THE PROTECTION OF COWS: ITS IMPACT ON MOOSE HUNTING AND MOOSE POPULATIONS

Réhaume Courtois and Gilles Lamontagne

Direction Générale du Patrimoine Faunique et Naturel, Service de la faune terrestre, 11e étage, 675 Boul. René-Lévesque, Est, Boîte 92, Québec, PQ, Canada G1R 5V7

ABSTRACT: Selective harvest of moose (*Alces alces*) was re-introduced in Québec in 1994 following 30 years of liberal hunting regulations in which all segments of the population were harvested. The aim of this regulatory change was to increase the population by 13 - 15% over a 5-year period while maintaining hunting activity and improving its quality. New hunting regulations were established in cooperation with users following public hearings and meetings with hunter representatives. It was agreed that all hunters would be allowed to harvest bulls and calves but that the harvest of cows would be managed through the issuance of special cow permits. Five harvest scenarios were adopted according to population status in each hunting zone and management objectives agreed upon with hunters: (1) cow harvest rate $\leq$10%; (2) no harvest of cows for 5 years; (3) no harvest of cows for 2 years and a 10% harvest rate thereafter; (4) no cow harvest in alternate years; and (5) non-selective harvest. One or two hunting zones that were representative of each scenario were chosen for comparison among scenarios. Regulation changes resulting in increased moose populations were favored by 78% of hunters consulted in a mail survey, and 84% of people in public hearings. Implementation of selective harvest, in 1994, was accompanied by a 9% reduction in hunter numbers, 7% of which was attributed to this regulatory change. However, the number of hunters stabilized starting in the second year. The initial decline in hunter numbers was greatest in the zones where the harvest of cows was subjected to the strictest quotas. Correspondingly the sport harvest fell by 16% in 1994. The decline was greatest (30-40%) in those zones where hunters were prohibited from harvesting cows and least (7%) in the zone where special cow permits were issued. During the plan it was difficult to sufficiently limit the number of cow permits so as not to exceed harvest quotas due to the very high success rate of hunters with special permits. This suggests that they had access to females spared by hunters without a special permit and that some of them possibly registered cows killed by other hunters. The harvest of bulls increased beginning in 1994, remained high for 1 or 2 years, then tended to decline. Overall, the harvest of calves rose by about 6%. Hunting success stayed stable or slightly increased during the plan despite selective harvest. The population sizes did not increase significantly (1.6% per year) where special permits were issued but increased rapidly and significantly (16.6% per year) in zones where all cows were protected. The proportion of bulls in the population has declined in all but 1 zone and the number of calves per 100 cows has increased in most zones. However, population structure changes were generally not significant. After 4 years of selective harvest the overall results appear positive. The number of hunters has stabilized, and harvest, hunting success, and moose populations have returned to prior levels or have increased. Aerial surveys suggest that the imbalance in the sex ratio resulting from the protection of cows does not appear to have impacted productivity.

Key words: *Alces alces*, density, harvest, harvest rate, population trends, productivity, selective harvest, sex ratio

RÉSUMÉ: La chasse sélective de l'orignal (*Alces alces*) a été réintroduite au Québec en 1994, après 30 ans de chasse libérale où tous les segments de la population étaient exploités. Cette modification réglementaire visait à augmenter la population de 13 à 15% en cinq ans tout en maintenant l'activité de chasse et en améliorant sa qualité. Les modalités de chasse ont été établies en collaboration avec les usagers grâce à des consultations publiques et des rencontres avec leurs représentants. Il fut

convenu de permettre à tous les chasseurs d'abattre les mâles adultes et les faons mais de protéger les femelles adultes en limitant leur récolte. Cinq scénarios de chasse sélective furent adoptés selon l'état des populations et les objectifs de croissance convenus avec les chasseurs:(1) émission d'un nombre limité de permis par tirage au sort de façon à ramener à 10% le taux d'exploitation des femelles; (2) aucune récolte de femelles pendant cinq ans; (3) aucune récolte de femelles pendant deux ans et taux d'exploitation limité à 10% par la suite; (4) récolte des femelles permise pour tous les chasseurs à tous les deux ans (alternance); (5) chasse non sélective. Une ou deux zones de chasse représentatives de chaque scénario furent retenues pour comparer les cinq modalités. Lors d'un sondage postal, 78% des répondants étaient favorables à des modifications réglementaires qui permettraient d'accroître les populations d'orignaux. Cet objectif de gestion fut retenu par 84% des répondants lors de consultations publiques. L'implantation de la chasse sélective a été accompagnée d'une diminution de 9% du nombre de chasseurs dont 7% seraient attribuables à la modification réglementaire. Cependant, le nombre de chasseurs s'est stabilisé dès la deuxième année. De façon générale, les baisses étaient plus importantes dans les zones ou au cours des années où la récolte de femelles était la plus fortement contingentée. La récolte sportive a diminué de 16% en 1994. La baisse fut plus importante (30-40%) dans la zone où la chasse de la femelle était interdite. À l'opposé, la baisse a été faible (7%) dans la zone où l'on émettait des permis spéciaux. De façon générale, il fut difficile de limiter suffisamment le nombre de permis de femelles pour ne pas dépasser les quotas de récolte à cause du succès de chasse élevé des chasseurs munis de permis spéciaux. Ceux-ci avaient accès aux femelles épargnées par les chasseurs sans permis spéciaux et certains ont possiblement enregistré des femelles tuées par d'autres chasseurs. La récolte de mâles a augmenté dès 1994, s'est maintenue élevée pendant un ou deux ans puis a eu tendance à diminuer. La récolte de faons a augmenté d'environ 6%. Malgré la chasse sélective, le succès de chasse s'est maintenu ou a augmenté légèrement durant le plan. Les populations d'orignaux n'ont pas augmenté significativement (1,6% par année) dans la zone où des permis spéciaux ont été émis. Par contre, la croissance fut très importante et significative (16,6% par an) dans les zones où toutes les femelles ont été protégées. La proportion de mâles chez les adultes a diminué presque partout alors que le nombre de faons par 100 femelles a augmenté. Cependant, les changements dans la structure des populations ne sont généralement pas significatifs. Après quatre ans de chasse sélective, le bilan global paraît plutôt positif. Le nombre de chasseurs s'est stabilisé, la récolte s'accroît de même que le succès de chasse et les populations d'orignaux. Les inventaires aériens suggèrent que le déséquilibre du rapport des sexes, engendré par la protection des femelles, ne provoque pas de baisse de productivité.

