THE IMPACT OF TWO LARGE FOREST FIRES ON MOOSE (*ALCES ALCES*) HARVESTING

Stéphane Tanguay[1], Gilles Lamontagne[2], Jean-Pierre Ouellet[1], and Réhaume Courtois[2]

[1]Université du Québec à Rimouski, Département de Biologie, 300 Allée des Ursulines, C.P. 3300, Rimouski, PQ, Canada G5L 3A1; [2]Faune et Parcs, Direction de la faune et des habitats, Service de la faune terrestre, 11e étage, 675 René-Lévesque Est, Boîte 92, Québec, PQ, Canada G1R 5V7

ABSTRACT: After the large forest fires on the Québec Côte-Nord in the summer of 1991, a study was conducted to determine the impact on the moose harvest, and the behavior and perception of moose hunters. Two areas were studied, corresponding to the fires of Forestville and of Betsiamites, where we compared the harvest before (1986 to 1990) and after the fires (1991 and 1992). Questionnaires ($n = 522$) were sent to hunters who had hunted in these areas between 1988 and 1992. In the fall of 1991, the harvest was reduced by up to 50% in the burned zones and increased in the zone which bordered on the fires. The composition of the harvest did not seem to change. In 1991, some hunters decided not to hunt or to distance themselves from the burned zones. This resulted in a marked decrease in the use of the burned zones in 1991. Changes in hunters' habits may explain the observed changes in the harvest. An important factor in hunters' decisions was hunting lodges damaged or destroyed by the fires. In 1992, the utilization and the harvest of burned zones was starting to reestablish itself to the levels recorded prior to the fires. Following the fires hunters did not notice any important variations in the abundance of moose, but they did notice a reduced presence of other hunters in the burned zones. Large forest fires may have a very short term impact (1 year) on the moose harvest and a short term (2 years) impact on the behavior and perception of hunters.

Key words: *Alces alces*, forest fires, harvest, hunters, hunting pressure, lodging, moose, movements

RÉSUMÉ: Une étude a été réalisée afin de préciser les impacts des grands feux de forêt de la Côte-Nord à l'été 1991 sur la récolte, le comportement et la perception des chasseurs d'orignaux. Deux secteurs ont été retenus, correspondants aux feux de Forestville et Betsiamites où l'on a comparé la récolte avant les feux (1986 à 1990) et celle après les feux (1991 et 1992). De plus, 522 questionnaires ont été expédiés à autant de chasseurs qui pratiquaient leur activité dans les secteurs retenus, entre 1988 et 1992. À l'automne 1991, immédiatement après les feux, la récolte a diminué jusqu'à 50% dans les zones incendiées et a augmenté dans les zones situées en bordure des feux. Cependant, la composition de la récolte ne semble pas avoir été modifiée de façon très sensible. En 1991, certains chasseurs ont décidé, dans une proportion plus importante qu'avant les feux, de ne pas chasser ou de s'éloigner des sites incendiés. Globalement, il en a résulté une baisse importante de la fréquentation dans les zones incendiées. Les changements des habitudes des chasseurs semblent expliquer en bonne partie les modifications au niveau de la récolte. Les moyens d'hébergement endommagés ou détruits par les feux ont été un facteur important dans les décisions des chasseurs. En 1992, la fréquentation et la récolte dans les zones brûlées ont commencé à se rétablir à leurs niveaux d'avant les feux. Les chasseurs n'ont pas observé, suite aux feux, de variations importantes de l'abondance des orignaux mais ils ont constaté une présence moins grande de chasseurs dans les zones incendiées. Les feux de forêts d'importance peuvent donc avoir un impact à très court terme (un an) sur la récolte et à court terme (deux ans) sur le comportement et la perception des chasseurs.

Mots-clés: *Alces alces*, chasseurs, déplacements, feux de forêt, hébergement, orignal, pression de chasse, récolte

ALCES VOL. 35: 59-72 (1999)

Forest fires influence the structure, diversity and dynamics of North American forests. They are an integral part of the succession process of the boreal forests (Crête 1988) and permit colonization by pioneer species. However, their intensity and frequency are influenced by forest cover and climate (Heinselman 1981) and, the composition and structure of the new forest depends on numerous local factors such as adjacent vegetation communities, intensity of the fire and available soil resources (Christensen 1988, Riverain and Gagnon 1996). All of these factors influence the associated animal community. For example, changes in the vegetative structure caused by fire may influence snow conditions and predator-prey relationships (Cimon and Maisonneuve 1990).

Forest fires can create good habitats for moose (*Alces alces*) over the short (1-10 years) and long term (25 years) by favoring the re-growth of browse species (Oldemeyer and Regelin 1987), by creating ecotones between areas of dense cover and more open feeding areas (Krefting and Lykke 1976) or by increasing productivity (Thomas 1990). On the other hand, it has been shown that loss of cover, similar to clear cuts, can be detrimental for moose, for example, by increasing the snow cover in open areas (Mastenbrook and Cumming 1989), by accentuating the vulnerability of animals to predation or hunting (Eason 1989), or by increasing hunting pressure (Eason 1985).

