A PRELIMINARY ASSESSMENT ON THE INFLUENCE OF HABITAT COMPOSITION AND STRUCTURE ON MOOSE DENSITY IN CLEAR-CUTS OF NORTH-WESTERN QUÉBEC

Réhaume Courtois and Aldée Beaumont

Société de la faune et des parcs du Québec, Direction de la recherche sur la faune, 675 René-Lévesque Est, 11e étage, boîte 92, Québec, PQ, Canada G1R 5V7; rehaume.courtois@fapaq.gouv.qc.ca

ABSTRACT: Aerial survey data were used to describe moose density changes in relation to habitat composition and structure in clear-cut areas, and to infer the impact of these variables on limiting factors. We hypothesized that moose density would be lower in cut areas due to increased hunting and predation. Four habitat types (food and cover stands, cover stands, cuts, and other habitats) and 7 fragmentation indices were used in our analyses. Aerial surveys conducted in seven 35-112-km^2 blocks showed that moose density was related to the proportion of deciduous and mixed (food and cover) stands within each block and edge between food and cover and resinous stands (cover). Density, productivity, and harvest rate were not significantly influenced by clear-cuts. Our results suggest that habitat models should consider food and food-cover border over other habitat components.

ALCES VOL. 38: 167-176 (2002)

Key words: *Alces alces*, cover, edge, food, habitat management, mortality, productivity

RÉSUMÉ: Des inventaires aériens ont été utilisés pour décrire les changements de densité de l'orignal (*Alces alces*) en fonction de la composition et de la structure des habitats dans des sites comportant des coupes forestières, et pour inférer l'impact de ces variables sur les facteurs limitatifs. Nous avons émis l'hypothèse que la densité serait plus basse dans les aires coupées à cause d'un accroissement de la chasse et de la prédation. Quatre catégories d'habitat (nourriture-abri, abri, coupe, autres habitats) ont été retenues et 7 indices de fragmentation ont été utilisés dans les analyses. Les inventaires aériens réalisés dans 7 blocks de 35 à 112 km^2 ont montré que la densité était reliée à la proportion de peuplements décidus et mélangés (nourriture-abri) à l'intérieur de chaque bloc et à l'effet de bordure entre les peuplements de nourriture-abri et ceux d'abri. La densité, la productivité et le taux d'exploitation ne semblaient pas influencés par la coupe. Nos résultats suggèrent que la nourriture et l'effet de bordure entre la nourriture et l'abri devraient être considérés de façon prioritaire dans les modèles d'habitat.

ALCES VOL. 38: 167-176 (2002)

Mots clés: abri, *Alces alces*, bordure, couvert, gestion de l'habitat, mortalité, nourriture, productivité

Over the long term (15-40 years), forest harvesting has a positive impact on moose by rejuvenating the forest (Crête 1977). However, the introduction of mechanized clear-cutting techniques in the early 1970s has provoked controversy and confrontations with wildlife users and outdoor recreationists. At that time, the only guideline aimed at protecting habitat was the maintenance of forest strips, for the preservation of water quality, along main watercourses. Cutovers were juxtaposed, creating large areas that were unsuitable for moose (Girard and Joyal 1984). Moreover, no particular techniques were used to protect advanced regeneration. Often, cutovers did not regenerate and had to be scarified and planted 5 to 10 years later, diminishing browse and cover quality for a longer period. Previous studies have reported very low moose densities in these habitats (Eason et al. 1981, Girard and Joyal 1984, Eason 1989), a situation also frequently cited and criticized by moose hunters.

In Québec, more restrictive forest harvesting guidelines were implemented in the late 1980s. In order to evaluate short term advantages of these regulation changes, moose densities were estimated by aerial survey over a period of 5 years in 7 study blocks with different types of clear-cuts. Because forest harvesting created new roads and removed cover which could facilitate access to hunters and predators (Eason et al. 1981, Girard and Joyal 1984, Eason 1989, Seip and Cichowski 1996), we hypothesized that moose density would be lower in cutovers due to increased hunting and predation. Consequently, in cut areas, we predicted that moose would experience a higher hunting rate, lower productivity, and lower density due to increased predation on adults and calves, and increased hunting vulnerability. The impact of forest harvesting on other species and on moose hunting has been previously reported (Courtois et al. 1998a, 2001; Dussault et al. 1998; Potvin 1998; Courtois and Beaumont 1999; Potvin et al. 1999; Turcotte et al. 2000).

