

MANAGEMENT SYSTEM AND CURRENT STATUS OF MOOSE IN QUÉBEC

Réhaume Courtois and Gilles Lamontagne

Ministère de l'Environnement et de la Faune, Service de la faune terrestre, 5e étage, 150 boul. René-Lésveque Est, Québec, (Québec) G1R 4Y1

ABSTRACT: Moose have been subject to major hunting pressure since the start of the settlement period. By the end of the last century, moose were considered on the verge of extinction throughout eastern North America. In Québec, the control of moose harvesting began in 1843 with the introduction of a no hunting period (February 1 - August 1). Gradually, regulations became stricter, finally resulting in imposing the bulls-only law in 1899. In 1955, harvest monitoring began with the systematic survey of the harvest and the number of licences sold. The first population estimates, based on the observations of forest workers and trappers, also date back to this period. However, it was only during the seventies that systematic population monitoring and survey methods were adopted, the latter becoming necessary due to increased sport hunting pressure. Currently, monitoring of moose is based on three main tools: registration of the harvest, aerial surveys of the populations and socioeconomic surveys of the hunters. Moose hunting increased noticeably over the last 25 years. The number of moose hunters grew from about 15,000 in the early sixties to over 155,000 by 1991. This important growth is the result of an increase in the potential clientele (baby-boomers) whose interest was stimulated by several regulatory or social measures. However, the sport harvest of moose has not followed the same growth pattern. In the early sixties, approximately 2,500 moose were harvested; this figure climbed to approximately 12,000 in the early eighties followed by a 1 % decrease per year, despite an increase in the number of hunters, the development of bow hunting and the increase in the harvest in wildlife reserves. Meanwhile, hunting success has gradually declined, falling from a peak of 20 % (bulls only) to less than 7.5 % (bulls, cows and calves) in recent years. All of the indicators tend to show that the harvest rate exceeded the optimum level in the early eighties. Aerial surveys conducted at the end of the eighties suggest that the harvest rate exceeded the capacity of the moose population in most hunting zones. Only the populations of those zones where only bow hunting was allowed, and possibly a few northern zones where access is difficult, seemed to be growing. In the early nineties, the post-hunting population was estimated at 52,543 moose outside wildlife reserves, and about 13,000 moose in the reserves. Outside wildlife reserves, densities are low (≈ 1 moose/10 km²) everywhere, except in western Québec and in zones where only bow hunting is authorized. The harvest rates associated with hunting are high (19 - 44%) in all zones offering easy access. The proportion of bulls is very low (25 - 39%) among adults in all the hunting zones except in the northern ones (19 and 22: 47 - 48%). A Management plan, focusing on the protection of cows, was introduced in 1994. The aim of this plan is to increase the population by 13 to 15% by the fall of 1998. In 1994, the Plan made it possible to diminish cow harvest by approximately 3,000 individuals.

RÉSUMÉ: L'original a subi de très fortes pressions de chasse depuis le début de la colonisation. Il était jugé en voie de disparition à la fin du siècle dernier dans tout l'est de l'Amérique du Nord. Au Québec, le contrôle de son exploitation a commencé en 1843 par l'imposition d'une période de chasse interdite (1 février - 1 août). La réglementation s'est graduellement resserrée jusqu'à l'imposition de la loi du mâle en 1899. Le suivi des populations a commencé en 1955 avec le recensement systématique de la récolte et des permis vendus. Les premières estimations de population, basées sur les observations des travailleurs forestiers et des trappeurs datent également de cette époque. Ce n'est toutefois que durant les années 1970 que les méthodes de suivi et d'inventaire des populations se sont développées, celles-ci devenant de plus en plus nécessaires à cause d'une pression de chasse accrue. Le suivi des populations repose actuellement sur trois outils principaux: l'enregistrement de la récolte, l'inventaire

aérien des populations et les enquêtes socio-économiques auprès des chasseurs. La chasse de l'orignal s'est développée de façon fulgurante au cours des 25 dernières années. De l'ordre de 15 000 au début des années 1960, le nombre d'adeptes dépassait les 155 000 en 1991. Cet accroissement est le fruit d'une augmentation de la clientèle potentielle (baby boomers) dont l'intérêt fut stimulé par plusieurs mesures réglementaires ou sociales. La récolte sportive de l'orignal n'a cependant pas suivi le même accroissement; de l'ordre de 2500 orignaux au début des années 1960, elle a atteint environ 12 000 bêtes au début des années 1980. Elle a par la suite diminué d'environ 1 % par année, malgré une augmentation du nombre de chasseurs, malgré le développement de la chasse à l'arc et malgré l'augmentation de la récolte dans les réserves fauniques. En contrepartie, le succès de chasse décroissait graduellement passant d'un sommet de 20 % (mâles seulement) à moins de 7,5 % (mâles, femelles et faons) au cours de ces années. Tous les indicateurs tendent à démontrer que le taux d'exploitation a dépassé le niveau optimal au début des années 1980. Les inventaires aériens de la fin des années 1980 suggéraient des taux d'exploitation dépassant la capacité du cheptel dans plusieurs zones. Seules les populations des zones où seulement la chasse à l'arc était permise et possiblement quelques zones nordiques, peu accessibles, semblaient en croissance. Au début des années 1990, la population après chasse était estimée à 52 543 orignaux à l'extérieur des réserves fauniques, ces derniers territoires comptant environ 13 000 orignaux. À l'extérieur des réserves fauniques, les densités demeurent faibles (≈ 1 orignal/10 km²) partout, sauf dans l'ouest du Québec et là où seul l'arc est autorisé. Les taux d'exploitation par la chasse sont élevés (19 - 44 %) dans toutes les zones facilement accessibles. La proportion de mâles est très faible (25 - 39 %) chez les adultes de toutes les zones de chasse sauf dans les régions nordiques (19 et 22; 47 - 48 %). Un plan de gestion, axé sur la protection des femelles adultes a été implanté en 1994. Il vise à faire accroître le cheptel de 13 à 15 % d'ici l'automne 1998. À sa première année d'application, le Plan a permis de diminuer la récolte de femelles d'environ 3000 individus.

ALCES VOL. 33 (1997) pp.97-114

Moose (*Alces alces*) are found throughout the northern latitudes of North America, Europe and Asia. Over all this area, harvest statistics have shown very similar trends. Throughout most of its range, moose was subject to strong hunting pressures during the 17th and 18th centuries resulting in gradual declines in densities up until 1850 - 1900. Populations remained low until 1920 - 1930 in Asia and Europe (USSR and Scandinavia: Filonov and Zykov 1974; Lykke 1974; Syroechkovskiy and Rogacheva 1974). In Canada, the status of moose populations was considered tenuous up until the early 1950's. All agencies applied strict regulations during this period, generally allowing bulls-only hunting and frequently prohibited hunting completely (Ritcey 1974). However, any over-harvesting was limited likely to the more accessible regions. During this time, the range,

density and productivity of moose were not well known, and management strategies tended to be very conservative.