Past research focused on the effects of forest fires on moose density (Irwin 1975), on movements of individuals (Gasaway and Dubois 1985, Gasaway *et al.* 1989) and on their use of burned zones as feeding sites (MacCracken and Viereck 1990). In general, authors have reported an increase in moose numbers over the long term (Kelsall *et al.* 1977, Viereck and Schandelmeir 1980). However, over the short term, hunters may have a negative perception towards forest fires due to the modification of the environment (Boxall *et al.* 1996b). Consequently, hunting activities and harvest may be negatively affected.

To our knowledge, no research has been conducted on the short term effect of forest fires on moose hunting despite their impact on recreation activities (Boxall *et al.* 1996b) and associated economic incomes. The large fires that devastated more than 3,300 km² of forest on the Côte-Nord of Québec in the summer of 1991 gave us a unique opportunity to address this question.

STUDY AREA

The study area was located on the Côte-Nord of Québec (in Hunting Zone 18 East). The forest is dominated by numerous young stands regenerating following clear cuts and small forest fires. Spruce (*Picea mariana*), fir (*Abies balsamea*), and mixed forests dominate. About 60% of the forests affected by the fires of 1991 were stands in regeneration and 40% were mature coniferous forests (MLCP 1991a). Before 1991, clear cuts were the most important rejuvenating factor, followed by the spruce budworm (*Choristoneura fumiferana*), which has ravaged balsam fir stands over the last 15 years, and minor forest fires (MLCP 1991b).

The fires of 1991 covered 2 main areas. The first area, Forestville (48° 45' N, 69° 05' W), is located 50 km north of its namesake town. The fire, which burned from

June to August 1991, covered about 977 km². The second area, Betsiamites, is located about 70 km to the north-west of Baie-Comeau (49° 15' N, 68° 10' W). The fire started June 1991 and was declared out 27 September, after having covered an area of about 2,414 km².

In the study area, 13 outfitters have exclusive rights and 5 ZECs (areas intensively harvested and managed by hunter associations; see Courtois and Lamontagne (1997) for more information about moose hunting organization in Québec) offer moose hunting. These areas are relatively accessible and are used by hunters.

METHODS

Impact on the Harvest

We used data from the Big Game Information System (SIGF), of the Ministère de l'Environnement et de la Faune of Québec (MEF), to study the impacts of forest fires on moose harvest. For every animal shot within the study area between 1986 and 1992, the following information was retained: geographical location, year, sex, and age class of the animal. The period "Pre-fire" was from 1986 to 1990 and the period "Post-fire" were the years 1991 and 1992. The study covers the burned zones of Forestville and of Betsiamites as well as a border zone 15 km wide around the perimeter of the fires. These border zones cover 2,414 km² for the Forestville area and 4,643 km² in the Betsiamites area. We assumed that the influence of fire should be limited to the border zones (Goudreault 1980, Labonté *et al.* 1998). The position of each animal shot within the study areas was reported on a 1: 250,000 topographical map, to determine if the kill took place in the border or the burned zone of a given area (Forestville or Betsiamites).

Impact on the Behavior and Perception of Hunters

The impact of forest fires on the behavior and perception of hunters was assessed by a mail survey (n = 522) sent the second week of June 1993 to hunters who had harvested a moose in the study areas between 1988 and 1992. The objective was to cover at least 30 kills per year for each zone. When less than 30 kills were reported in a given year and zone (burned or border), every reported case was retained. Since a hunter may have taken more than 1 moose in the study areas between 1988 and 1992 their answer can cover these 2 events, and as a result more than 30 cases could be covered for certain years in a particular zone. A self addressed envelope permitted the respondents to return the questionnaire anonymously.

Data Analysis

We tested the impact of each forest fire (Forestville and Betsiamites) on the total number of moose killed per unit area and on the harvest composition (percentage of adult males, adult females, and calves) in each zone (burned and border) using the Welch t-Test (Krebs 1999). As a control, we used the harvest statistics recorder in the 18 East Hunting Zone (29,069 km²) excluding the harvest recorded in Forestville and Betsiamites areas, as they were part of this hunting zone.

RESULTS

Impact of the Fires on the Harvest

All tests conducted to assess the impact of both fires (Forestville and Betsiamites) on the harvest (number of moose killed and the composition of the harvest) recorded in the burned and border zones were not significant ($P > 0.05$). However, because we expected the power of the statistical procedures used to be low we looked for possible trends in our results. As an example, the

impact of the fires on moose harvest is suspected when the harvest recorded following the fires is outside the range obtained the years preceding the fires.

