4). Consequently, better survival of cows may allow a larger number of them to reach their full reproductive potential. However, in Ontario, Timmermann and Rempel (1998) observed a decrease in the mean age of cows harvested which they attributed to an increase in hunting pressure on calves. Stewart (1985) also noted an increase in the mean age of adult cows in Saskatchewan. The mean age of bulls harvested in Hunting Zone 2 declined. This decrease may have been a consequence of greater hunting pressure on this segment of the population and, more importantly, an

increase in young (1.5-year-old) bulls in the population. In the Bas-Saint-Laurent region, 1.5-year-old moose represented 55% of the harvested adult bulls in 1996 in Zone 2, and continued to increase to 60 % by the fall of 1997, which was the fall following the last aerial survey (Fig. 5).

Since the introduction of the selective harvest program, the Bas-Saint-Laurent moose population has shown a better growth rate due to a higher proportion of adult cows and the maintenance of good productivity. These factors have effectively increased the recruitment of calves to the fall population. This apparent growth of the population, however, did not have the effect expected at the start. One of the objectives of the management plan was to increase winter density of the population to 2.6 moose / 10 km^2, but the density of this population remained unchanged at 1.8 moose / 10 km^2, even though the fall growth rate remained positive. This result is explained by the fact that the quota on adult cows brought a transfer of hunting pressure to adult bulls and, to a lesser extent, to calves, which slowed down the growth rate of the population. Courtois and Lamontagne (1999) reported annual growth rates varying from 1.6 - 16% in certain hunting zones in Québec, depending on the adult cow quotas. The lowest annual growth (1.6%) was observed in Zone 18 West which had the same harvest quotas as the zone in this study. In Ontario, Timmermann and Whitlaw (1992) did not observe a significant transfer of hunting pressure to other segments of the population and densities increased significantly in several hunting zones of that province. In Saskatchewan, the population declined despite the selective harvest. However, Stewart (1985) attributes the cause to other factors than sport hunting, such as the severity of winters, collisions with vehicles, and predation by black bears.

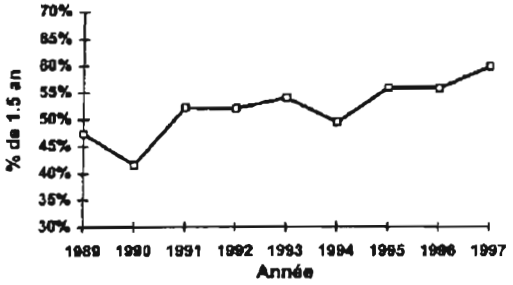

Fig. 5. Proportions of 1.5-year-old bulls harvested. [*Pourcentage d'orignaux de 1,5 an parmi les mâles adultes récoltés à la chasse.*]

Harvest rates in the Bas-Saint-Laurent region are among the highest in Québec (Courtois *et al.* 1994). It is also greater than that measured by Timmermann and Whitlaw (1992), which varied from 16.7 - 17.2% in the very accessible hunting zones of northern Ontario. Since the establishment of selective harvest in Québec's Zone 2, the harvest rate is even slightly higher than it was before, opposite to the results expected. This is probably attributable to the extension of the firearm-hunting season by 2 days. Based on harvest dates from recorded data, 2.6% of the moose were taken on the last 2 days of the fall hunting season in 1996. This represents almost exactly the observed difference between the harvest rates measured in the fall of 1990 and the fall of 1996. If not for this last factor, the apparent population growth rate (λ) in the fall would have been 1.091 instead of 1.053.

MANAGEMENT IMPLICATIONS

In conclusion, selective harvest with protection of adult cows did not reduce the harvest rate of the moose population in the Bas-Saint-Laurent region. The lower harvest quota on adult cows resulted in a transfer of hunting pressure to the other segments of the population, particularly adult bulls and, to a lesser extent, the calves. This transfer prevented the demographic growth of the population, such that the apparent growth in the fall, which was anticipated in

the management plan, was largely absorbed by the sport hunt. With selective hunting, the hunters benefited from a larger harvest and had greater hunting success due to a larger number of available moose in the fall. Considering the strong exploitation by sport hunting and the excellent access to the region, this population will probably increase more slowly than was initially foreseen in the management plan. Furthermore, the effects of the selective harvest will be positive as long as the firearm-hunting season follows the principal rutting period of moose. To increase this moose population more quickly, it would be necessary to adopt regulations allowing significant reductions in the total harvest, such as further reductions in the number of special permits for cows, shortening the length of hunting seasons, or limiting the number of hunters.

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REFERENCES

CHILD, K. N. and D. A. AITKEN. 1989. Selective harvests, hunters, and moose in Central British Columbia. Alces 25: 81-97.

COURTOIS, R. 1991a. Normes régissant les travaux d'inventaires aériens de l'orignal. Ministère du Loisir, de la Chasse et de la Pêche, Service de la faune terrestre, Québec, PQ. 24 pp.