RECENT HISTORICAL ACCOUNTS OF MOOSE IN QUÉBEC

European Settlement Period

Moose were considered abundant when settlers first arrived in New France, at least along the St. Lawrence River (Brassard *et al.* 1974). During the 16th century, harvest of moose was low and limited primarily to subsistence hunting in winter by Native peoples. In Europe, hunting was the privilege of the noble class. However, in the interest of strategically protecting the colony, economics (furs), and subsistence (famine), the authorities decided to grant all inhabitants of New France the right to hunt beginning in 1652 (Martin 1990). This right has remained a

characteristic of the very close bond that Quebecers have forged with the wildlife resource. Commercial hunting (hides and venison) began during the 17th century and then intensified in the 18th and 19th centuries. Big game (caribou, white-tailed deer, moose, wapiti) had almost been exterminated in the St. Lawrence Valley at the start of the 18th century. The moose population was deemed to be threatened with extinction in the mid-19th century (Crête 1985). These conditions continued through to the beginning of the 20th century.

Sport hunting in Québec began during the mid-19th century. With this new activity came the first regulations to protect the species, by prohibiting harvesting during most of the gestation and young raising periods (Table 1). This regulation likely was insufficient and during the next 50 years, other restrictive measures were introduced to limit the harvest (hunting seasons, individual quotas, prohibition on hunting calves) or to facilitate the protection of game (creation of parks and private clubs). Finally, a bulls-only law was imposed in 1899 and commercial hunting as well as the sale of meat was officially abolished in 1928 (Guay 1983; Martin 1990).

Modern Era

Moose hunting increased as a sport activity during the first half of the 20th century. However, it was primarily an activity for the elite, under the control of private clubs. In 1909, big game hunters were required to purchase a hunting licence which was valid for caribou (*Rangifer tarandus*), white-tailed deer (*Odocoileus virginianus*) and moose (Courtois 1989 ; Courtois and Lamontagne 1990, 1991). It was not until 1955 that a specific licence was created for moose hunting.

The post-war economic boom and concurrent demographic growth, associated with social evolution making more time and money available for leisure, stimulated participa-

tion of Quebecers in sport hunting. The sale of hunting licences rose from 6,500 (licence valid for all species) in 1930 to 25,000 (specific for moose) in 1963. In 1964, government officials determined that the moose population in Québec could support a much greater harvesting level and therefore, abolished the bulls-only law. Many other measures facilitated access to the resource: the opening of hunting in wildlife reserves in 1962, the abolition of limited access hunting clubs to create more liberal controlled harvesting zones in 1978, and a decrease, in mid-seventies, in the appeal associated with white-tailed deer hunting due to depleted populations. The number of moose hunting enthusiasts increased dramatically, reaching 155,000 approximately 25 years later. During this same quarter of a century, the harvest increased from 2,500 to stabilize between 11,000 and 12,000.

The economic impact of moose hunting has not been evaluated recently, but in 1981, each moose hunter spent an average of \$561 (STATBEC 1984). Given the increase in consumer prices, Courtois (1989) estimated that these hunters spent an average of \$797 by the end of the eighties, thereby annually injecting approximately \$117 million into Québec's economy.

QUÉBEC'S MOOSE MANAGEMENT SYSTEM

Québec is subdivided into 25 hunting, fishing and trapping zones which constitute the basic management units. Hunting licences and regulations are specific for each hunting zone. Hunting may occur on four types of territories within each hunting zone: wildlife reserves (managed by the government), controlled harvesting zones (managed by non-profit organisations, generally hunters' associations), outfitter establishments (private businesses sometimes holding exclusive fishing, hunting and trapping rights), and non-designated zones. In wildlife reserves, the

Table 1. Most important laws and regulations for moose management in Québec (adapted from Courtois 1989).

Year	Regulation	Year	Regulation
Before 1843	Moose hunting allowed anytime	1955	Hunting licence specific to moose; two-week moose hunting season (October 15-31)
1843	No moose hunting: 1 February- 1 August	1958	Mandatory registration of big game harvest
1857	No moose hunting: 1 March - 1 September	1961	Division of the province into seven hunting zones
1858	First amalgamation of all hunting laws	1962	First controlled hunt in a reserve (Laurentides)
1868	No moose hunting: 1 February - 1 September	1964	Abolition of the bulls-only law Date and length of the hunting season specific to each zone
1882	Hunting licence mandatory (\$20) for non-residents	1971	Adoption of the Modified Transverse Mercator System to locate big game harvest; first version of the computerized big game registration system
1884	No cow hunting until 15 October 1888; hunting bag limited to two moose	1974	Experimental bow hunting pre-season in one zone
1885	Deed to facilitate private clubs formation	1978	Creation of the controlled harvesting zones
1887	No moose hunting allowed	1979	Party licence in two experimental zones
1889	No moose hunting between 1 February and 1 September	1980	Cancellation of two licences per moose harvested; extension of bow hunting pre-season in two additional hunting zones
1895	No moose hunting: 1 January - 1 October; no calves allowed; creation of Laurentides and Mont-Tremblant National Parks	1981	Bow hunting pre-season in all hunting zones where hunting is allowed
1899	Imposition of the bulls-only law	1984	Adoption of the same management zones for fishing, hunting and trapping
1909	First big game licence valid for caribou, white-tailed deer and moose	1986	Cancellation of three hunting licences per moose harvested (zones 1-2); last version of the computerized big game registration system
1928	Ban on sale of moose and deer venison	1987-88	Testing of selective harvest (Le Chasseur outfitter)
1929	Creation of the first reserve (Provencher)	1989	Zone licence; no licence sales after season opening
1937	Division of the province into four hunting zones for moose and deer	1994	Cow selective harvest; first moose management plan
1939	Creation of the first public hunting and fishing reserve (La Vérendrye)		

number of hunters is limited by computer draw and moose hunting seasons generally begin sooner and last longer than in the rest of the hunting zone. The same general regulation applies in all other territories and there, the number of hunters is not limited. However, a few specific rules can be adopted by the members of controlled harvesting zones (daily and annual fees, hunting territories, groups of hunters, etc.). Outfitters must respect the general regulation but determine the criteria associated with access to their territories.

Registration of kills is mandatory and hunters can use a firearm or a bow to hunt moose during the firearm season. However, there is an exclusive archery season that generally precedes the regular hunting season by one week.

Up until 1993, the harvest was controlled exclusively by the length and timing of hunting seasons outside wildlife reserves. Users were allowed to harvest one animal of any sex or age, but two licences were canceled (three in some zones) for each animal bagged. Since 1994, cow harvest is limited through selective harvesting in all types of territories of most hunting zones.

Monitoring Methods

Monitoring of moose populations is conducted using three basic tools: registration of the harvest, survey of hunting effort, and population surveys.

Registration of the Harvest

The annual moose harvest has been monitored through a registration system since 1955 and registration of hunter kills has been mandatory since 1958. Initially, registration stations provided the opportunity to quantify the harvest, estimate hunting effort and collect biological information on the moose populations and habitat, and gather hunter demographic information (Gonthier 1977). The information collected during registration has been coded and entered in a database

since 1972. This system was completely revamped between 1984 and 1986. The current system, known as the computerized big game information system, allows retrieval of information on any kill and to compile data by sex, age class (adult/young), cause of death and Mercator coordinates on any spacio-temporal basis. A sample of incisor teeth (100 bulls and 100 cows per hunting zone) is collected to estimate the age structure of the populations. Other details have been added to meet specific needs (hunting device, date and time of licence purchase and of kill, temperature of the meat, etc.).