In the Forestville area in 1991 the harvest declined in the burned zone, bottoming out at 14 moose while the annual pre-fire average was 33 animals (Fig. 1). The border zone of this area recorded its highest level since 1986 with 112 moose in 1991, while the annual pre-fire average was 94 moose. In 1992, the harvest in the burned zone had risen to 24 moose, lower than the lowest harvest recorded (28 moose in 1988) prior to the fires. In the border zone, in 1992, the harvest had come back to a value within the range recorded before the fires.

In the Betsiamites area, the harvest of 1991 in the burned zone decreased less than at Forestville from 38 to 22 moose (Fig. 1). Although it was lower than the average recorded before the fires (29 moose) it was comparable to that of 1986 when 22 moose were shot. In the border zone, the harvest was 82 moose, a level comparable to the pre-fire annual average of 81 moose. In 1992, the harvest increased to 35 moose in the burned zone and decreased to 75 individuals in the border zone. But these values fall within the range of values recorded before the fires. The Betsiamites fire had no significant impact on the harvest re-

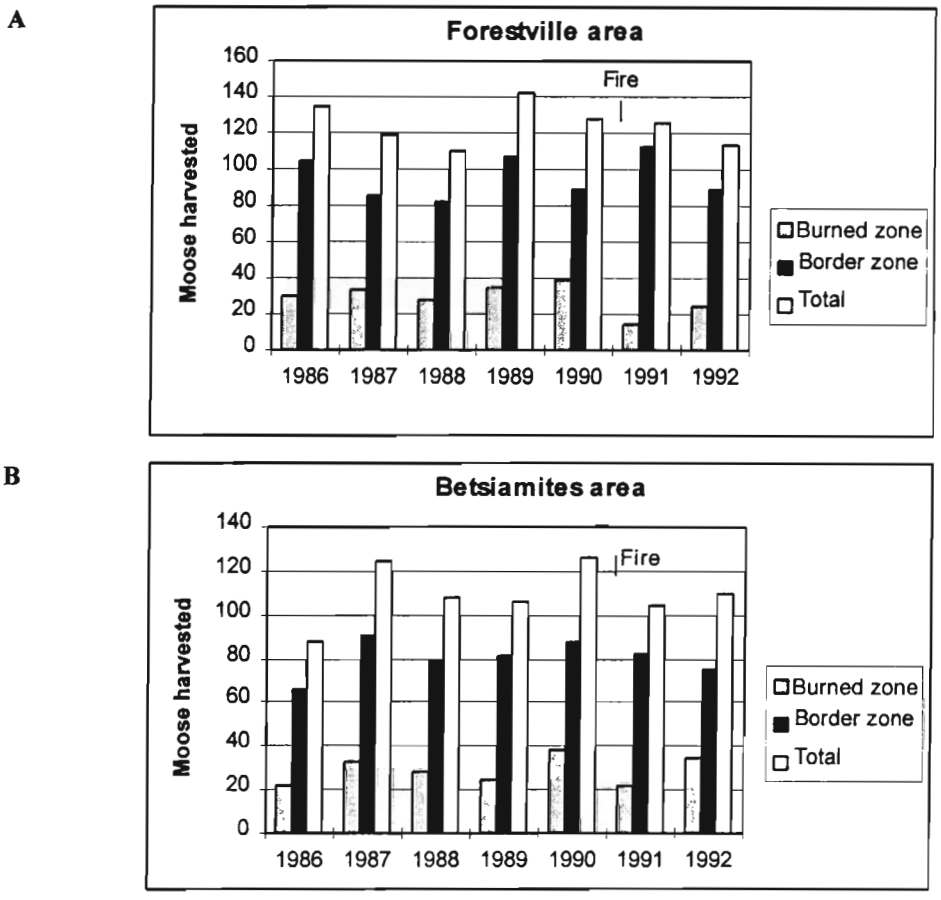

Fig. 1. Moose harvest for the 1986-1992 period in the burned and the border zones of (A) the Forestville and (B) the Betsiamites areas subject to large forest fires in summer 1991.

corded in the burned and border zones ($P > 0.05$).

In 1991, the first post-fire hunting season, the proportion of males in the adult moose harvest in all cases remained comparable to that before the fires (Table 1). In both the Forestville and the Betsiamites burned zones, the proportion of adult males in the harvest in 1992 was one of the lowest in the 7 years considered. The proportion of calves in the harvest stayed stable in 1991 in all zones, except in the burned zone of the Forestville area (Table 2). Only 2 calves were taken in 1992 in the burned zone of Forestville and in the border zone of the Betsiamites, while a dozen should have been harvested based on the harvest recorded the previous years. By contrast, the proportion of calves increased in the burned zone of Betsiamites, whereas it decreased in the border zone. Overall, the proportion of calves in harvest of 1992 for the 2 areas remained relatively low when compared to the previous years.