STUDY AREA

The study was conducted in a 2,183 km^2 area located in north-western Québec. The dominant tree species of the area are black spruce (*Picea mariana*), jack pine (*Pinus banksiana*), paper birch (*Betula papyrifera*), and trembling aspen (*Populus tremuloides*). The terrain is gently rolling with hills rarely exceeding 350 m above sea level. Temperature, as measured at the Belleterre meteorological station, is -16.2°C ± 0.6 (29) in January (mean ± SE [*n* years]) and 17.3°C ± 0.2 (29) in July. Total precipitation is moderate with 1,013 mm ± 23 (24) including 291 mm ± 12 (26) of snow. Maximum snow depth (66 cm ± 7 [17]) occurs in February and did not exceed 90 cm during the study. Wolf (*Canis lupus*) and black bear (*Ursus americanus*) are found in the study area at ~0.01 and ~0.14 individuals / km^2 respectively (Lamontagne et al. 1999, Larivière et al. 2000).

The area was divided into 25 blocks delineated using identifiable landmarks, mostly streams, roads, and forest harvesting plans, so as to contain different proportions of clear-cuts (see Courtois and Beaumont 1999 for a map). Aerial surveys were conducted in 7 of these blocks (Fig. 1). Lakes and streams represented between 8 and 17% of the area depending on the study block, whereas cuts occupied between 4 and 68%. Two main types of cutting methods were employed: large clear cuts without protected regeneration (CT) that were 7-11 years old at the time of the study, and recent cuttings with protected regeneration (CPR) that were mostly made between 1992 and 1994. Characteristics of these two types of cuts have been previously described (Courtois et al. 1998b). At the end of the project, block 5 (112 km^2) was still dominated by undisturbed mature conifer stands (4% cut). Blocks 3 (96 km^2; cut during the summer and fall of 1992), 11 (35 km^2; cut in 1989), 13 and 20 (74 and 59 km^2, respectively; cut in the winters 1992 to 1994) were covered by large recent cuts on 29%, 45%, 46%, and 43% of their areas, respectively, but residual forests were relatively abundant and well dispersed within the blocks. In blocks 16 and 19, dominated by 7- to 11-year-old clear-cuts (68 and 62 km^2; 50% and 69% cut, respectively), remnant forest was small and restricted to the fringe of the blocks.