Currently, there are approximately 275 big game registration stations located in offices of wildlife officers, check stations of wildlife reserves, controlled harvesting zones and outfitters as well as a few private stations. Teeth for age data are collected at the registration stations but are processed at a central location. Other data are generally entered and validated at stations equipped with microcomputers. The few stations that are not equipped with computers note information on paper forms that are entered at the regional offices of the Ministry. During the hunt, information is downloaded to a central computer, daily. An annual report entitled "Big game in Québec" is prepared. It summarizes general statistics and information about the hunt.

For each hunting zone, 10 indicators are calculated using harvest statistics. Three of these indicators make it possible to evaluate fluctuations in abundance (harvest, harvest / 10 km², deaths not due to hunting); three indicators determine changes in the harvesting rate (% of bulls, mean age of males and females). Other indicators (% yearlings, calves/100 females, % females in lactation, sex ratio of calves) show the annual recruitment trends (Crête and Dussault 1986; Courtois and Crête 1993). Several studies show that these indirect indicators are correlated with population parameters (Cumming

1974; Mercer and Manuel 1974; Crête and Dussault 1987; Fryxell *et al.* 1988; Courtois and Crête 1993). These harvest data are interpreted by (i) examining historical trends, (ii) comparing estimates from each hunting zone with provincial estimates, and (iii) considering that populations produce at maximum yield when annual harvests fluctuate minimally, when the harvest sex ratio is balanced or in favour of bulls among adults (55 - 60%) and when proportions of calves and yearlings in harvest are high ($\approx 40\%$) (Lykke 1974; Ritcey 1974; Timmermann 1974). Models (Crête and Dussault 1987; Courtois and Crête 1993) are sometimes used to predict population parameters based on harvest statistics. The techniques employed involve a certain degree of uncertainty. Harvest registration rates were evaluated at 60 - 85% (Institut québécois d'opinion publique 1985). The mean age has a confidence interval of about 15 - 20% ($\alpha=0.05$) and the percentage of yearlings in the harvest is estimated with a confidence interval of about 7 - 10% ($\alpha=0.05$; Courtois 1989).

Survey of the Hunting Effort

The sale of hunting licences has been recorded annually in Québec since 1955. Since 1989, moose hunting licences have been valid for only a single zone, which makes it possible to survey hunters by management unit. Hunting effort has been estimated using mail surveys that are conducted at approximately five-year intervals. These surveys allow moose managers to estimate the number of active hunters, the number of hunting days expended, harvests, hunting success, number of days required to kill an animal, hunting pressure per unit area (hunting days/km²), and the daily number of hunters (hunters / km² • day). Before 1989, questionnaires were not anonymous which also made it possible to estimate the harvest registration rate (Institut québécois d'opinion publique 1985). Generally, managers take

advantage of surveys to obtain additional information on hunter demographics, opinions, and expenditures.

Recently, surveys had been modified to minimize sampling biases by (i) reducing the time elapsed between the end of hunting and mail-out of the questionnaires, (ii) sending two reminder letters, and (iii) reducing the length and the complexity of the questionnaire to increase the return rate (Gollat and Timmermann 1987). Sampling bias attributable to the return rate is not known.

Population Surveys

Terrestrial surveys were tested in Québec during the 1950's (Moisan 1952). Initially, direct estimates were attempted, by asking hunting wardens, fire wardens and club wardens and trappers to record moose sightings (bulls, cows and calves). The information received was poor because only a portion of moose range was accessible, resulting in populations being considerably underestimated ($\approx 12,000$ moose for the entire province of Québec). Productivity also was underestimated since cows accompanied by young are more discreet than lone cows (Simkin 1974). Moose density estimates were attempted by conducting pellet group surveys in winter, a technique that proved to be inadequate, except for comparing relative densities from one site to another and for describing trends over the medium term (Timmermann 1974).

Aerial surveys were utilized during the 1950's and 1960's, following successful studies carried out in the United States in the 1940's (Brassard 1968). In the initial trials, moose populations were estimated by counting the number of moose along transects flown at low altitudes and then extrapolating results to the entire zones. This method underestimated the actual moose densities because only a portion (25 - 67%) of animals were observed within transects.

Today, moose populations are estimated

by intensively searching sample plots using helicopters and counting moose. Aerial surveys are carried out in January and February when the snow cover exceeds 30 cm, because moose are easier to detect (Crête et al 1986). Several survey approaches have been developed (Crête 1979 ; Crête and St-Hilaire 1979; Rivest *et al.* 1990; Courtois and Crépeau 1995) and used depending on the terrain, the area to be surveyed and the financial and aircraft resources available (Courtois 1991). Double sampling (Rivest *et al.* 1990) usually is employed for large areas (> 10,000 km²); stratified random sampling is preferred for smaller zones, whereas total coverage with counting moose in a subsample of the track networks (Courtois and Crépeau 1995) is used for areas < 3000 km². Sites to be surveyed are first divided into 60 km² sample plots. These plots are then grouped into two or three strata according to estimated densities from pre-surveys or to the magnitude of the sport harvest so as to obtain homogenous groups and minimize variability in estimates. Random samples (50 - 100 plots according to the size of the zone or group of zones) are selected by assigning, via Neyman's optimal allocation, a greater number of plots to the most variable strata. These survey techniques are described in detail in Courtois (1991) and Courtois and Crête (1993).

Surveys make it possible (i) to determine changes in density, (ii) to identify if the density objectives established in management plans have been achieved, (iii) to evaluate the status of moose populations with respect to carrying capacity, and (iv) to estimate moose productivity. Productivity is considered high when surveys indicate > 60 calves /100 cows in winter, low at < 40 calves /100 cows, and average at intermediate values (Crête and Dussault 1987). Survey data are combined with harvest statistics using methods described by Courtois and Crête (1993) to calculate harvest rate, percent calves in the fall population and a growth rate indi-

cator which makes it possible to estimate population trends. Generally, aerial surveys provide estimates of density, productivity, and sex ratio, with confidence intervals of approximately 20, 15 and 9 % respectively (Gingras *et al.* 1989, Courtois *et al.* 1994).

To minimize survey costs and provide coverage of moose range, it was decided to group small zones (< 5000 km²) and to re-survey zones at five- to seven-year intervals. The assumption is that moose populations change rather slowly and that any major change occurring during the time between two surveys would be detected from annual hunting statistics. Recently, the optimum interval between two surveys was re-evaluated taking into account precision and growth rates expected according to the Gerrodette (1993) method. The results (Courtois *et al.* 1996) suggest carrying out surveys every seven years in most of the hunting zones.

Management and Coordination

Senior wildlife managers meet annually to assess big game populations. Indicators from harvest are described on a provincial basis and then examined zone by zone. Data from special areas, such as reserves and controlled harvesting zones, are also analyzed. Results of aerial surveys and mail surveys are presented and discussed when new data are available. Finally, research work and analyses of problems originating from ministerial or users' concerns are considered. All information is then incorporated into a series of recommendations. The basic data, recommendations and a summary of the presentations are published yearly (e.g. Daigle 1995). The recommendations are examined by Ministry officials who, following discussion with representatives of hunters and outfitters, may modify regulations.