In the 2 ZECs affected by fires (i.e. more than 5% of their area), the number of hunting days decreased by 18% in 1991 and by an additional 10% in 1992 (3,423, 3,465, 2,822, and 2,519 hunting days between 1989 and 1992, respectively). For affected outfitter areas, the number of hunting days decreased by 50% after the fires (236, 234, 243, 105, and 132 hunting days between 1988 and 1992). However, in both the ZECs and the outfitter areas, the total harvest was less affected than the number of hunting days. In the ZECs, 21 and 35 moose were harvested during the pre-fire period while 20 and 15 were harvested post-fire. In the outfitter areas, 2 moose were harvested annually between 1988 and 1990 whereas 2 and 3 moose were killed in 1991 and 1992, post-fire.

Behavior and Perception of Hunters According to the Survey

Of 485 questionnaires that reached their destination, 244 were returned, for a response rate of 50.3%. Thirty-three questionnaires were rejected as not usable. The

Table 1. Percentage of males in the adult moose harvest in the different zones of the Forestville and Betsiamites areas before (1986-1990) and after (1991-1992) the 1991 fires.

	Forestville		Betsiamites	
Year	Burned Zone	Border Zone	Burned Zone	Border Zone
Pre-fire				
1986	52.0 (25)[1]	42.2 (83)	59.1 (22)	71.4 (56)
1987	48.1 (27)	51.4 (72)	73.3 (30)	63.5 (74)
1988	52.0 (25)	57.1 (70)	73.1 (26)	50.0 (70)
1989	55.9 (34)	67.3 (98)	52.2 (23)	67.6 (71)
1990	59.0 (39)	59.2 (76)	62.9 (35)	50.6 (79)
Average	53.3 (33)	56.2 (80)	66.7 (27)	60.0 (70)
Post-fire				
1991	53.8 (13)	49.0 (96)	70.0 (20)	60.0 (70)
1992	41.7 (24)	57.7 (78)	51.7 (29)	46.6 (73)

[1]Total harvest

Table 2. Percentage of calves in the harvest for the different zones of the Forestville and Betsiamites areas before (1986-1990) and after (1991-1992) the 1991 fires.

	Forestville		Betsiamites	
Year	Burned Zone	Border Zone	Burned Zone	Border Zone
Pre-fire				
1986	16.7(30)[1]	20.2(104)	0.0(22)	15.2(66)
1987	18.2(33)	16.3(86)	9.1(33)	17.8(90)
1988	10.7(28)	14.6(82)	7.1(28)	11.4(80)
1989	2.9(35)	8.4(107)	8.0(25)	12.3(81)
1990	12.8(39)	14.6(89)	7.9(38)	10.2(88)
Average	12.1(33)	14.9(94)	6.9(29)	13.6(81)
Post-fire				
1991	7.1(14)	14.3(112)	9.1(22)	14.6(82)
1992	0.0(24)	12.4(89)	17.1(35)	2.7(75)

[1]Total harvest

final sample then consisted of 211 questionnaires documenting 285 moose kills.

In the burned zones of the 2 study areas, 10.5% and 11.8% of hunters did not hunt in 1991, compared to a rate of abandonment varying from 0 to 1.3% in the pre-fire period (Table 3). More hunters than usual (29.4 and 34.2%) hunted in another zone or outside the study area as compared to the preceding period (6.3 and 4.0%, respectively). Most hunters who abandoned traditional areas decided to hunt outside the study area. However, it should be noted that an important proportion of respondents (58.8% in Forestville and 53.3% in Betsiamites) continued to hunt in burned zones as before. In 1992, the situation seemed to stabilize, but the proportion of respondents who did not hunt or who hunted elsewhere was still higher than before 1991. In the border zones, the same trends were observed as in the burned zones, but the variation was less dramatic and, as in 1992, the situation approached that before the fires. The available indices indicated a decrease of about 50% in the use of the burned zones in 1991. This tendency was less marked in the border zones, and may have been counter-balanced by the arrival of new hunters from other burned zones. In general, there was more variation, in the Betsiamites area, particularly in 1991.

The majority of hunters who stopped hunting agreed that the fires influenced their decision. In 1991, these respondents generally cited important damage to the forest around their hunting site (90.9%) or to their hunting lodge or camp (45.5%) (Table 4). In 1992, the reasons stayed the same but a smaller percentage of hunters (50.0%) attributed their decision to the impact of the fire on the forest.

Among the respondents who hunted in 1991, almost 26% said the fires had influenced their choice of hunting site; 82% of these tried to distance themselves from burned zones (without necessarily changing zone at the same time). In 1992, 23% of hunters said the fires influenced their choice of hunting site; 74% tried to distance them-

Table 3. Behavior of hunters, who shot at least 1 moose in 1 of the study areas between 1988 and 1992, with respect to their decision to hunt and where to hunt (% of the number of respondents who hunt in each zone).