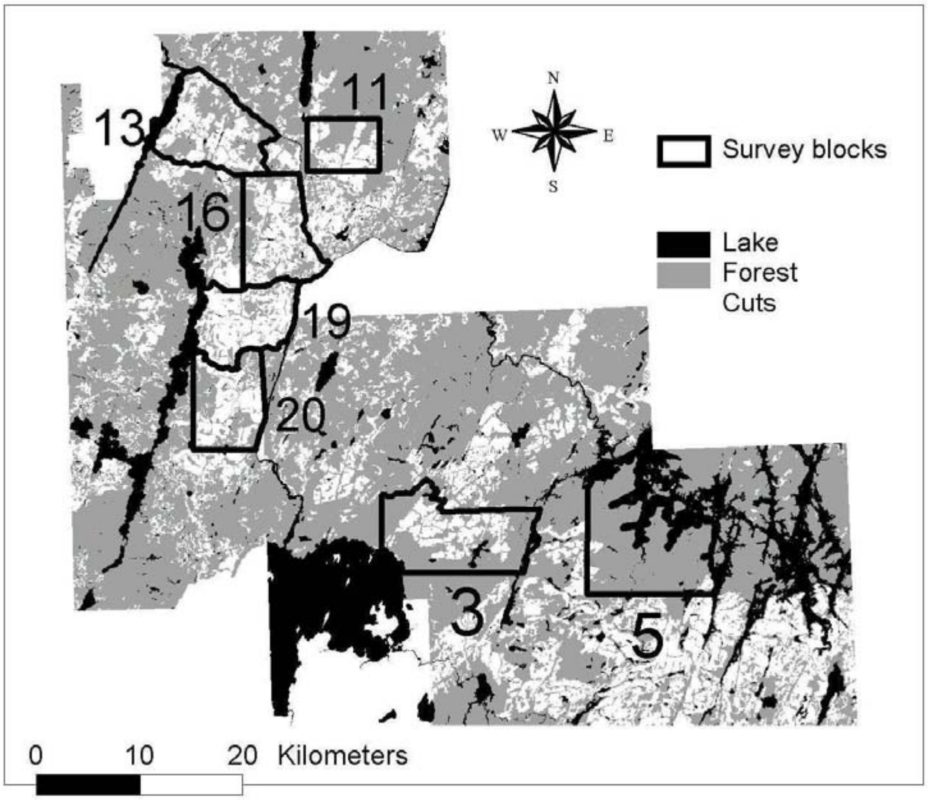

Fig. 1. Location of the study site in north-western Québec (78° 40' W, 47° 50' N). Numbers refer to blocks delineated for aerial surveys.

METHODS

Aerial Surveys

Moose density and population structure (adult males, adult females, and calves) were estimated by aerial surveys 3 to 5 times in each of the 7 blocks between 1991 and 1995 using standard methods (Crête and Goudreault 1980, Courtois 1991). Surveys were conducted between late January and mid-February. Adjacent blocks were surveyed simultaneously to avoid counting the same animals in 2 blocks. As visibility bias likely varied according to habitat type, moose densities were corrected using year- and block-specific visibility rates estimated with marked animals. To remove the influence of hunting on annual density, winter densities were converted to fall densities by adding harvest density recorded at mandatory registration stations during the fall that preceded each survey. Harvest rates (percent) were computed as the fall harvest density × 100 / fall moose density. In spite of the relatively small size of our study blocks, trends are likely to be correctly estimated since each block was surveyed 2-5 times over a 5-year period, and moose are resident and have relatively small home ranges.

Habitat Composition and Structure

Habitat composition was obtained from digitized 1:20,000 forest maps produced by interpretation of 1:15,000 aerial photographs (MER 1984). This information was used to produce a 10 m × 10 m raster map imported into ArcView 3.1 and managed with the Spatial Analyst extension (ESRI 1996). Habitat types were grouped into 4 classes according to food and cover quality for moose (FOOD&COVER: deciduous, mixed, and spruce budworm outbreak stands; COVER:

conifer; CUTS: cut with and without protection of advanced regeneration; OTHER: unproductive stands, usually *Alnus rugosa*, and water). Based on vegetation surveys conducted in the study area (Courtois et al. 1998b, Dussault et al. 1998, Turcotte et al. 2000) and in comparable sites (Dussault 2001), FOOD&COVER stands roughly correspond to those comprising $\geq$ 10,000 deciduous stems / ha with at least 1 twig of browse per tree between 0.5 and 3.0 m with conifer trees occupying < 3.5 m^2 / ha. COVER stands represent those with scarce understory deciduous species (< 2,000 stems / ha) and where the basal area of conifer trees occupy $\geq$10 m^2 / ha. Recently cut sites usually had < 5,000 understory deciduous stems / ha with conifer trees occupying < 0.2 m^2 / ha. Old cuts and those recently done in mixed stands of block 20 supported dense deciduous browse (11,000-18,000 stems / ha) but very few conifer trees (< 0.2 m^2 / ha).