Hunting, fishing and trapping regulations undergo in-depth revisions every three years. Regional biologists, wildlife officers and administrators meet with the intervening

parties (hunters' representatives and other groups interested in wildlife) and submit proposals which are harmonized at the headquarters level, taking into account inter-regional differences and the proposals made by federations of users. Major regulation changes are made in consultation with these federations. Every five years, managers must prepare management plans that include a comprehensive assessment of the biological, sociological and administrative situations. Following public consultations with user groups, five-year utilization rules are established for each hunting zone.

Monitoring and protection of moose require approximately 8.1 persons-year and cost approximately \$502,000. The five-year plan of aerial surveys is the most costly tool and employs 55 % of the human resources and 74 % of the material resources assigned to moose. The computerized big game information system requires 41 % of the human resources but the material costs associated with this system are low (5 %).

CURRENT STATUS AND TRENDS

All potential habitats likely to support significant moose populations in Québec have recently been surveyed to determine the populations' status.

Provincial Distribution

The mapping of track networks (Fig. 1) shows declining densities from south to north and from west to east. Densities are generally low, the provincial average being about 1 moose/10km². The greatest densities (3 - 4 moose/10 km²) are found in the western central portion of Québec (zones 9, 10, 12 and 13). However, the distribution of moose is very heterogeneous. Generally, densities are 2 to 10 times greater in wildlife reserves than in the other parts of the hunting zones where they are located (St-Onge *et al.* 1995). However, low density sectors are found even in the best zones. Similarly, high density pockets have been found in areas that in the past were deemed not particularly favorable. These are often sites where moose have appeared over the last twenty years and where harvesting has been limited, until recently, due to

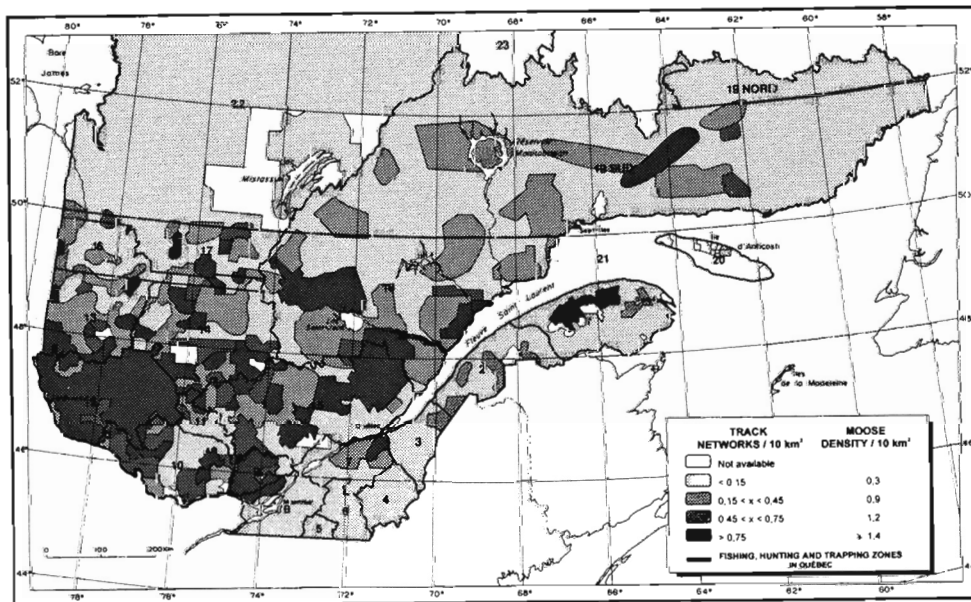


Fig. 1. Distribution (km² of track networks/10 km²) and relative abundance (moose/10 km²) of moose in Québec's hunting zones from track networks area. Hunting zones are numbered 1 to 25.

low hunting pressure or regulatory constraints. Very low density areas are usually a reflection of a poor quality habitat (taïga in Northern Québec and on the Lower North Shore, agriculture and urbanization in Southern Québec) or of intensive hunting (south of the St. Lawrence River).

Demographic Trends

Winter survey data (1987 - 1991) show that there were, outside of parks and wildlife reserves, approximately 52,500 moose \pm 9 % ($\alpha=0.10$; Courtois *et al.* 1994). An additional 13,000 moose were estimated to occur in wildlife reserves (St-Onge *et al.* 1995). The harvest rate of Québec's moose population was approximately 17 % outside parks and reserves between 1987 and 1991. This is a high harvest level when one considers that the net annual recruitment is about 20 % (Desmeules 1966). Moreover, the northern populations are believed to be under-harvested due to limited accessibility. This underscores the probable over-harvesting of Québec's moose population in the southern

zones. Courtois *et al.* (1994) present further details on populations and their structure by hunting zone.

According to the fragmented historical data available, Québec's moose herds likely declined over the last 30 years. The winter density is thought to have dropped from about 3 moose/10 km² in the mid-sixties to 1.3 moose / 10 km² in 1980 - 81, and finally reaching 0.9 moose / 10 km² between 1987 and 1991. Now densities are usually far from that insuring maximum production which is of approximately 10 moose / 10 km² south of the St. Lawrence River (Crête 1989) and 2 - 3 moose / 10 km² in the central part of Québec (Crête 1987). The percentage of bulls in the adult segment of the populations is also below the target threshold (40 %; Crête *et al.* 1981).

Number of Hunters and Hunting Pressure

The popularity of moose for sport hunting has rapidly grown since the mid-fifties (Fig. 2). The historical peak in hunter interest was reached in 1991 when more than 155,000

Licences sold and moose harvest between 1955 and 1995

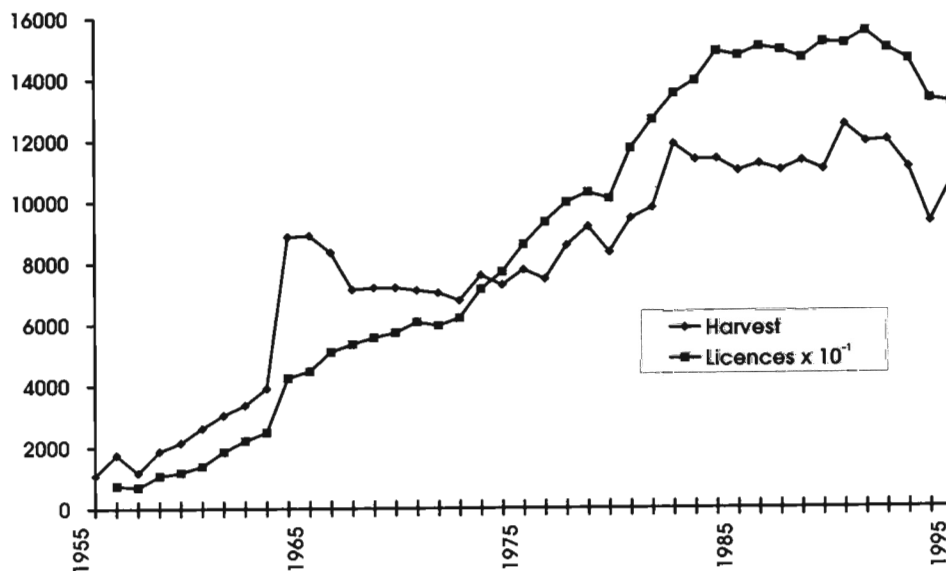


Fig. 2. Changes in moose licences sold and moose harvest in Québec since 1955.

licences were sold. Currently, licences sold fell to approximately 133,000 annually due to insufficient hunter recruitment and tightening of harvest regulations. Hunters are distributed unequally over the province. Distribution estimates are available for 1984, based on a mail survey and, since 1989, based on the survey of licences sold by hunting zone. Zones 12, 13, 14, 15 and 18 receive approximately 60 % of the hunters (Table 2). Of these, zones 15 and 18 have had the greatest number of hunters, namely 16,385 (12 %) and 27,747 (21 %) respectively, in 1994.