Area	Behavior[1]	Pre-fire	Post-fire	
		1988-1990	1991	1992
FORESTVILLE				
Burned Zone	Didn't hunt	0.0	11.8	9.5
	Hunted elsewhere[2]	6.3	29.4	9.5
	Hunted in the same zone	93.8	58.8	81.0
	Number of respondents	64	34	21
Border Zone	Didn't hunt	1.0	5.8	1.9
	Hunted elsewhere	3.9	9.6	5.8
	Hunted in the same zone	95.1	84.6	92.3
	Number of respondents	102	52	52
BETSIAMITES				
Burned Zone	Didn't hunt	1.3	10.5	4.2
	Hunted elsewhere	4.0	34.2	12.5
	Hunted in the same zone	94.7	55.3	83.3
	Number of respondents	75	38	24
Border Zone	Didn't hunt	3.0	9.8	2.4
	Hunted elsewhere	0.0	14.6	7.3
	Hunted in the same zone	97.0	75.6	90.2
	Number of respondents	66	41	41

[1]Behavior with respect to the previous year. For example, 29. 4% of the 34 respondents who hunted in the burned zone of the Forestville area in 1990, hunted elsewhere in 1991. The Pre-fire values are averages.

[2]Elsewhere means "in another zone or outside the study area".

Table 4. Reasons given by those hunters who did not hunt due to the fires (% of the number of respondents).

Reasons[1]	1991 (11)[2]	1992 (8)
I didn't think there would be enough moose	27.3	37.5
I didn't have the financial means necessary to find another hunting site	9.1	0.0
I didn't have the time to find another hunting site	9.1	0.0
My lodging was damaged or destroyed by the fires	45.5	50.0
Access to my hunting site was too difficult	18.2	25.0
The forest around my hunting site was too badly damaged by fire for me to hunt	90.9	50.0
Other reasons	0.0	12.5

[1] As the respondents could mark more than 1 reason, a summation of the values will not total 100%.

[2]Number of respondents.

selves from burned zones. The main reason that motivated the respondents who hunted closer to burned sites in 1991, was the hope that there were more moose and fewer hunters at the new site (Table 5). In 1992, the same reasons applied, but more hunters wanted to occupy the burned zones, in anticipation of future years.

In both 1991 and 1992, the fires of 1991 did not seem to have a major impact on the average number of moose hunting days practiced by the hunters in the study area (Table 6). Hunters planned their hunting excursions in advance, and as the length of the hunting season does not vary much from year to year, the fires did not cause the hunters to shorten or lengthen their stay in any notable way.

In the burned zone of Forestville, most hunters estimated that they saw as many moose in 1991 (or signs of their presence) as in previous years (Table 7). Only 25% said they saw fewer. In 1992, the majority of them were of the same opinion, a larger proportion saying they had seen more. In the border zone, the perception of moose abundance stayed the same. In the burned zone of the Betsiamites area, almost 50% of hunters said they saw fewer moose or signs in 1991. In 1992, hunters seemed to notice more moose. In the border zone of this area, the situation seems to have stayed the same.

In 1991, in the burned zone of the Forestville area, respondents observed fewer hunters than in 1990 and even less than in 1992 (Table 8). In the border zone a slight increase was noticed. In the burned zone of the Betsiamites area, respondents also observed fewer hunters in 1991 than in 1990 and this decrease continued in 1992. In the border zone of this area, the opposite situation was observed, as close to half of the respondents thought there was an increase in the number of hunters.

DISCUSSION

Statistical tests failed to detect any significant impact of the forest fire on the number of moose killed and on the harvest

Table 5. Reasons given by hunters influenced by the fires in their choice of a new hunting site, for why they stayed close (C) or tried to distance (D) themselves from burned zones (% of respondents).

Reasons[1]	1991		1992	
	C (10)[2]	D (35)	C (13)	D (25)
I thought there would be more moose at this hunting site	50.0	40.0	46.2	44.0
I thought there would be fewer moose hunters at this site	40.0	0.0	38.5	4.0
I thought it was important to occupy this site as of 1991 (1992) for future years	20.0	31.4	30.8	28.0
My lodgings were damaged or destroyed by the fires	20.0	62.9	15.4	44.0
Access to my new hunting site is easier	0.0	5.7	23.1	4.0
Other reasons	10.0	8.6	0.0	4.0

[1] As respondents could mark more than 1 response, a summation of the values will not total 100%.

[2] Number of respondents.

Table 6. Impact of the fires on the average number of hunting days by year and by zone.