Mots-clés: *Alces alces*, chasse sélective, densité, productivité, rapport des sexes, récolte, taux d'exploitation

ALCES VOL. 35: 11-29 (1999)

The autumn of 1994 saw a turning point in the management of moose in Québec. It marked the first year of a new management plan re-introducing selective harvest after 30 years of liberal hunting practices. In the mid-sixties, harvest was restricted to bulls only (Courtois and Lamontagne 1990, 1997). About 20,000 licenses were sold each year, and harvest was about 3,500 animals. Consequently, managers introduced an unlimited non-selective harvest strategy to stimulate interest in moose hunting. Since the mid-eighties, up to 155,000 hunters have harvested 11,000 -12,000 moose annually. Cows represented over a third (± 4,500) of the kill from a population estimated at 67,000 in the early 1990's (MLCP 1993, Courtois *et al.* 1994). Several indices suggest a

population decline in the last 2 decades (Courtois and Lamontagne 1997) indicating that this harvest was not sustainable.

At the beginning of the 1990's, 5 major observations were made (Courtois and Lamontagne 1990): (1) hunting success and hunting quality had declined since 1964; (2) the harvest rate was high and oriented towards adults; (3) overall moose densities were low (0.3 - 2.5 / 10 km^2; Courtois 1991) everywhere outside reserves, even though habitat carrying capacity was high (Crête 1989); (4) hunting regulations were geared towards controlling hunter activity rather than directly limiting moose harvest; and (5) because of the high harvest rates, the mean age of adult moose was much lower (i.e., ~3.2 years; Courtois and Lamontagne 1997) than the age of maximum reproductive capacity (i.e., $\geq$ 4.5 years).

A management plan was proposed to address those concerns (MLCP 1993). The objective of the plan was to increase the overall population by about 13 - 15% between 1994 and 1998 and to maintain an annual average of 1,000,000 moose hunting days of recreation. The plan proposed protecting cows by limiting their harvest rate to 10% in most of the hunting zones to stimulate the population growth. Further, no limits were imposed on the hunting of bulls and calves in an effort to maintain interest in moose hunting. Hunter support was stimulated by involving hunters and their representatives in implementation details. Five hunting scenarios were adopted. They ranged from the *status quo* in zones with few problems or low hunting pressure, to the complete exclusion of cow harvest for 5 years in zones where the situation warranted or where hunters desired a rapid population increase.

This paper details results obtained after 4 years of selective harvest (1994-1997) and compares the relative efficiency of the 5 hunting scenarios. We address hunter numbers, harvest, and moose population trends. Daigle *et al.* (1995) and Sigouin *et al.* (1997a, 1999) evaluated the impact of the new regulations on the activity of hunters and their perception towards the regulation. Laurian *et al.* (1996) described the impacts on the reproduction of moose in study areas.

METHODS

Consultation with Hunters

In February 1992 we mailed 10,000 questionnaires to moose hunters chosen systematically (500 in each of the 22 hunting zones) from among those who had purchased hunting licenses in the autumn of 1990. In Zone 18, subdivided administratively in 2 parts, 1,000 hunters received the questionnaire, while all hunters received the questionnaire in zones frequented by less than 500 hunters. Because some addresses were incomplete, actual mailings varied between 35 and 994, for sampling rates varying between 2 and 95%. We mailed a reminder 4 weeks after the first invoice. We received 6,380 valid questionnaires, a response rate of 64.4%, 10 weeks after the first invoice. Questionnaires were rejected if they were blank (46) or if multiple answers (70) were chosen. Stratified sample results were weighted by the number of hunters per hunting zone, to reflect the hunter perception at the provincial level.

Hunters were asked to choose a management objective (either *status quo* or population growth) and their preferred hunting regulation (reduction of cow harvest, reduction of either cow or bull harvest, reduction of hunter number or *status quo*). The questionnaire was pre-tested in January 1992, with 20 hunters from 4 zones (Zones 3, 7, 15, 19) with a range of moose densities and regulations.

Public hearings were held in March and April, 1992, by the 3 principle user groups (Fédération québécoise de la faune,

Fédération des gestionnaires de zecs, and Fédération des pourvoyeurs du Québec). The public was notified of the hearings by way of media (TV, radio, and newspapers) announcements. At each hearing, biologists from the Ministry presented an overview of the provincial moose status, and then detailed the current situation in each local hunting zone. A question period followed, after which participants were invited to fill out a questionnaire identical to that of the February mail survey, but which included a space for suggestions. Approximately 10,000 people attended 44 public meetings, and 6,267 filled out the questionnaire. Hunter federations compiled questionnaire data and collectively made their recommendations to the Minister.

Evaluation of the Management Plan Results

In Québec, license dealers receive a pre-determined number of licenses from the Ministry about a month before the hunting season opens. License sales end the day before hunting season opens. Dealers then return unsold licenses, and a copy of all licenses sold. Licenses are only valid for individual zones, specified on each license. About 2% of the hunters fail to use their licenses in each zone (Daigle *et al.* 1995, Sigouin *et al.* 1997a). Thus, total annual sales were used to determine the number of hunters per hunting zone.

The registration of big game sport harvest is mandatory in the province. Harvested moose are examined at 1 of the 275 registration stations and are categorized by age (adult, calf), sex, and biological characteristics (real age [tooth sample], presence of milk, etc.) are evaluated. Those data, were used to evaluate harvest changes by zone. *t*-tests were used to compare annual license sales, harvest per segment of the population (bulls, cows, calves), and hunting success before (1990-1994) and after (1994-1997) the introduction of selective harvest.

The moose population in each hunting zone is estimated by aerial survey every 5-7 years, such that 2-3 zones are inventoried annually (Courtois *et al.* 1996, Courtois and Lamontagne 1997). We used the results of the aerial surveys to evaluate the impact of the protection of cows on the growth rate of the populations, population structure (% bulls), and productivity (calves/100 cows) by the mean of the normal approximation (Courtois *et al.* 1994). A complete survey in the winter of 1993 followed by a second complete survey in the winter of 1998 was not possible for logistical and budgetary reasons. Consequently we chose zones which were judged representative of the hunting scenarios adopted in the management plan and which were surveyed 1 or 2 years before, and 3-4 years after initiation of the plan. To maximize the chances of detecting changes, the same plots were overflown during each of the 2 surveys (Courtois *et al.* 1994), except in Zone 7. The data from both of 2 aerial surveys were used to calculate mean annual rate of population increase ($r = 1/t * \ln N_t/N_0$, where t = the number of years between surveys; N_0 and N_t = the number of moose counted in the first and second survey respectively; Lassus 1987; $\lambda = e^r$).