Zones located near major cities (e.i. zones 3, 4, 7, 12, 13 and 15) are subject to high hunting pressure. Zones 3, 4 and 7 have received four to six times more hunters / km² of habitat (0.75 - 1.23) than the Québec average (0.21). Between 1984 and 1989, the distribution of hunters / km² appeared to decline in the southern zones and to increase in the more northern and remote zones (12, 13, 18 and 19). Since 1989, this trend has reversed, likely due to the higher costs associated with hunting in remote areas.

Harvest and Hunting Success

The moose harvest also has increased from 2,500 to 12,000 over the last 34 years. However, its growth rate was not proportional to that of licence sales. Moose harvest more than doubled in 1964, following the abolition of the bulls-only law (3,909 moose in 1963 and 8,857 in 1964). After a decline, followed by a temporary stable period, the harvest began to grow due to the increase in hunter recruitment during the early seventies. The creation of controlled harvesting zones in 1978 led to increases in harvest which peaked in 1982. Thereafter, the harvest declined steadily at about 1 % per year to 10,972 moose in 1989. After a last peak in 1991, harvest declined again due to a reduction in the number of hunters. Various non-sport-hunting mortality (traffic collisions,

subsistence activities, poaching, etc.) account for an additional 5 % of moose killed (Courtois *et al.* 1994).

Hunting success remained at around 18 % until 1966. Since 1967, it has gradually declined, stabilizing at about 7.5 % in 1984. This latter figure would be lower if only bulls were harvested, as had been the case prior to 1964.

Harvest by Type of Zones and Hunting Equipment

Most (74 %) of harvested moose come from non-designated zones, whereas controlled harvesting zones, wildlife reserves and outfitters report 17, 6 and 3 % of the registered moose. Hunters primarily use a firearm which accounts for 89 % of harvests but interest in bowhunting has been steadily growing since 1981 (Fig. 3). Archers are mainly concentrated in southern Québec in hunting zones 5 to 9 and 10 east where only this equipment is authorized. In 1990, the number of bow hunters was estimated at 14,000 individuals. About 20 % of the archers also hunt using a rifle, during the firearm season.

Abundance, Productivity and Harvesting Level Indicators

Harvest / 100 km² increased from the beginning of the seventies until the mid-eighties (Fig. 4a). An increased hunting effort helped to maintain it around 15 thereafter. Percentage of males in harvest declined between 1972 to 1993 and rose again in 1994 due to protection of females through selective harvest. Mortality not due to hunting increased from 1972 and 1983 and then declined. These three abundance indicators suggest that moose population tended to decrease during recent years.

The sport harvest has always comprised a high percentage (nearly 50%) of bulls. However, increased hunting pressure has been put on cows which represented \approx 37 % of the

Table 2. Moose hunting licences sold in Québec in 1993, before the beginning of the selective harvest program, and in 1994, after it's introduction. Licences/km², harvest and hunting success in 1994 are also presented. Hunting in wildlife reserves excluded.

Zone	Licences sold			Habitat (km ²)	1994		
	1993	1994 (%)	Change		Licences / km ²	Total harvest	Success (%)
1	11,876	12,654	6.6	17,861	0.66	857	6.8
2	7,124	7,327	2.8	10,496	0.68	656	9.0
3	5,680	4,464	-21.4	4,618	1.23	175	3.9
4	4,500	4,028	-10.5	6,019	0.75	344	8.5
5	129	63	-51.0	1,457	0.09	4	6.3
6	650	684	5.3	3,666	0.18	41	6.0
7	3,087	3,163	2.5	3,903	0.79	305	9.6
8	220	228	3.5	1,500	0.15	13	5.7
9	1,857	1,807	-2.7	4,484	0.41	143	7.9
10	8,268	8,000	-3.2	17,101	0.48	429	5.4
11	1,436	960	-33.1	4,361	0.33	64	6.7
12	11,088	9,979	-10.0	18,500	0.60	688	6.9
13	14,800	12,928	-12.6	22,758	0.65	756	5.8
14	13,543	11,415	-15.7	37,750	0.36	598	5.2
15	19,207	16,385	-14.7	34,902	0.55	768	4.7
16	3,720	3,087	-17.0	17,775	0.21	186	6.0
17	1,221	1,111	-9.0	20,170	0.06	49	4.4
18	29,812	27,747	-6.9	84,073	0.35	1,915	6.9
19	6,421	5,878	-8.5	180,170	0.04	608	10.3
20	457	239	-47.7	7,600	0.06	3	1.3
22	664	572	-13.8	204,142	> 0.01	73	12.8
TOTAL	145,750	132,789	-8.9	703,306	0.21	8,675	6.5

harvest at the beginning of the nineties. Calves only account for 13 % of the harvest. From 1974 to 1980, the harvest of adults of both sexes increased more rapidly than that of calves suggesting that hunters were being selective.

The number of calves / 100 females in the harvest grew considerably between the first either sex season (in 1964) and 1971 (Courtois and Lamontagne 1990). This growth could

suggest a stimulation of productivity shortly after the abolition of the bulls-only law as a result of the reduction in the mean proportion of old cows. However, it is more likely that the increase in the number of calves harvested was due largely to the reduction in selectivity of hunters. Whatever the cause, productivity seems to have reached a plateau and varied around a central value since the early seventies indicating a more or less sta-