Area	Pre-fire			Post-fire	
	1988	1989	1990	1991	1992
FORESTVILLE					
Burned Zone	8.9 (29)[1]	9.4 (33)	9.3 (33)	9.3 (21)	8.4 (22)
Border Zone	11.6 (48)	11.0 (54)	11.5 (54)	12.1 (54)	12.5 (58)
BETSIAMITES					
Burned Zone	9.8 (39)	10.2 (39)	10.4 (40)	9.8 (25)	10.4 (32)
Border Zone	9.9 (30)	9.7 (37)	9.8 (41)	00.6 (39)	8.3 (46)

[1] Number of respondents.

Table 7. Perceptions of hunters of the abundance of moose at hunting sites, during the post-fire period (1991-1992) as compared to the previous year.

Area	Observations	1991	1992
FORESTVILLE			
Burned Zone	More moose	30.0	41.2
	As many moose	45.0	41.2
	Fewer moose	25.0	17.6
	Number of respondents	20	17
Border Zone	More moose	12.2	13.3
	As many moose	68.3	62.2
	Fewer moose	19.5	24.4
	Number of respondents	41	45
BETSIAMITES			
Burned Zone	More moose	9.5	15.0
	As many moose	42.9	55.0
	Fewer moose	47.6	30.0
	Number of respondents	21	20
Border Zone	More moose	3.6	3.2
	As many moose	75.0	71.0
	Fewer moose	21.4	25.8
	Number of respondents	28	31

composition. However, the power of the statistical tests used is likely very low because we had little control over the experimental design. Although, the global impact of the fires on the harvest was not very important, some effects are suspected. Further, some obvious impacts were recorded on hunters habits and perceptions.

The most obvious impact of the 2 large forest fires of 1991 on the Côte-Nord was a decrease in moose harvest in the burned zones. However, this decrease was not

dramatic. In 1991, the harvest stayed close to 50% of that recorded before fire in the burned zone of Forestville and close to 75% of the pre-fire level in the Betsiamites area. The second year, the harvest came back to 75% of that recorded before fire in the burned zone of Forestville, and to the pre-fire average in the Betsiamites area. The recovery was therefore rapid. A similar result was observed with white-tailed deer (*Odocoileus virginianus*) following a fire of 180 km^2 (Johnson *et al.* 1992). The impact is even less in the border zones, that of Forestville seeing a slightly higher harvest the year of the fire.

The harvest is the result of 2 components: the abundance of moose and hunting pressure, both defined by other factors such as availability of food, vegetation cover, susceptibility of moose to exploitation, and the number of hunters. Therefore, any variation in 1 of these components will have an effect on the harvest. The decrease in the harvest in the burned zones in 1991 could partly be the result of a decrease in moose number. But in general, the literature suggests few mortalities as a direct result of fire (see reviews by Cimon and Maisonneuve 1990, Child 1998). Moose are capable of moving very quickly and some may have left the burned zones momentarily, only to return after the fires. Others may have stayed in residual forest patches since Gasaway and Dubois (1985) reported that radio-collard moose were not displaced from traditional May-August home ranges when a portion of their range was altered by fire. Moreover, they observed a moose as close as 2 m from small flames. Further, it is unlikely that several moose left the burned zones in favor of the border zones as the harvest did not increase markedly in those zones. Our results suggest that the decrease in the harvest in the burned zones is more likely attributed to the decrease in hunting pressure.

In 1992, we cannot reject that the recovery of the harvest in the burned zones could be explained by a more intense utilization by moose (Gasaway *et al.* 1989) due to the presence of ecotones (Cumming 1980), greater quantity and better quality of browse in young stands (Oldemeyer and Regelin 1987, Regelin *et al.* 1987, MacCracken and Viereck 1990), or even a decrease in the number of parasites (Drew *et al.* 1985). However, the increase in the harvest was certainly, and more importantly, influenced by greater hunting pressure due to improved access (Girard and Joyal 1984, Eason 1989, Colin and Walsh 1991).

The Forestville area seemed more strongly affected by the fires than the Betsiamites area. This may be explained by the intrinsic differences between the fires that ravaged these areas. The greater abundance of residual forest patches inside the burned zone of the Betsiamites area could have favored moose survival or utilization. Secondly, the hunting characteristics of each area (greater or lesser presence of ZECs and outfitter establishments, variable accessibility to the area, etc.) could have equally influenced the harvest. A greater mortality of females and calves may have been predicted, but the results of the hunt do not appear to demonstrate this except, perhaps, for the calves in the Forestville area.

MANAGEMENT IMPLICATIONS

Immediately after the fires, the harvest decreased in the burned zones and increased in the border zones. However, the decrease in the burned zones is not as large (25 - 50%) as that which might be expected and the situation almost completely recovered in the second year.

Changes in the harvest seem to depend on the reactions of hunters, which manifests itself principally in the same year as the fire. Almost 10% stopped hunting, 50%

Table 8. Perception of hunters of the abundance of moose hunters at hunting sites, during the post-fire period (1991-1992), as compared to the previous year.