RESULTS

Public Hearings and Management Objectives

Population growth was the management objective chosen by 78% of the respondents to the mail survey and by 84% of those who attended the public hearings (Fig. 1). Cow harvest restrictions were supported by 53% and 49% of the mail survey and public hearing respondents respectively. Public hearing responses were more variable as 28% suggested other hunting regulations. The addition of a "fill in the blank" question at the public hearings only de-

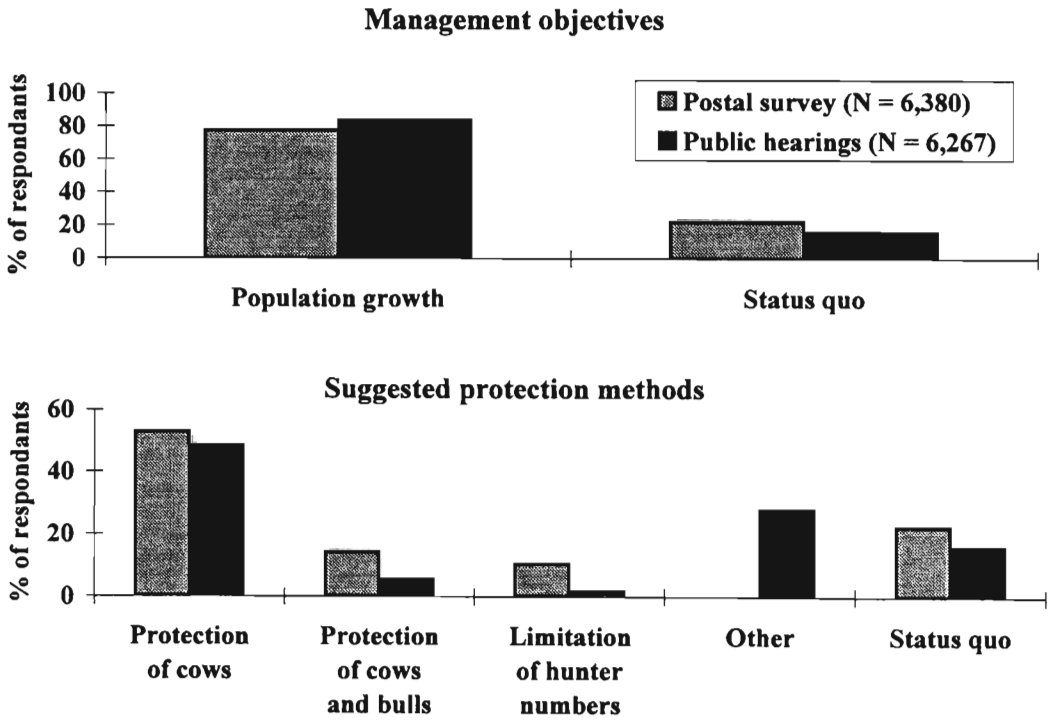

Fig. 1. Management objectives and harvest regulations suggested by hunters consulted in the mail survey and public hearings held in 1992.

creased by 4% the proportion of hunters in favor of the protection of cows; relative importance of other choices decreased by 6 - 9%. The most common "fill in the blank" suggestions were the shortening of the hunting season and the institution of a bulls only regulation. Only 11% of mail survey and 2% of public hearing respondents were in favor of restricting hunter numbers. Choices of hunting regulation varied slightly from zone to zone, but the protection of cows was always the most popular, receiving between 35 and 57% support. The *status quo* was particularly popular in the northern zones (36 - 42%) and in those zones supporting an archery only season (28 - 35%), but generally received fewer supporters than the protection of cows.

Considering the results of the consultations, 3 management objectives were retained: (1) to increase the moose population of the province by about 13 - 15%; (2) to maintain hunting access to all hunters who desire it; and (3) to improve the quality of the moose hunt. Specific hunting regulations in each zone were modeled after the recommendations received from hunting federations. Five hunting scenarios were chosen (Fig. 2). In most hunting zones the cow harvest rate was limited to 10% by issuing a limited number of special permits which allowed cow hunting (general scenario). In Zones 3 - 6, cow hunting was prohibited for the entire duration of the plan, between 1994 and 1998. In Zones 12, 13, 16, and 17, cow hunting was only allowed in alternate years, beginning in 1995. In Zones 14 and 15, cows were completely protected for 2 years and then the general scenario was applied. Finally, an unlimited, non-selective harvest strategy was authorized in Zones 7, 19, 20, and 22. Other zones where moose were rare remained closed to hunting. Zones 3-4, 13, 14, and 18 West were retained as

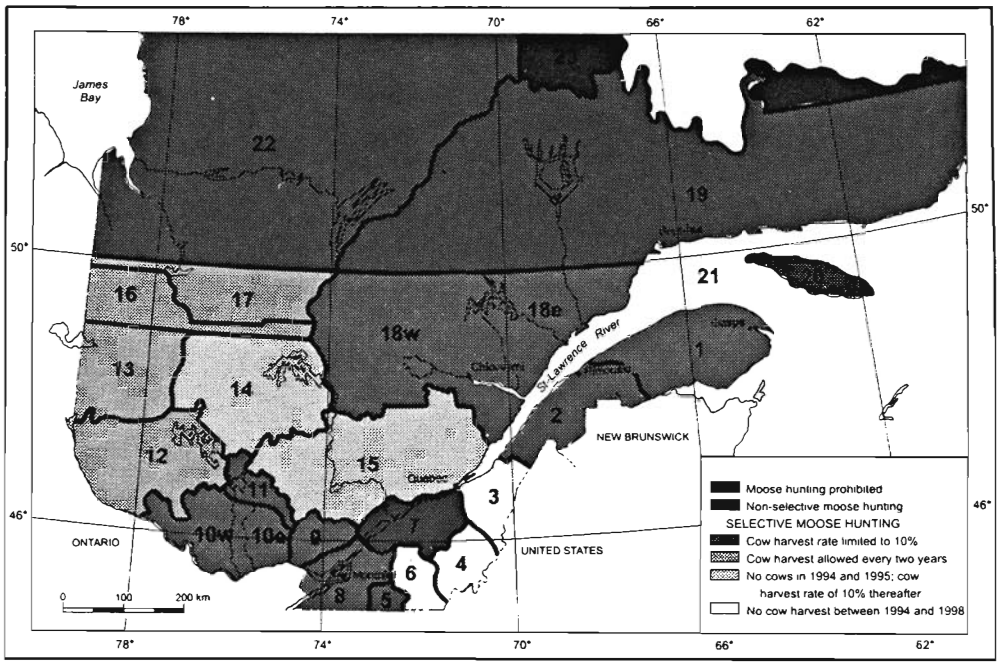

Fig. 2. Harvest scenarios retained for the 1994-1998 moose management plan in Québec.

representative zones and were the subject of a particular monitoring program (e.g., changes in harvest characteristics, hunter number and attitude, and moose population abundance, sex-ratio, and productivity) to compare the efficiency of the different scenarios of selective harvest. Zones 7 and 19, where the *status quo* was maintained, were retained as Control sites of high and low hunting pressure.

Changes Induced by the Selective Harvest

Number of hunters. – At the provincial level, the number of hunters decreased by 12% from 1993 - 1997 (Table 1). The decrease (-9%) was most pronounced in 1994 when selective harvest was first introduced while it was about 1% per year between 1995 and 1997. In hunting zones where special permits were issued the decline in 1994 was 7 - 8% but was twice as much (13 - 17%) in those zones where cow hunting was banned. In Zone 13 where cow hunting was allowed every second year, the sale of hunting licenses increased in the years when cows were allowed. On the other hand, the sale of licenses increased annually by 2 - 8% in the Control Zone to the south of the St. Lawrence, but a more or less consistent decrease of about 6 - 9% per year was noted in Zone 19, north of the River, in absence of regulation change. In Québec, hunting pressure (per km^2) is more intense south of the St. Lawrence River in zones situated closer to large urban centers (Courtois and Lamontagne 1990).