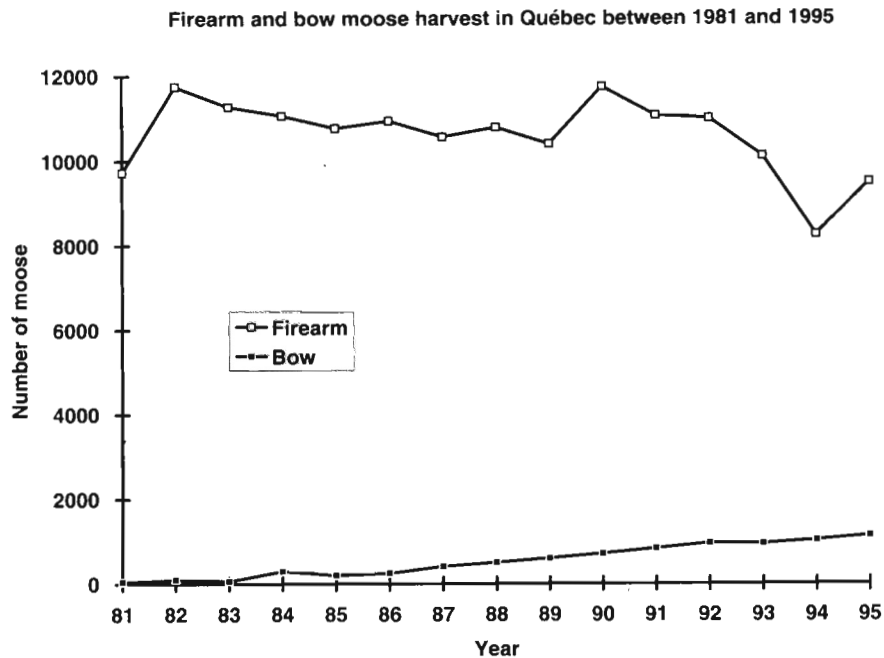


Fig. 3. Bow and firearm harvest changes from 1981 to 1994, Québec.

ble productivity (Fig. 4b).

The mean age of moose steadily declined as harvest level increased until the beginning of the 1980's. Since then, mean age has stabilized around 3.0 years for bulls and 3.5 years for cows. During the eighties, an ongoing decline in harvest in combination with no change in the mean age, and an increasing number of hunters, suggests over-harvesting and a net decline in moose populations.

MOOSE MANAGEMENT PLAN

A turning point in moose management began in the fall of 1994 with the reintroduction of selective harvest after 30 years of either sex and any age hunting. The new Management Plan aims at reversing the declining trend exhibited by the moose population. A 13 - 15 % increase is targeted over the next five years while maintaining hunting activity of more than 1,000,000 hunting-days annually. To achieve this goal, the Management Plan introduces selective harvest focused on protection of cows. All hunters are eligible to shoot a bull or a calf but only

those hunters having special permits, granted through a computer draw, may hunt cows.

Population objectives and modes of enforcement of selective harvesting vary from one hunting zone to the next. They were adopted in cooperation with hunters and their representatives during an extensive public hearing campaign reaching nearly 10,000 persons. Five harvest scenarios were adopted, varying from the status quo, i.e. harvest of any sex and age category, in hunting zones where few problems were detected, to complete protection of cows for the next five years in zones where moose were scarce or where hunters wanted a rapid increase in the population. In the majority of the hunting zones, the number of cows to be harvested is limited to 10 % of the fall population. In zones 3 to 6, the cow harvest will be excluded during the plan. In zones 14 and 15, all cows were protected in 1994 and 1995 but a limited number of female permits will be delivered thereafter. In zones 12, 13, 16 and 17, all cows were protected in 1994 and in every subsequent second year, while all hunters

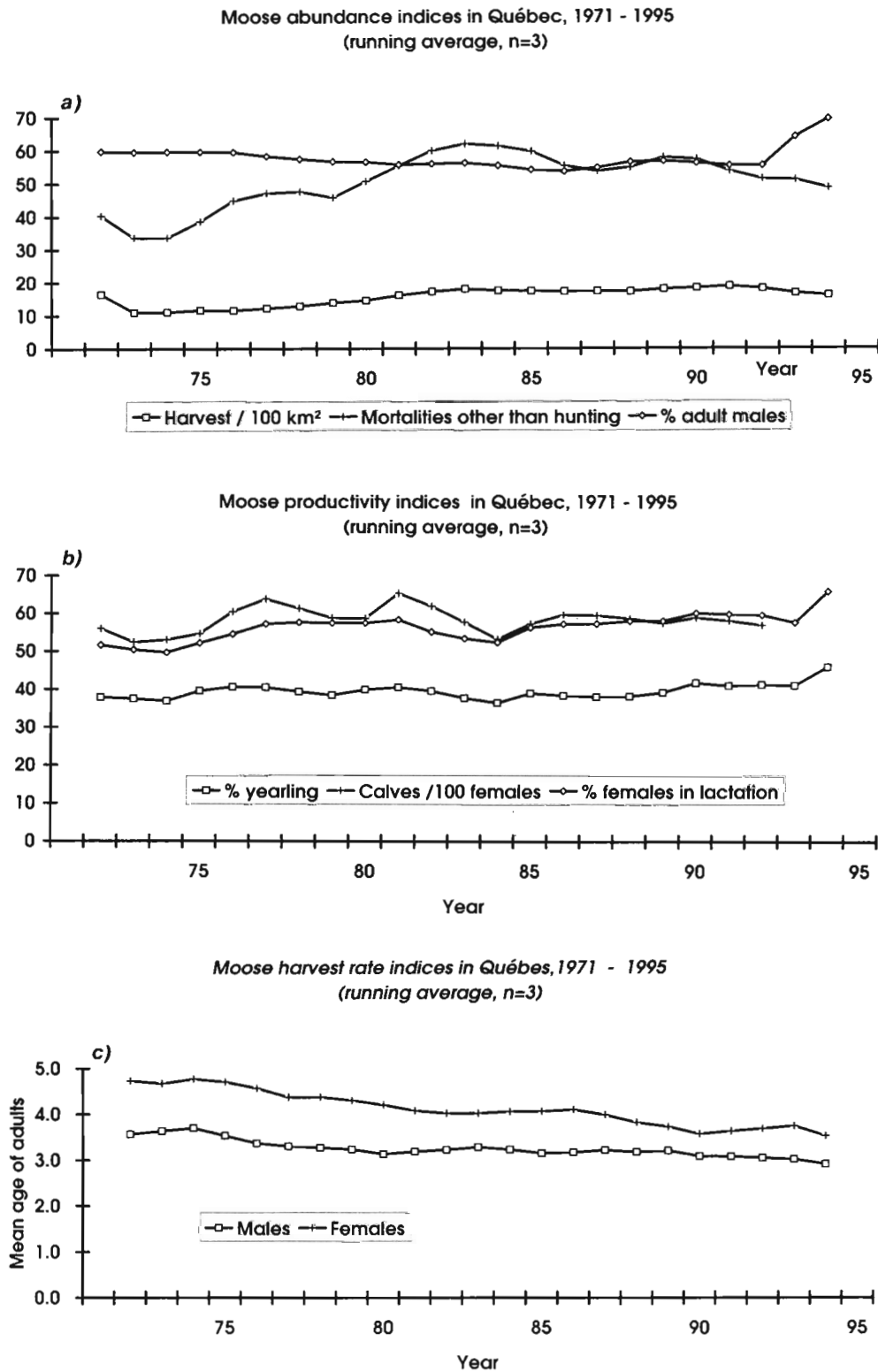


Fig. 4. Moose abundance, productivity and harvest rate indices from hunting statistics between 1971 and 1994, Québec. Data smoothed by mean of running averages (n = 3).

were or will be authorized to hunt cows in 1995 and 1997. The status quo will be maintained in zones 7, 19, 20 and 22.