Area	Observations	1991	1992
FORESTVILLE			
Burned Zone	More hunters	0.0	0.0
	As many hunters	40.0	14.3
	Fewer hunters	60.0	85.7
	Number of respondents	10	7
Border Zone	More hunters	22.6	24.2
	As many hunters	64.5	63.6
	Fewer hunters	12.9	12.1
	Number of respondents	31	33
BETSIAMITES			
Burned Zone	More hunters	14.3	13.3
	As many hunters	21.4	26.7
	Fewer hunters	64.3	60.0
	Number of respondents	14	15
Border Zone	More hunters	43.4	47.8
	As many hunters	47.8	48.0
	Fewer hunters	8.7	8.0
	Number of respondents	28	31

continued to hunt in the burned zones, and the rest continued to hunt but changed their hunting site. Less impact occurred in the border zones. The impact of forest fires seems to be over the short term, on the order of 2 years. In fact, in 1992, the harvest returned to levels similar to the pre-fire average except in the burned zone of Forestville.

These results show how lodgings damaged or destroyed by fire are an important factor in hunters' reactions. Respondents who tried to distance themselves from burned zones in 1991 did so mostly because their lodgings were damaged or destroyed, and to a lesser extent, because there would be more moose at this new hunting site. When lodging is not destroyed, hunters prefer to remain in the same area, even if hunting success may be expected to be lower. The salient elements (Boxall 1996a) explaining this situation are: (1) moose hunters of the study site are more or less sedentary because they normally hunt from a camp they have previously built; and (2) because it could be more advantageous in terms of harvesting opportunities to hunt in a well known area as opposed to moving to a new site. In 1992, the situation stabilized at the harvest level but the influence of fire persisted, in the behavior and perception of hunters.

Forest fires translate, to a loss of revenue due to a reduction in the number of hunters, and by an overall decrease in the number of hunting days, as some hunters abandon the sport or "emigrate" elsewhere. ZECs and outfitters establishments are particularly sensitive to this loss of revenue. However, these losses are only over the

short term as utilization goes up again in the second year after a fire.

Our study also shows that the impact of forest fires varies between areas. Hunters' general comments suggest that the characteristics of the area after a fire, such as the importance of residual patches of vegetation, determine the impact of forest fire on moose abundance. This potential relationship may merit consideration in granting cutting rights in recently burned out areas.

ACKNOWLEDGEMENTS

Special thanks are addressed to Peter Boxall and one anonymous referee who made very constructive comments on the previous version of this paper. We also thank the staff of the Ministère de l'Environnement et de la Faune du Québec (MEF) for the efforts made in gathering and sending data for this study. We express our gratitude to Michel Brault, for revising this text, and to Shannon Fizer who translated the manuscript. The production and mailing of the questionnaires was made possible by the technical support and financing of the Direction de la faune et des habitats (MEF). Finally, special thanks to the numerous people who helped with data entry: Fariel Benameur, François Blouin, Nancy Dénomée, Johanne Labonté, Daniel Sigouin, and Quentin van Ginhoven.

REFERENCES

BOXALL, P.C., W.L. ADAMOWICZ, J. SWAIT, M. WILLIAMS, and J.J. LOUVIERE. 1996a. A comparison of stated preference methods for environmental valuation. Ecol. Economics 18: 243-253.

_____, D.O. WATSON, and J. ENGLIN. 1996b. Backcountry recreationists evaluation of forest and park management features in wilderness parks of the western Canadian Shield. Can. J. For. Res. 26: 982-990.

CHILD, K. N. 1998. Incidental mortality. Pages 275-301 *in* A. W. Franzmann and C.C. Schwartz (eds.) Ecology and management of the North American moose. Smithsonian Inst. Press, Washington, DC.

CHRISTENSEN, N. L. 1988. Succession and natural disturbance: paradigms, problems and preservation of natural ecosystems. Pages 62-86 *in* J.K. Agee and D.R. Johnson (eds.) Ecosystems management for park and wilderness. University of Washington Press, Seattle, WA.

CIMON, A. and B. MAISONNEUVE. 1990. Effet du feu sur la faune et ses habitats. Ministère de l'Énergie et des Ressources du Québec, Direction de la conservation, Charlesbourg, PQ. 77 pp.

COLIN, L. and R. WALSH. 1991. Influence de la coupe forestière sur la chasse à l'orignal en Abitibi (1973-1987): Étude basée sur le système Mercator. Ministère des Forêts du Québec, Québec, PQ. 30 pp.

COURTOIS, R. and G. LAMONTAGNE. 1997. Management system and current status of moose in Québec. Alces 33: 97-114.

CRÊTE, M. 1988. Forestry practices in Québec and Ontario in relation to moose population dynamics. For. Chron. 64: 246-250.

CUMMING, H. G. 1980. Relation of moose track counts to cover types in north-central Ontario. Proc. N. Am. Moose Conf. Workshop 16: 444-462.