Changes in the sport harvest. – The total sport harvest decreased by 16% in 1994 (Table 2). The drop was largest (30 - 40%) in the zones where cow hunting was banned. In Zone 18 West, where a limited number of special permits were issued in order to limit the cow harvest rate to 10% per year, the harvest only decreased by 5%, a rate similar to that of the Control Zone (Zone 19 = -4%). Between 1995 and 1997, the harvest increased everywhere, except

Table 1. Number of licenses sold between 1993 and 1997 in hunting zones retained for the evaluation of the management plan and in all hunting zones of Québec.

Hunting Zone	Harvest scenario	1993	1994[1]	1995	1996	1997	Licenses / 10 km² in 1997	Significance of change after 1993[2]
South of the St. Lawrence River								
3-4	No cow harvest	10,180	8,457	7,678	7,946	8,853	8.4	Decrease
7	Non-selective harvest	3,087	3,150	3,314	3,184	3,436	8.8	Increase
North of the St. Lawrence River								
13	Alternating	14,800	12,873	13,171	12,827	12,694	5.6	Decrease
14	No cows in 1994 and 1995; cow harvest rate of 10% thereafter	13,543	11,362	10,660	10,846	11,739	3.1	Decrease
18 West[3]	Cow harvest rate of 10%	19,154	17,755	17,060	17,146	16,137	2.9	Decrease
19	Non-selective harvest	6,421	5,853	5,315	5,500	5,143	0.3	Decrease
Total Québec		**145,760**	**132,214**	**130,929**	**129,561**	**128,854**	**1.9**	Decrease

[1] Selective harvest initiated

[2] $P < 0.05$

[3] Distributed according to the declarations of hunters of Zone 18 during mail surveys (1994 = 64%; 1995 = 65%; 1996= 64%; Daigle *et al.* 1995; Sigouin *et al.* 1997, 1999)

Table 2. Number of moose harvested by sport hunters between 1993 and 1997 in hunting zones retained for the evaluation of the management plan and in all hunting zones of Québec.

Hunting Zone	Harvest scenario	1993	1994[1]	1995	1996	1997	Harvest / 10 km² in 1997	% bow hunting	Significance of change after 1993[2]
South of the St. Lawrence River									
3-4	No cow harvest	867	519	614	760	767	0.71	31.6	Decrease
7	Non-selective harvest	243	305	331	344	343	0.88	100.0	Increase
North of the St. Lawrence River									
13	Alternating	1,077	756	1,424	648	1,239	0.28	3.7	No change
14	No cows in 1994 and 1995; cow harvest rate of 10% thereafter	905	598	698	901	930	0.24	0.8	Decrease
18 West	Cow harvest rate of 10%	1,318	1,248	1,030	1,096	1,134	0.21	0.7	Decrease
19	Non-selective harvest	643	617	502	496	469	0.03	0.0	Decrease
Total Québec		**11,044**	**9,270**	**10,610**	**9,930**	**11,342**	**0.13**	**11.3**	Decrease

[1]Selective harvest initiated

[2]$P < 0.05$

in Zone 19 and approached or surpassed the hunt in 1993. Since 1994, the harvest has grown by 22% at the provincial level, but only by 12% in the south Control Zone while it has decreased by 24% in the Control Zone north of the St. Lawrence River. The most important increase occurred in Zones 3-4 (48%) despite the ban on cow hunting. Substantial increases were also noted in Zones 13 and 14 (64 and 56% respectively), but, as opposed to 1994, cow harvest was authorized in these zones in 1997 (Zone 13: for all hunters; Zone 14: for 1,800 hunters). As well, in Zone 13, the alternating program made the harvest oscillate, and the tendency was a decline in harvest if we compare the years with a similar hunting program (1994 vs. 1996 and 1995 - 1997).

The management plan targeted a maximum harvest of 1,243-2,827 cows per year. However these targets were exceeded in most zones except those with a ban on cows. Excess cow harvest was particularly important in 1994 in Zone 18 West (82%) where special permits were sold. Despite a 18% surplus in 1994, the provincial cow harvest decreased by 65% (Table 3). The annual number of special permits was adjusted to meet cow harvest quotas and cow harvest exceeded targets by only 4-6% annually after 1994. When compared with the 1990-1993 period, the 1994-1997 cow harvest decreased significantly ($P < 0.05$) in hunting Zones 3-4, 14, and 19. We noted an increase in Zone 7 ($P < 0.01$) and no change ($P = 0.30$) in Zone 13 due to the annual fluctuations caused by the alternating program (Fig. 3). In Zone 13 the mean annual harvest (284 ± 164) was nevertheless 40% lower during the plan than before 1994 (471 ± 35).

Contrary to prediction, harvest of bulls increased from the first year of the management plan in most of the hunting zones. The only exceptions were Zones 3-4 and 19 where a 6% decline was noted. At the provincial level, the increase in bull harvest was 17% in 1994. Generally, the harvest of bulls remained elevated for 1 or 2 years, then tended to decrease, as in Zone 13 as much as 23%. The only exceptions were the southern zones where the bull harvest increased from 1994 onward. Overall, bull harvests increased ($P < 0.05$) in Zones 3-4 and 7, decreased in Zone 19 ($P = 0.02$), and remained stable in Zones 13, 14, and 18 West ($P > 0.05$) after 1993.

Between 1994-1997 the calf harvest increased only in Zone 7 while it decreased in 2 zones (18 West and 19; $P < 0.05$) and remained stable in 3 zones (3-4, 13, and 14; $P > 0.05$). At the provincial level, calves comprised 18% of the harvest in 1997 as compared to only 12% in 1993.

Hunter success. – Hunter success was maintained or increased slightly throughout the course of the management plan because of a decrease in the number of hunters and a constant increase in the harvest (Table 4). At the provincial level, success rates declined from 7.6 in 1993 to 7.0% in 1994, but increased to 8.8% in 1997. Increased hunter success was most notable south of the St. Lawrence and in zones where cow harvest was strongly reduced but changes relative to the 1990-1993 period were significant only in Zone 7 ($P = 0.01$).

Population Status. – Moose populations seemed to increase in all the hunting zones surveyed (Table 5). Most notable were changes in Zones 3-4 where populations more than doubled in 5 years ($t = 4.19$, $P < 0.01$, $n = 56$). Increases were of 49% in Zone 7 ($t = -2.67$, $P = 0.01$, $n = 29$, 32), and of 24% in Zones 13 ($t = 3.38$, $P < 0.01$, $n = 63$), and 14 ($t = 0.53$, $P = 0.59$, $n = 99$) in 3-5 years. In Zone 18 West, the growth of the population was modest (6% in 4 years) and there was no significant difference between the 2 surveys ($t = -0.29$, $P > 0.10$, $n = 63$). The mean annual rate of

Table 3. Number of special cow permits and cows harvested between 1993 and 1997 in hunting zones retained for the evaluation of the management plan and in all the hunting zones of Québec.