Edge, food, interspersion, and the size and form of cuts are thought to influence moose distribution and are intensively used to define moose habitat guidelines (OMNR 1988, MER 1989, Rempel et al. 1997). The habitat structure was estimated with 7 Fragstats landscape pattern indices (McGarigal and Marks 1995) computed with the ArcView extension Patch Analyst (Elkie et al. 1999). We selected 2 indices to measure edge (the length of the interface) between habitat types (ED: edge density, perimeter of all habitat patches per unit area [m / ha]; CWED: contrast-weighted edge density, edge between FOOD&COVER and COVER stands [m / ha; weights: FOOD&COVER versus COVER = 1; other edges = 0]). One metric was selected to estimate the importance of FOOD&COVER stands (CAD: number of FOOD&COVER stand core areas [inside part beyond 100 m] / 100 ha). Two indices measured the diversity of the landscape (SDI: Shannon's diversity index [McGarigal and Marks 1995], the amount of information per habitat patch [without units]; IJI: interspersion and juxtaposition index, the extent to which patch types are equally adjacent to each other [%]). Two others were selected to quantify the shape and size of cutovers (MSI: mean shape index, average perimeter-to-area ratio of the cuts [without units]; TCAI: total core area index, relative importance of the core areas [buffer: 100 m] within the CUTS [%]).

Data Analysis

The influence of habitat composition and structure on moose density and population structure among blocks and year were assessed using stepwise multiple regression analysis (Proc Stepwise, SAS 1989). Year, habitat composition, and landscape indices were considered independent variables. Each survey was considered independent due to annual habitat changes, the elapsed time (12 months) between two surveys, movements of animals (200-300 m / d), and the impossibility of using repeated measures in Proc Stepwise. To prevent multicollinearity problems, Pearson's correlation analyses were used to identify redundant variables. Only those variables that were not significantly correlated at P = 0.05 were retained in the stepwise regression analyses. Moose density and population structure before and after cutting operations were compared in blocks 3 (coniferous) and 20 (mixed), which were harvested during the study, using t-tests and chi-square analysis, respectively. In 1994 and 1995, the same analyses were used to compare moose density and population structure between the forested part and the cut areas of these blocks.

RESULTS

Effect of Habitat Composition and Structure on Moose Density

Many habitat variables in the survey blocks were correlated (P < 0.01). Among the 4 habitat composition indices, FOOD&COVER vs. COVER (*r* = -0.51), COVER vs. CUTS (*r* = -0.89), COVER vs. OTHER habitats (*r* = 0.77), and CUTS vs. OTHER habitats (*r* = -0.82) were correlated. Similarly, among landscape pattern indices, ED, CWED, and CAD ($r > 0.59$) as well as MSI and IJI ($r = 0.63$) were correlated. CWED was also weakly correlated to TCAI ($r = 0.44$, $P = 0.027$). Consequently, only block, FOOD&COVER, CUTS, CWED, TCAI, and IJI were used in the stepwise regression analysis. Among them, only FOOD&COVER and CWED were retained in the model (fall density = -0.496 + 0.100 FOOD&COVER + 0.066 CWED, $R^2 = 0.89$, $F = 90.63$, $P < 0.001$) and both variables were highly significant ($P \leq 0.007$, $R^2 \geq 0.85$). Simple regression models illustrate the relationship between moose density and CWED, FOOD&COVER, and COVER, and the absence of relationship between moose density and CUTS (Fig. 2).

Effects of Clear-Cuts on Moose Productivity and Mortality

The stepwise multiple regression analysis did not reveal any relationship between habitat composition or landscape indices and the number of calves per 100 females. On average, among blocks and years, harvest rate was 18.9% ± 2.3 before and 23.6% ± 2.2 after cutting ($t = 1.23$, $P = 0.16$). Also, population structure did not differ before and after cutting. During the 5-year study, we observed a total of 35 males and 41 calves / 100 females before cutting and 37 males and 49 calves / 100 females after cutting ($n = 371$ moose; adult sex ratio: $\chi^2 = 0.003$, $P > 0.05$; productivity: $\chi^2 = 0.437$, $P > 0.05$). We found 45 calves / 100 females in the cutovers and 64 calves / 100 females in the remnant forest, this difference being non-significant ($n = 163$; $\chi^2 = 1.160$, $P > 0.05$). Moose density being low relative to habitat carrying capacity (Crête 1989), calves / 100 females were not