DREW, M. L., W. M. SAMUEL, G. M. LUKIWSKI, and J. N. WILLMAN. 1985. An evaluation of burning for control of winter ticks, *Dermacentor albipictus*, in central Alberta. J. Wildl. Diseases 21: 313-315.

EASON, G. 1985. Overharvest and recovery of moose in a recently logged area.

Alces 21: 55-75.

_____. 1989. Moose response to hunting and 1 km² block cutting. Alces 25: 63-74.

GASAWAY, W. C. and S. D. DUBOIS. 1985. Initial response of moose, *Alces alces*, to a wildfire in interior Alaska. Can. Field-Nat. 99: 135-140.

_____, _____, R. D. BOERTJE, D. J. REED, and D. T. SIMPSON. 1989. Response of radio-collared moose to a large burn in Central Alaska. Can. J. Zool. 67: 325-329.

GIRARD, F. and R. JOYAL. 1984. L'impact des coupes à blanc mécanisées sur l'orignal dans le nord-ouest du Québec. Alces 20: 3-25.

GOUDREAULT, F. 1980. Influence d'un parc de conservation et d'une réserve sur la récolte d'orignaux dans les territoires adjacents intensément chassés dans le centre-sud du Québec. Proc. N. Am. Moose Conf. Workshop 16: 527-548.

HEINSELMAN, M. L. 1981. Fire intensity and frequency as factors in distribution and structure of northern ecosystems. Pages 7-57 *in* H.A. Mooney (ed.) Fire regime and ecosystems properties. USDA For. Serv. Gen. Tech. Rep. WO-26.

IRWIN, L. L. 1975. Deer-moose relationship on a burn in northeastern Minnesota. J. Wildl. Manage. 39: 653-662.

JOHNSON, A. S., P. E. HALE, J. S. OSBORNE, O. F. ANDERSON, and W. M. FORD. 1992. Deer in Pocosin habitat after catastrophic wildlfire. Proc. Ann. Conf. Southeast Assoc. Fish Wildl. Agencies 46: 118-127.

KELSALL, J. P., E. S.TELFER, and T. D. WRIGHT. 1977. The effect of fire on the ecology of the Boreal Forest, with particular reference to the Canadian north: a review and selected bibliography. Pêche et Environnement Canada, Service canadien de la faune. Occasional Papers 32. 58 pp.

KREBS, C. J. 1999. Ecological methodology. Second ed. Addison-Wesley Educational Publishers, Inc. Menlo Park, CA. 620 pp.

KREFTING, L. W. and J. LYKKE. 1976. A comparison of moose habitats in North America and Norway. Int. Union Inst. For. Res.16: 731-743.

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.

MACCRAKEN, J. G. and L. A.VIERECK. 1990. Browse regrowth and use by moose post-fire in interior Alaska. Northwest Sci. 64: 11-18.

MASTENBROOK, S. and H. CUMMING. 1989. Use of residual strips of timber by moose within cutovers of northwestern Ontario. Alces 25: 146-155.

(MLCP) MINISTÈRE DU LOISIR, DE LA CHASSE ET DE LA PÊCHE DU QUÉBEC. 1991a. Impacts appréhendés des feux de forêt de Forestville et de Baie-Comeau, été 1991, sur la faune. Ministère du Loisir, de la Chasse et de la Pêche du Québec, Direction de la gestion des espèces et des habitats, Québec, PQ. 14 pp.

_____. 1991b. Plan de gestion de l'Orignal, 1993-1997. Objectifs de gestion et scénarios d'exploitation proposés. Ministère du Loisir, de la Chasse et de la Pêche du Québec, Direction de la gestion des espèces et des habitats et Direction générale des opérations régionales, Québec, PQ. 246 pp.

OLDEMEYER, J. L. and W. L. REGELIN. 1987. Forest succession, habitat management and moose on the Kenai National Wildlife Refuge. Swedish Wildl. Res. Suppl. 1: 163-180.

REGELIN, W. L., C. C. SCHWARTZ, and

A. W. FRANZMANN. 1987. Effects of forest succession on nutritional dynamics of moose forage. Swedish Wildl. Res. Suppl. 1: 247-263.

RIVERIN, S. and R. GAGNON. 1996. Dynamique de la régénération d'une pessière à lichen dans la zone de la pessière noire à mousse, nord du Sagnenay-Lac-Saint-Jean (Québec). Can. J. For. Res. 26: 1504-1509.

THOMAS, D. C. 1990. Moose diet and uses of successional forests in the Canadian Taiga. Alces 26: 24-29.

VIERECK, L. A. and L. A. SCHANDELMEIR. 1980. Effects of fire in Alaska and adjacent Canada - a litterature review. U.S. Dep.Int., Land Manage. Office, Alaska, Tech. Rep. 6. 124 pp.