Hunting	Harvest	Number of cow permits					Cow harvest					
Zone	scenario	1993	1994[1]	1995	1996	1997	1993	1994	1995	1996	1997	Target
South of the St. Lawrence River												
3-4	No cow harvest	Unlimited	0	0	0	0	290	0	0	0	0	0
7	Non-selective harvest	Unlimited	Unlimited	Unlimited	Unlimited	Unlimited	87	105	113	120	116	-[2]
North of the St. Lawrence River												
13	Alternating	Unlimited	Unlimited	0	Unlimited	0	480	0	587	0	549	520[3]
14	No cows in 1994 and 1995; cow harvest rate of 10% thereafter	Unlimited	0	0	2,000	1,800	328	1	1	265	257	240
18 West	Cow harvest rate of 10%	Unlimited	3,100	1,900	2,370	1,980	488	334	217	301	281	268
19	Non-selective harvest	Unlimited	Unlimited	Unlimited	Unlimited	Unlimited	222	211	189	162	164	-[2]
Total Québec		Unlimited	10,730	8,570	12,805	11,915	4,201	1,464	2,445	1,834	2,940	1,270[4]
	Provincial target							1,243	2,338	1,732	2,827	

[1] Selective harvest initiated

[2] Non-selective harvest

[3] 10% of the pre-hunt cow population in 1989 multiplied by 2, cow harvest being permitted every 2 years

[4] In 1994 and 1996 when no cow harvest was allowed in zones where the alternating program is applied

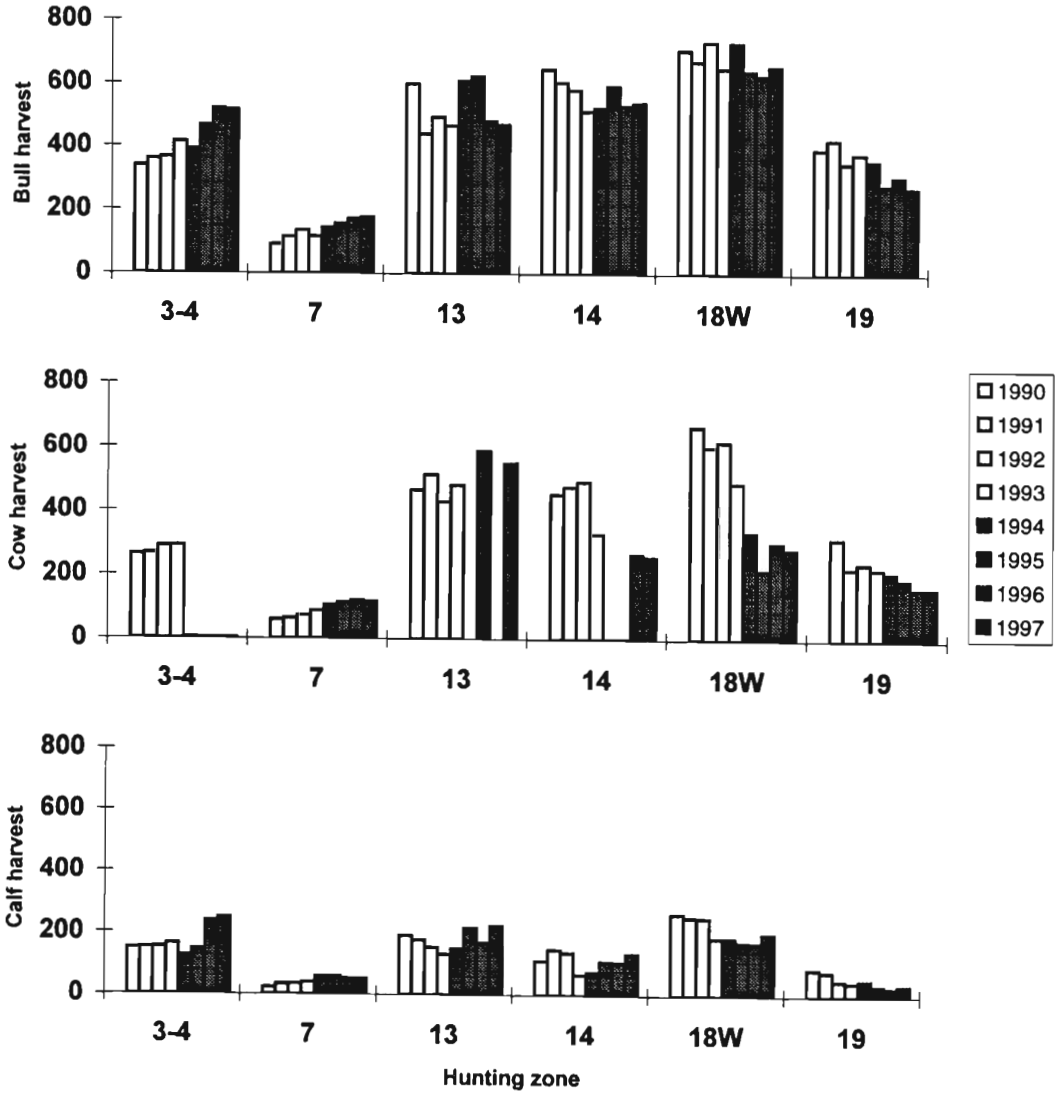

Fig. 3. Bull, cow, and calf harvest trends between 1990 and 1997 in hunting zones retained for the evaluation of the moose management plan. White = before, and black = during the management plan.

increase in Zones 3-4 was 16.6% where cow hunting was banned, while it was 4 - 5% in the zones where cows were hunted in alternating years or where they were protected for 2 years before the issuing of special permits. The growth rate was also high in Zone 7 (13.4% per year) where only archery hunting was authorized, but where no additional measures were taken in the management plan to protect moose populations. In Zone 18 West, where special cow permits were issued annually, the rate of population increase was 1.6% per year. In Zone 19, the growth rate is not known as only 1 survey was available due to administrative constraints.

With the exception of Zone 18 West, the proportion of bulls in the population tended to decrease. However, changes were only significant in Zones 13 and 18 West ($z > 1.38$, $P < 0.10$). The overall bull segment of the population ranges from

Table 4. Percent hunter success (moose harvested / 100 hunters) between 1993 and 1997 in hunting zones retained for the evaluation of the management plan and in all hunting zones of Québec.