_____. 1991b. Résultats du premier plan quinquennal d'inventaires aériens de l'orignal au Québec, 1987-1991. Ministère du Loisir, de la Chasse et de la Pêche, Service de la faune terrestre, Québec, PQ. 36 pp.

_____ and G. LAMONTAGNE. 1991. Modalités de chasse utilisables pour l'exploitation de l'orignal. Écho-Faune, Vol. 1(5). 4 pp.

_____ and _____. 1999. The protection of cows: its impact on moose hunting and moose populations. Alces 35: 11-29.

_____, Y. LEBLANC, J. MALTAIS, and H. CRÉPEAU. 1994. Quebec moose aerial surveys: methods to estimate population characteristics and improved sampling strategies. Alces 30: 159-171.

GASAWAY, W. C. and S. D. DUBOIS. 1987. Estimating moose population parameters. Swedish Wildl. Res. Suppl. 1: 603-617.

LABONTÉ , J., J.-P. OUELLET, R. COURTOIS, and F. BÉLISLE. 1998. Moose dispersal and its role in the maintenance of harvested populations. J. Wildl. Manage. 62: 225-235.

LAMOUREUX, J. and J.-M. PARISÉ. 1995. Inventaire aérien de l'orignal dans les réserves fauniques de Rimouski, de Matane, de Dunière, de Port-Daniel et des Chic-Chocs ainsi que dans la réserve de chasse et pêche Duchénier à l'hiver 1995. Pages 33-43 *in* S. St-Onge, R. Courtois, and D. Banville (eds.) Rapport des inventaires aériens de l'orignal dans les réserves fauniques du Québec. Ministère de l'Environnement et de la Faune, Service de la faune terrestre, Québec, PQ. 109 pp.

_____ and _____. 1997. Inventaire aérien de l'orignal dans la zone de chasse 2 à l'hiver 1991. Pages 5-11 *in* S. St-Onge, R. Courtois, and D. Banville (eds.) Rapport annuel des inventaires aériens de l'orignal à l'hiver 1997.

Ministère de l'Environnement et de la Faune, Service de la faune terrestre, Québec, PQ. 46 pp.

_____ and A.PELLETIER. 1997. Inventaire aérien de l'orignal dans la zone de chasse 2 à l'hiver 1997. Pages 13-23 *in* S. St-Onge, R. Courtois, and D. Banville (eds.) Rapport annuel des inventaires aériens de l'orignal à l'hiver 1997. Ministère de l'Environnement et de la Faune, Service de la faune terrestre, Québec, PQ. 46 pp.

LEBLANC, Y., D. COUTLÉE, and R. COURTOIS. 1996. Programmes DBASE et SAS pour l'analyse des données d'inventaires aériens d'orignaux: guide d'utilisation du logiciel INVENT.ORI, version 4.0. Ministère de l'Environnement et de la Faune, Service de la faune terrestre, Québec, PQ. 29 pp.

MARTIN, P.-L. 1980. Histoire de la chasse au Québec. Éditions du Boréal Express, Québec, PQ. 409 pp.

(MLCP) MINISTÈRE DU LOISIR, DE LA CHASSE ET DE LA PÊCHE. 1985. Consultation pour l'expansion des populations d'orignaux dans les zones de chasse 1 et 2 de la région 01. Ministère du Loisir, de la Chasse et de la Pêche, Direction régionale du Bas-Saint-Laurent—Gaspésie—Îles-de-la-Madeleine et Direction de la faune terrestre, Québec, PQ. 43 pp.

_____. 1993. Plan de gestion de l'orignal 1994-1998: objectifs de gestion et scénarios d'exploitation. Éditeur officiel du Québec, Québec, PQ. 139 pp.

OUELLET, R. 1977. Une méthode améliorée dans la préparation des incisives des ongulés. Ministère du Tourisme, de la Chasse et de la Pêche, Direction de la Recherche Faunique, Québec, PQ. 27 pp.

RIVEST, L.-P. , H. CRÉPEAU, and M. CRÊTE. 1990. A two-phase sampling plan for the estimation of the size of a moose population. Biometrics 46: 163-176.

SCHWARTZ, C. C., K. J. HUNDERTMARK, and T. D. SPRAKER. 1992. An evaluation of selective bull harvest on the Kenai Peninsula, Alaska. Alces 28: 1-13.

SNEDECOR, G.W. and W.G. COCHRAN. 1971. Méthodes statistiques. Association de coordination technique agricole, Paris. 649 pp.

STEWART, R. R. 1985. A sex- and age-selective harvest strategy for moose management in Saskatchewan. Pages 229-238 *in* S. Beason and S.S. Robertson (eds.) Game harvest management. Proc. Third Int. Symp., Caesar Kleberg Wildlife Research Institute, Kingsville, TX, Oct. 3-6, 1983.

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

_____ and R. S. REMPEL. 1998. Age and sex structure of hunter harvested moose under two harvest strategies in Northcentral Ontario. Alces 34: 21-30.

_____ and H. A WHITLAW. 1992. Selective moose harvest in North central Ontario - A progress report. Alces 28: 137-163.