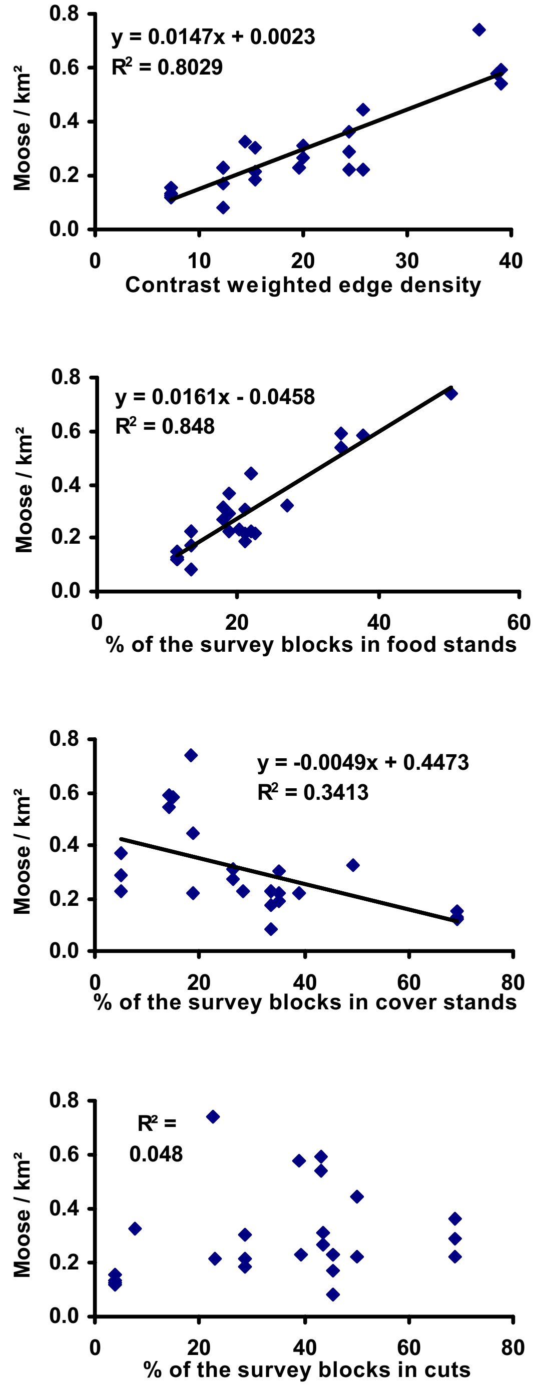

Fig. 2. Influence of habitat structure and habitat composition on moose density by block, estimated by aerial surveys ($n = 26$ surveys), northwestern Québec, January 1991 to January 1995.

correlated to moose density changes (r = -0.21, $P > 0.05$).

DISCUSSION

Influence of Habitat on Population Demography

As observed by Rempel et al. (1997), some cutting patterns may result in hunters having a major influence on moose populations. Due to the creation of new roads and the removal of cover that potentially increase accessibility for hunters and predators, and increase moose visibility (Eason et al. 1981, Girard and Joyal 1984, Eason 1989, Seip and Cichowski 1996), we expected that the parameters of moose demography would be lower in the presence of clear-cuts, but the 2 predictions associated with this hypothesis were rejected. We failed to detect an influence of clear-cuts on moose mortality from hunting and on population productivity. As observed by Courtois and Beaumont (1999), density and harvest rate could be slightly modified by recent clear-cuts but the changes were not important enough to be significant. Moose densities were relatively low in our study site (annual mean: 0.13-0.61 moose / km^2 in fall depending on the survey block), hunters were quite evenly distributed, and hunting pressure (2-11 hunting-days / km^2) and hunting rate (19-24%) were high but not related to the importance of clear-cuts (Courtois and Beaumont 1999). The study site has been hunted for a long time and moose hunters often access their hunting sites by boats and all-terrain vehicles with little consideration of forest roads (Courtois and Beaumont 1999). The impact of clear-cuts on density and harvest rate would probably have been more important in an area experiencing a low hunting pressure before cutting. Moreover, telemetry data suggest that moose preferred the forested part of their home range (Courtois et al. 1998a). This behavioural adaptation may have helped give access to habitats that minimized mortality risks.