Hunting Zone	Harvest scenario	1993	1994[1]	1995	1996	1997	Significance of change after 1993[2]
South of the St. Lawrence River							
3-4	No cow harvest	8.5	6.1	8.0	9.6	8.6	No change
7	Non-selective harvest	7.9	9.6	10.0	10.8	10.0	Increase
North of the St. Lawrence River							
13	Alternating	7.3	5.9	10.8	5.1	9.8	No change
14	No cows in 1994 and 1995; cow harvest rate of 10% thereafter	6.7	5.3	6.5	8.3	7.9	No change
18 West	Cow harvest rate of 10%	6.9	7.0	6.0	6.3	7.0	No change
19	Non-selective harvest	10.0	10.5	9.4	9.0	9.1	No change
Total Québec		7.6	7.0	8.1	7.7	8.8	No change

[1] Selective harvest initiated

[2] $P < 0.05$

36% to as low as 21% where all cows were protected. However, this change does not appear to be accompanied by a drop in productivity. After 1992 the number of calves remained at or above 54 - 73 per 100 cows and has increased in most zones. However, the differences were significant only for Zone 7 ($z = 1.62$, $P < 0.10$).

DISCUSSION

Impact of the Selective Harvest on Hunters

The introduction of selective harvest reduced hunter numbers as suggested by the decrease in the number of hunting licenses sold in 1994. The decrease was much greater in those zones where cow harvest was completely banned. The data suggests many hunters chose to stop hunting rather than change hunting zones where the regulation had not changed. Hunters also hunted longer to compensate for constraints placed on them by selective harvest (Daigle *et al.* 1995, Sigouin *et al.* 1999).

However, selective harvest is not the only reason for the decrease in the number of hunters. License sales increased nearly tenfold following the abolition of the bulls only regulation in 1964 (Courtois and Lamontagne 1990). Sales slowed down in the late 1980's and then declined 2 - 3% annually after 1991. If this tendency continued during our study we would anticipate a 6 - 7% decrease in hunter numbers caused directly by the implementation of selective harvest (Daigle *et al.* 1995, Courtois and Lamontagne 1997). Such gradual reduction in the number of hunters, visible in Zone 19 where the regulation did not change during the management plan, is probably due to a lack of recruitment of hunters, in part due to a perception of reduced hunt quality. In the early 1990's, 60% of hunters foresaw problems (too many hunters, not enough moose,

etc.) and almost half believed the survival of moose was threatened (INFRAS 1990). The stabilization in the sale of hunting licenses in the last few years, despite the initiation of selective harvest, suggests that the decline in the number of hunters will be less pronounced in the immediate future. Moreover, hunting success is increasing and hunters have more opportunities to observe a moose during the hunting season (Sigouin *et al.* 1997a, 1999) thus increasing hunting quality and encouraging hunters to remain active. Offering a good hunting experience through population increases is probably the most promising way to retain current moose hunters and attract new ones.

Mail survey data suggest that hunters are generally satisfied with the selective harvest program (Daigle *et al.* 1995; Sigouin *et al.* 1999). Since 1994, barely 5% have expressed any concerns about eventual negative impacts. The extensive public hearings and the participation of hunters through their hunting federations in the decision making process permitted the adoption of management scenarios better adapted to their needs and desires. The direct involvement of users has proven to be useful in obtaining overall support, as noted in Ontario (Wedeles *et al.* 1989).

Impacts of Selective Harvest on Moose Populations

Cow protection had a positive impact on the moose population. Despite more restrictive hunting regulation and a decrease in the number of hunters, the overall harvest is increasing. At the provincial level, harvests are higher than prior to initiation of the management plan. We believe this increase is due, in part, to the emphasis of hunting pressure on bulls and calves, and protection of cows. Aerial surveys suggest that populations are growing and thus helping to increase the harvests.

Hunters report observing positive changes at the population level. Mail surveys suggest a growing proportion of respondents believe that moose populations are increasing (1994: 3 - 11% of hunters depending on the hunting scenario; 1997: 10 - 16%) and, the number of animals seen per 100 hunting days has grown from 7 - 19 to 8 - 30 per 100 hunting days depending on the hunting scenario (Sigouin *et al.* 1999). All of these indicators (harvest, aerial surveys, hunting success, animals seen) suggest population increase. These tendencies are more pronounced in zones where the protection of cows was emphasized. For example, in Zones 3 and 4, the number of animals seen per 100 hunting days has gone from 19 in 1994 to 31 in 1997, and the annual rate of increase as measured by aerial survey was 17% (Table 5).

According to the aerial surveys undertaken during the management plan, the harvest rate of cows oscillated between 0 and 10% (15% every 2 years in Zone 13; median = 8%), which is well below values observed before the plan (15 - 24%, median = 18%) and corresponds to the objective (10 -15%, MLCP 1993). Targets of cow harvest were exceeded (Lamoureux 1999), particularly in 1994, but cow numbers increased sufficiently to compensate for this harvest surplus. Coincidentally, the harvest rate of calves (7 - 38%, median = 10%) remained acceptable with regard to the values observed before the plan (8 - 26%, median = 11%, St-Onge *et al.* 1994) and of the stated objective of the plan (15 - 20%). On the other hand, the harvest rate of bulls was quite high before the management plan (31 - 50%, median = 31%) and it increased over the course of the plan (32 - 75%, median = 35). The percentage of bulls in the population decreased without a corresponding decline in productivity (this study and Lamoureux 1999).

In a 1,000-km^2 study site subjected to selective harvest and surveyed for 4 years,

Table 5. Summary of aerial surveys conducted before and during the management plan in hunting zones retained for the evaluation of the moose management plan in Québec.

Hunting Zone	Harvest scenario	Year (Jan-Feb)	Population No. ± CI[1]	Annual rate of increase, r (λ)	Moose sexed	% bulls in adults	No. /100 cows bulls	calves
3-4	No cow harvest	1993	557 ± 156		155	29	41	53
		1998	1,277 ± 311	0.166 (1.181)	367	24	32	63
7	Non-selective harvest	1989	657 ± 164		257	40	67	65
		1992	981 ± 147	0.134 (1.143)	415	35	52	73
13	Alternating	1994	4,723 ± 668		288	36	60	63
		1998	5,873 ± 1,057	0.054 (1.055)	375	25	33	60
14	No cows in 1994 and 1995;	1992	4,368 ± 764		245	27	37	50
	cow harvest rate of 10%	1997	5,549 ± 1,276	0.048 (1.049)	262	27	36	54
	thereafter							
18West	Cow harvest rate of 10%	1994	4,923 ± 1,575		90	19	23	50
		1998	5,241 ± 1,677	0.016 (1.016)		33	49	62
19	Non-selective harvest	1988	7,809 ± 2,260		71	47	88	44
		-	-	-	-	-	-	-

Sources: Gingras *et al.* (1989), Banville *et al.* (1990), Banville and St-Onge (1993, 1998), Paré (1996), Tremblay and Dussault (1996), Milette and Paré (1998), Gosselin and Dubois (1998, 1999), Dussault (1999)

[1] Confidence interval, $\alpha = 0.10$

Laurian *et al.* (1996) observed similar harvest rates (median: bulls = 33%; cows = 8%; calves = 12%) as those observed in our study. Despite this, the studied population increased by 17 - 24% per year, even though the percentage of bulls among adult moose decreased from 29 - 30% to 17 - 22%. Likewise, observed productivity increased gradually from 39 to 54 calves per 100 cows. While the presence of 2 wildlife reserves helps to support the harvest and supply male reproducers in this study area (Labonté *et al.* 1998), the results of Laurian *et al.* (1996) suggest that bull moose are sufficiently polygamous to mate several cows (Timmermann 1992).