INITIAL RESULTS OF THE MANAGEMENT PLAN

The introduction of selective harvest resulted in reduced hunting pressure. Less than 133,000 licences were sold in the fall of 1994, a decrease of 8.9 % over 1993. However, considering that licence sales have been declining for a few years, we estimate that the new hunting regime caused a decline of about 5 - 6 %. A mail survey sent to 3,500 hunters showed that they maintained their general support for the Plan (Daigle *et al.* 1995); only 5 % of the respondents expressed concerns about its negative impacts. However, hunters frequently mentioned that it would be preferable to allow only the harvesting of bulls with the general licence.

The Management Plan stipulated that the harvest of bulls and calves would remain equivalent to the average of the 1991 - 1993 period. Based on the number of special permits issued for 1994, managers expected a harvest of 1,270 cows. A harvest of 9,266 moose (including wildlife reserves), of which

1,462 were cows, was recorded. As a result, harvest of females was reduced by 3,001 moose compared to the average of 1991 - 1993. This represents 95% of the target objective. The harvest of bulls (6,434) was 14 % greater than that of past years (5,659), whereas that of calves (1368) was slightly lower (-9 %) than the average (1,504). Contrary to our expectations, hunters seem to have applied a slightly greater pressure on bulls and a slightly lesser pressure on calves. To avoid the potential illegal harvest of cows mistaken for calves, hunters seemed to orient hunting pressure to the adult bulls whereas we believed hunters without a cow permit would be willing to hunt calves.

In zones where the special cow permit was required, the quota of cows was considerably exceeded in zones 1, 2 and 18 west, slightly exceeded in zone 10, and less than expected in zones 8, 9, 11 and 18 east (Table 3). In keeping with the objectives of the Management Plan, the number of cow permits was revised to ensure that the objectives will be achieved because female hunting success increased where cow permits were limited (Table 4). In the case of zones 8, 9, 10, 11 and 18 east, the small variation margin (\pm

Table 3. Moose cows harvested in hunting zones where a special cow permit was required, Québec 1994.

Zone	Cow permits	Cow harvest		Difference	
		Expected	Observed	N	%
1	1,280	110	205	95	86
2	880	101	138	37	37
8	100	10	2	-8	-80
9	410	50	39	-11	-22
10	900	115	133	18	16
11	300	27	23	-4	-15
18 East	3,760	262	239	-23	-9
18 West	3,100	268	335	67	25
Total	10,730	943	1,114	171	18

10 %) or the small numbers (< 15) in question led managers to maintain the same number of cow permits. For the other zones, adjustments were made to the number of permits to be issued to take into account the previous hunting success and regional population growth objectives.

The large discrepancy between forecasts

and the harvest of cows in certain zones may be explained by an under-estimate of cow populations in zones 1 and 2 when the Management Plan was initially prepared. However, it also appears that hunters altered their behaviour. The individual cow hunting success in 1994 was three to five times greater than that of 1993, for six of the eight zones

Table 4. Hunting success (moose killed / 100 hunters) for each segment of the population in 1993 and 1994, Québec.

Zone	Bull hunting success		Cow hunting success		Calf hunting success	
	1993	1994	1993	1994	1993	1994
Cows limited (special permits)						
1	4.7	5.2	2.9	16.0	0.9	1.1
2	5.1	5.7	3.8	15.5	1.4	0.6
8	3.5	3.6	1.3	2.0	0.9	1.4
9	2.9	4.7	3.5	9.5	1.0	0.9
10	3.5	3.5	3.0	14.8	1.0	0.9
11	2.7	3.1	3.5	7.7	1.3	1.1
18	3.2	3.8	2.7	8.3	0.9	1.0
No cow allowed (bulls and calves only)						
3	3.0	3.0	2.1	0	1.4	0.9
4	5.3	6.3	3.7	0	1.8	2.1
5	0.8	6.4	0.8	0	0.0	0
6	4.8	4.5	2.7	0	0.7	1.4
12	4.9	6.8	4.0	0	1.2	1.1
13	3.3	4.7	3.4	0	0.9	1.1
14	3.9	4.6	2.5	0	0.5	0.6
15	3.5	5.2	2.7	0	0.8	0.8
16	4.5	5.4	3.1	0	0.7	0.6
17	4.2	3.8	2.5	0	0.9	0.4
Either sex						
7	3.9	4.5	3.	3.3	1.4	1.8
19	6.3	6.0	3.7	3.6	0.7	0.8
20	1.6	0.4	0.2	0.8	0.0	0
22	8.1	7.9	2.4	4.2	0.6	0.5
Total	3.9	4.8	3.0		0.9	1.0

where the special permit applied, whereas it changed to a much lesser extent in zones 7, 19, 20 and 22 where either sex hunting was allowed. A portion of this increase in success can be explained by the effects of selective hunting. The cows passed up by hunters without cow permits remained available for those hunters with cow permits. However, the extent of the increase suggests that the right to bag a cow was generally shared by all of the members of the group, and possibly between groups.

A large majority of moose hunters complied with the new regulations. In 1994, wildlife conservation officers recorded 541 violations of the new hunting rules. Of that number, 450 concerned transport and registration (scrotum as proof of sex missing) violations, 47 concerned the killing of cows by mistake but reported by hunters, and 39 concerned the killing of cows without a special permit for the zone. Overall, we consider that the 1994 experience was positive and the Management Plan, effective.

CONCLUSION

Moose populations outside of wildlife reserves in Québec clearly have been subjected to heavy harvesting until recent times. The introduction of selective hunting strategies in 1994 will help to rectify this situation. Harvest objectives of the Management Plan have been achieved. Approximately 3,000 cows were protected in the fall of 1994. The number of hunters has declined by 9 %, of which 6 - 7 % may be attributable to changes in the rules. However, a mail survey showed that hunters remained active for a longer period which may have increased their hunting success (Daigle *et al.* 1995).

We continue to observe a progressive change in the distribution of hunters. The zones of Southern Québec and, in particular those where only bow hunting is authorized, continue to gain in popularity, whereas the clientele of the central and northern zones

has tended to decline. We believe, however, that the introduction of selective harvest will not significantly contribute to make the number of hunters decline over the next few years as hunting success stabilizes. Moreover, the regulations have been relaxed in certain zones beginning in 1995. Finally, hunters should see more moose which should help in stimulating their interest in hunting this species.

ACKNOWLEDGMENTS

We would like to thank regional biologists of the Ministère de l'Environnement et de la Faune for their help in preparing and revising previous drafts of this paper. We also thank the two anonymous reviewers of the manuscript for their helpful comments on the content and the form of the manuscript.

REFERENCES

- BRASSARD, J.-M., E. AUDY, M. CRÊTE and P. GRENIER. 1974. Distribution and winter habitat of moose in Québec. *Naturaliste can.* 101: 67-80.
- _____. 1968. La distribution des ongulés sauvages de la province de Québec. Min. Tour. Chasse Pêche. Québec. 8 pp. MS.
- COURTOIS, R. 1989. Analyse du système de suivi de l'orignal au Québec. Québec, Min. Loisir Chasse Pêche, Dir. gestion espèces habitats 48 pp. SP 1770-09-90.
- _____. 1991. Normes régissant les travaux d'inventaires aériens de l'orignal. Québec, Min. Loisir Chasse Pêche, Dir. gestion espèces habitats, 23 pp. SP 1907-08-91.
- _____ and H. CRÉPEAU. 1995. Inventaire aérien des populations d'originaux par couverture totale de petits territoires et dénombrement sur une partie des ravages. Pages 91-100 *dans* ST-ONGE, D. BANVILLE et R. COURTOIS. Inventaires aériens de l'orignal dans les réserves fauniques du Québec. Québec, Min. Env. Faune, Dir. Faune Habitats.