Achievement of the Management Objectives

The prime objectives of the management plan were achieved. In the early 1990's, the winter population of moose in Québec was estimated at 52,543 ± 4,917 individuals (moose ± confidence interval, α = 0.10) outside of parks and wildlife reserves (Courtois *et al.* 1994). Recent surveys suggest 58,898 ± 4,719, an increase of 14%. Such a difference is not significant (P = 0.13) but the change conforms to the goals of the management plan. To these estimations we must add the 12,700 moose in wildlife reserves (St-Onge *et al.* 1995) and approximately 1,900 moose in parks (Courtois 1991) for a total winter population of about 74,500 moose. Taking into account the sport harvest, the total pre-hunt moose population was estimated at 85,800 in fall 1997.

Despite the decrease in their numbers to about 130,000, hunters appear to have increased their level of activity from about 8.4 (Nedelca 1991) to 9.6 days a year (Sigouin *et al.* 1997a), resulting in about 1,250,000 hunting days annually. This level of activity surpasses the 1 million hunting days targeted in the management plan.

Finally, the management plan aimed for mean hunting success of 10% by 1998. The success rate reached 8.8% in 1997 and will likely remain below target as fewer cows will be harvested in 1998 due to the alternating program in the zones of north-western Québec (Fig. 2). The target of 10% will not be attained before 1999. However, the number of moose seen per hunting day increased (Sigouin *et al.* 1999). This may suffice to raise hunter satisfaction and at least partially compensate for a lower success rate than targeted.

Suggestions for the Next Management Plan

Selective harvest is an effective way to attain management objectives. Swedish managers increased their populations and harvests through the protection of cows and an increase in hunting pressure on calves (Lavsund and Sandegren 1989). A partial protection of cows and bulls permitted the growth of moose populations in western Ontario (Timmermann and Whitlaw 1992). The sex ratio of the Kenai Peninsula population improved 3 years after the replacement of an any bull season with a selective harvest system oriented on yearlings and large bulls (Schwartz *et al.* 1992). An emphasis on yearling harvest resulted in an increase in the proportion of prime bulls in British Columbia (Child and Aitken 1989). In most jurisdictions where selective harvest has been applied, including those where biological results were less convincing (Stewart 1985, Lamoureux 1999), socio-economic impacts have been maintained or increased. Some hunters may quit hunting after the introduction of such a program but some of them start again when they feel more comfortable with the new regulation (Schwartz *et al.* 1992) and, possibly, when hunting conditions improve. When hunters understand the biological basis underlying the selective harvest system, they tend to

support it (Rollins and Romano 1989).

Without a doubt the next management plan will be developed in collaboration with hunters. Thus, at this time it is impossible to predict its content. However, keeping in mind the results presented here, we predict that the protection of cows will likely remain at the center of managers' and hunters' interest.

Six major concerns have resulted from the first plan: (1) counter the decrease in hunter numbers; (2) promote population growth in zones where the plan was less successful; (3) increase the involvement of hunters and their representatives; (4) avoid emphasizing the imbalance in the sex ratio of adult moose; (5) continue to maximize productivity; and (6) simplify regulations.

To achieve these objectives, we suggest the maintenance of a selective harvest program oriented towards the protection of cows in Québec. This measure permits growth of the moose population, as well as that of hunting quality, an essential prerequisite to retain hunting clientele. The hunting of cows should be banned in the zones where hunters desire a rapid increase in the population. Elsewhere, the program of alternating years seems to be the most appropriate hunting scenario because it is administratively simple and is seen as fair towards all hunters in Québec, while at the same time permitting moderate population growth. In areas where managers desire a stable clientele (i.e., reserves, outfitters areas, etc.), a limited number of cow permits could be issued annually under the direct administration of the area managers, so as to involve them in the management of the local moose populations. Finally, the standardization of the opening date of the firearm hunting season is suggested, since the period of the rut varies little in the overall distribution area of moose (Sigouin *et al.* 1995, 1997b).

Even if selective harvest generally has positive results, other factors may undermine the managers' efforts (Stewart 1985, Timmermann and Whitlaw 1992, Timmermann and Rempel 1998). Only strict monitoring can predict population trends and no one can guarantee that the moose population in each hunting zone of the province will continue to grow. Consequently, the next management plan should include an evaluation program to adequately monitor plan impact. The monitoring system should include the mandatory registration of the harvest everywhere in Québec and, at least in representative zones, aerial surveys at 5-year intervals and annual mail surveys.

ACKNOWLEDGEMENTS

The authors are indebted to Chuck Schwartz and an anonymous referee who reviewed this paper and to regional biologists and technicians, particularly Sylvie Desjardins, Marc-Jacques Gosselin, Benoît Langevin, Jean Milette, and Marcel Paré, for the realization of the aerial surveys. Special thanks are also given to Johanne Nicolas, who furnished data relative to the sale of hunting licenses, Lucie Gignac and Sylvain St-Onge for the compilation of the sport harvest data, and to Shannon Fizer for the translation of the first draft of this paper.

REFERENCES

BANVILLE, D., M.-J. GOSSELIN, J. MILETTE, S. ST-ONGE, and R. COURTOIS. 1990. Inventaire aérien de l'orignal dans la zone de chasse 7 à l'hiver 1989. Ministère de l'Enironnement et de la Faune du Québec, Direction régionale de Québec, Direction régionale de l'Estrie, Direction régionale Mauricie-Bois-Francs et Direction de la gestion des espèces et des habitats, Report 1775. 27 pp.

_____ and S. ST-ONGE. 1993. Inventaire aérien de l'orignal dans la zone de

chasse 7 à l'hiver 1992. Ministère de l'Enironnement et de la Faune du Québec, Direction régionale de Québec, Report 2308. 19 pp.

_____ and _____. 1998. Inventaire aérien de l'orignal dans la zone 3 à l'hiver 1993. Pages 25-33 *in* S. St-Onge, R. Courtois, and D. Banville (eds.) Rapport annuel des inventaires aériens de l'orignal à l'hiver 1992 et à l'hiver 1993. Ministère de l'Environnement et de la Faune du Québec, Service de la faune terrestre, Québec, PQ.

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

COURTOIS, R. 1991. Résultats du premier plan quinquennal d'inventaires aériens au Québec, 1987-1991. Ministère de l'Environnement et de la Faune, Service de la faune terrestre, Report 1921. 36 pp.

_____ and G. LAMONTAGNE 1990. Diagnostic sur l'état des populations d'orignaux au Québec. Ministère de l'Environnement et de la Faune du Québec, Service de la faune terrestre, Report 1785. 37 pp.