- NO. CAT.: 95-3111-12
 _____ and M. CRÉTE. 1993. Predicting moose population parameters from hunting statistics. *Alces* 29: 75-90.
- _____ and G. LAMONTAGNE. 1990. Diagnostic sur l'état des populations d'orignaux au Québec. Québec, Min. Loisir Chasse Pêche, Dir. gestion espèces habitats. 37 pp. SP 1785-04-91.
- _____ and _____. 1991. Modalités de chasse utilisables pour l'exploitation de l'orignal. Québec, Min. Loisir Chasse Pêche, Dir. gestion espèces habitats. 45 pp. SP 1916-11-91.
- _____, 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.
- _____, F. POTVIN, S. COUTURIER and A. GINGRAS. 1996. Révision des programmes d'inventaires aériens des grands cervidés. Québec, Min. Environnement et Faune, Dir. faune et habitats, 49 pp. NO CAT.: 96-3425-10.
- CRÉTE, M. 1979. Estimation de la densité d'orignaux au moyen d'inventaires aériens incomplets. *Naturaliste can.* 106: 487-495.
- _____. 1985. Plan tactique - Orignal. Québec, Min. Loisir Chasse Pêche, Dir. gén. faune. 57 p. MS
- _____. 1987. The impact of sport hunting on North American moose. *Swedish. Wildl. Res. Suppl.* 1: 553-563.
- _____. 1989. Approximation of K carrying capacity for moose in eastern Québec. *Can. J. Zool.* 67: 373-380.
- _____ and C. DUSSAULT. 1987. Using hunter statistics to estimate density, cow-calf ratio and harvest rate of moose in Québec. *Alces* 23: 227-242.
- _____, L.-P. RIVEST, H. JOLICOEUR, J.-M. BRASSARD and F. MESSIER. 1986. Predicting and correcting helicopter counts of moose with observations made from fixed-wing aircraft in southern Québec. *J. Appl. Ecol.* 23: 751-761.
- _____ and D. ST-HILAIRE. 1979. L'hélicoptère et l'avion pour dénombrer les orignaux dans le sud-ouest du Québec. *Naturaliste can.* 106: 487-495.
- _____, R.J. TAYLOR and P.A. JORDAN. 1981. Optimization of moose harvest in southwestern Québec. *J. Wildl. Manage.* 95: 598-611.
- CUMMING, H.G. 1974. Annual yield, sex and age of moose in Ontario as indices to the effects of hunting. *Naturaliste can.* 101: 539-558.
- DAIGLE, C. 1995. Compte rendu de l'atelier sur la grande faune 1995. Québec, Min. Env. Faune, Dir. faune habitats, Serv. faune terr 334 pp.
- DAIGLE, É., R. COURTOIS and J.P. OUELLET. 1995. Enquête sur la perception des chasseurs d'orignaux après la première année d'application du plan de gestion de l'orignal, 1994-1998. Min. Env. Faune, Dir. faune habitats, Serv. faune terr., Québec, 68 pp. NO. CAT.: 95-2924-09
- DESMEULES, P. 1966. Controlled moose hunts in Québec's provincial parcs. *Proc. N.E. Sect. Wildl. Soc., Boston Mass.*
- FILONOV, C.P. and ZYKOV. 1974. Dynamics of moose populations in the forest zone of the European part of USSR and in the Urals. *Naturaliste can.* 101: 605-613.
- FRYXELL, J.M., W.E. MERCER and R.B. GELLATELY. 1988. Population dynamics of Newfoundland moose using cohort analysis. *J. Wildl. Manage.* 52: 14-21.
- GERRODETTE, T. 1993. Trends: software for a power analysis of linear regression. *Wildl. Soc. Bull.* 21: 515-516.
- GINGRAS, A., R. AUDY and R. COURTOIS. 1989. Inventaire aérien de l'orignal dans la zone de chasse 19 à l'hiver 1987-88. Québec, Min. Loisir Chasse Pêche, Dir. rég. Côte-Nord and

- Dir. gestion espèces habitats, 58 pp. SP 1553-02-89.
- GOLLAT, R. and H.R. TIMMERMANN. 1987. Evaluating Ontario moose harvest using a postcard questionnaire. *Alces* 23: 157-180.
- GONTHIER, S. 1977. Revue des statistiques à prélever aux stations d'échantillonnage durant la saison de chasse à l'orignal. Ministère du Tourisme, de la Chasse et de la Pêche, Service d'aménagement et d'exploitation de la faune. 15 pp. + annexes. MS.
- GUAY, D. 1983. Histoires vraies de la chasse au Québec. VLB éditeur et Donald Guay. Montréal. 268 p.
- INSTITUT QUÉBÉCOIS D'OPINION PUBLIQUE. 1985. Étude sur la chasse récréative au gros gibier en 1984 par les résidents du Québec. Québec, Min. Loisir Chasse Pêche, Dir. gén. faune.
- LYKKE, J. 1974. Moose management in Norway and Sweden. *Naturaliste can.* 101: 723-735.
- MARTIN, P.-L. 1990. La chasse au Québec. Réédition. Les Éditions du Boréal. Montréal. 409 p.
- MERCER, W.E. and F. MANUEL. 1974. Some aspect of moose management in Newfoundland. *Naturaliste can.* 101: 657-671.
- MOISAN, G. 1952. Enquête sur l'orignal. Québec, Min. Chasse Pêche, 11 pp. MS.
- PELLETIER, J. and G. THERRIEN. 1978. La chasse sportive à l'orignal au Québec en 1976. Québec, Ministère du Tourisme, de la Chasse et de la Pêche, Serv. rech. socio-écono., Dir. planif. 57 p.
- RITCEY, R.W. 1974. Moose harvesting programs in Canada. *Naturaliste can.* 101: 631-642.
- RIVEST, J.-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.
- SIMKIN, D.W. 1974. Reproduction and productivity of moose. *Naturaliste can.* 101: 517-525.
- STATBEC. 1984. La chasse récréative au Québec en 1981. Québec, Min. Loisir, Chasse, Pêche, 170 pp.
- ST-ONGE, S., R. COURTOIS and D. BANVILLE (éd.). 1995. Inventaires aériens de l'orignal dans les réserves fauniques du Québec. Québec, Min. Env. Faune, Dir. faune habitats, Serv. faune terr. 109 pp. NO. CAT.: 95-3111-12
- SYROECHKOVSKIY, E.E and V. ROGACHEVA. 1974. Moose of the Asiatic part of USSR. *Naturaliste can.* 101: 595-604.
- TIMMERMANN, H. R. 1974. Moose inventory methods: a review. *Naturaliste can.* 101: 615-629.