_____ and _____. 1997. Management system and current status of moose in Québec. Alces 33: 97-114.

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

_____, F. POTVIN, S. COUTURIER, and A. GINGRAS. 1996. Révision des programmes d'inventaires aériens des grands cervidés. Ministère de l'Environnement et de la Faune du Québec, Service de la faune terrestre, Report 3425. 49 pp.

CRÊTE, M. 1989. Approximation of K carrying capacity for moose in eastern Québec. Can. J. Zool. 67: 373-380.

DAIGLE, É., S. ST-ONGE, R. COURTOIS, and J.-P. OUELLET. 1995. Enquête sur la perception des chasseurs après la 1re année d'application du plan de gestion de l'orignal, 1994-1998. Ministère de l'Environnement et de la Faune du Québec, Service de la faune terrestre, Report 2924. 68 pp.

DUSSAULT, C. 1999. Inventaire aérien de l'orignal dans la zone 18 ouest à l'hiver 1998 *in* S. St-Onge, R. Courtois, and D. Banville (eds.) Rapport annuel des inventaires aériens de l'orignal à l'hiver 1998. Ministère de l'Environnement et de la Faune, Service de la faune terrestre, Québec, PQ. *In Press.*

GINGRAS, A, R. AUDY, and R. COURTOIS. 1989. Inventaire aérien de l'orignal dans la zone de chasse 19 à l'hiver 1987-88. Ministère de l'Environnement et de la Faune du Québec, Direction régionale de la Côte-Nord et Direction de la gestion des espèces et des habitats, Report 1553. 58 pp.

GOSSELIN, M.-J and J.-J. DUBOIS. 1998. Inventaire aérien de l'orignal dans la zone 4 à l'hiver 1993. Pages 35-43 *in* S. St-Onge, R. Courtois, and D. Banville (eds.) Rapport annuel des inventaires aériens de l'orignal à l'hiver 1992 et à l'hiver 1993. Ministère de l'Environnement et de la Faune du Québec, Service de la faune terrestre, Québec, PQ.

_____ and _____. 1999. Inventaire aérien de l'orignal dans la zone 4 à l'hiver 1998. *in* S. St-Onge, R. Courtois, and D. Banville (eds.) Rapport annuel des inventaires aériens de l'orignal à l'hiver 1998. Ministère de l'Environnement et de la Faune du Québec, Service de la faune terrestre, Québec, PQ. *In Press.*

(INFRAS) RECHERCHE ET ANALYSE

DE LA SOCIÉTÉ. 1990. Enquête auprès des détenteurs de permis de chasse à l'orignal. Recherche et Analyse de la Société Inc., Québec, PQ. 88 pp.

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. 1999. Effects of selective harvest on moose populations of the Bas-Saint-Laurent region, Québec. Alces 35: 191-202.

LASSUS, C. 1987. Croissance exponentielle et logistique des populations. Pages 99-126 *in* R. V. Jean (ed.) Une approche mathématique de la biologie. Gaëtan Morin Éditeur, Chicoutimi, Québec, PQ.

LAURIAN, C., R. COURTOIS, L. BRETON, A. BEAUMONT, and J.-P. OUELLET. 1996. Impact du déséquilibre du rapport des sexes chez l'orignal (*Alces alces*). Ministère de l'Environnement et de la Faune du Québec, Service de la faune terrestre, Report 3420. 27 pp.

LAVSUND, S. and F. SANDEGREN. 1989. Swedish moose management and harvest during the period 1964-1989. Alces 25: 58-62.

MILETTE, J. and M. PARÉ. 1998. Inventaire aérien de l'orignal dans la zone de chasse 14 à l'hiver 1992. Pages 17-24 *in* S. St-Onge, R. Courtois, and D. Banville (eds.) Rapport annuel des inventaires aériens de l'orignal à l'hiver 1992 et à l'hiver 1993. Ministère de l'Environnement et de la Faune du Québec, Service de la faune terrestre, Québec, PQ.

(MLCP) MINISTÈRE DU LOISIR, DE LA CHASSE ET DE LA PÊCHE. 1993. Plan de gestion de l'Orignal, 1994-1998. Objectifs de gestion et scénarios d'exploitation. Éditeur officiel du Québec, Québec, PQ. 137 pp.

NEDELCA, S. 1991. Enquête postale auprès des chasseurs d'orignaux de l'Automne 1990. Direction de la méthodologie, Bureau de la statistique du Québec, Québec, PQ. 45 pp.

PARÉ, M. 1996. Inventaire aérien de l'orignal dans la zone de chasse 13 à l'hiver 1994. Pages 13-18 *in* S. St-Onge, R. Courtois, and D. Banville (eds.) Rapport annuel des inventaires aériens de l'orignal à l'hiver 1994. Ministère de l'Environnement et de la Faune du Québec, Service de la faune terrestre, Report 3291.

ROLLINS, R. and L. ROMANO. 1989. Hunter satisfaction with the selective harvest system for moose management in Ontario. Wildl. Soc. Bull. 17: 470-475.

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

SIGOUIN, D., R. COURTOIS, and S. ST-ONGE. 1997a. L'activité de chasse entre 1994 et 1996 suite à l'application du plan de gestion de l'orignal, 1994-1998. Ministère de l'Environnement et de la Faune du Québec, Service de la faune terrestre, Report 3710. 36 pp.

_____, J.-P. OUELLET, and R. COURTOIS. 1995. Moose (*Alces alces*) rutting period variations. Alces 31: 185-197.

_____, _____, and _____. 1997b. Geographical variation in the mating and calving periods of moose. Alces 33: 85-95.

_____, S. ST-ONGE, R. COURTOIS, and J.-P. OUELLET. 1999. Change in hunting activity and hunters' perceptions following the introduction of selective harvest in Québec. Alces 35:

105-123.

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.

ST-ONGE, S., R. COURTOIS, and D. BANVILLE, éditors. 1994. Rapport annuel des inventaires aériens de l'orignal à l'hiver 1994. Ministère de l'Environnement et de la Faune du Québec, Service de la faune terrestre, Report 3291. 34 pp.

_____, _____, and _____, éditors. 1995. Inventaires aériens de l'orignal dans les réserves fauniques du Québec. Ministère de l'Environnement et de la Faune du Québec, Service de la faune terrestre, Report 3111. 109 pp.

TIMMERMANN, H. R. 1992. Moose sociobiology and implications for harvest. Alces 28: 59-77.

_____ 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.

TREMBLAY, R. and C. DUSSAULT. 1996. Inventaire aérien de l'orignal dans la zone de chasse 18 ouest à l'hiver 1994. Pages 27-34 *in* S. St-Onge, R., Courtois, and D. Banville (eds.) Rapport annuel des inventaires aériens de l'orignal à l'hiver 1994. Ministère de l'Environnement et de la Faune du Québec, Service de la faune terrestre, Report 3291.

WEDELES, C. H. R., H. SMITH, and R. ROLLINS. 1989. Opinions of Ontario hunters on changes to the selective harvest system. Alces 25: 15-24.