Although our work should be seen as a preliminary assessment due to the relatively small size of our study blocks (35-112 km^2), the short-term influence of forest cutting on moose seemed marginal. Variations in moose density were not related to the importance of clear-cuts. After cutting, densities decreased by 23-30% in blocks 3 and 20 but these changes were likely not only related to clear-cuts, since a greater inter-annual variability was observed in block 5 where no cutting was carried out during the study (Courtois and Beaumont 1999). Relatively few moose (2-28) were present in each survey block. Movements of a few animals in and out of a survey block would suffice to explain annual density changes.

Based on aerial surveys, a significant dependence on edge was noted, but this relationship was partly due to the correlation between edge indices and FOOD&COVER. FOOD&COVER and COVER stands were generally small (FOOD&COVER: 11.6 ± 0.3 ha, [n = 7,837]; COVER: 11.6 ± 0.4, [7,685]; CUTS: 46.5 ± 8.0, [1,405]; OTHER: 14.0 ± 4.4, [5,776]), and edge was automatically high in areas supporting an important proportion of FOOD&COVER or COVER stands.

Dalton (1989) reported higher productivity in a site with 30% of its area cut, compared to another where cuts covered 50% of the area. Girard and Joyal (1984) also observed a lower productivity in cutovers. In our study, productivity varied from year to year and among study blocks, but as in Eason (1989), without any relation to the proportion of cuts, for up to 69% of area cut. The productivity we measured was intermediate between estimates made immediately south of the study site (40-41 calves / 100 females) and within the hunting zone where our study was conducted (58-62 calves / 100 females; Paré and Courtois 1990; Paré 1991, 1996). Wolf and black bear were probably responsible for the relatively low calf recruitment (Crête and Jolicoeur 1987) but we did not detect any effects of clear-cuts on that variable.

MANAGEMENT IMPLICATIONS

The juxtaposition of several clear-cuts in order to facilitate logging operations and minimize costs of road construction has produced 15-250-km^2 landscapes dominated by clear-cuts (F. Potvin and R. Courtois, unpublished data). At a scale of about 100 km^2, this has a minor influence on moose, who can continue to use parts of their home range that remain forested. However, moose do not intensively use the cut part of the landscape which leads to the observation of a decline in moose numbers by hunters. Because they hunt in small hunting sites and they try to be isolated from each other, hunters would benefit from forest harvesting guidelines that favour the maintenance of moose in cut areas.

Two alternatives have been suggested to maintain moose in cut landscapes (Courtois et al. 1998b): (1) maintain abundant deciduous browse (> 10,000-15,000 stems / ha) and adequate cover (shrub layer $\geq$ 2-3-m high; lateral obstruction $\geq$ 50% at 15 m); or (2) distribute 50-100 ha cuttings over the landscape while keeping about 50% of the area uncut. However, each wildlife species has its own requirements and each needs specific habitat management guidelines. Dussault et al. (1998) proposed keeping 50% of the basal area of mixed and deciduous stands in order to protect ruffed grouse (*Bonasa umbellus*). For spruce grouse (*Falcipennis canadensis*), Turcotte et al. (2000) suggested two non-contiguous 25-ha cuts per 200-ha block and per 25-30 years. For marten (*Martes americana*), Potvin (1998) proposed cuts of 50-150 ha at 20-30-year intervals in blocks of 10 km^2 while maintaining 50% of the landscape in residual forests > 7 m.

Multi-scale planning which takes several species and several land uses into account, including the needs of the forest industry, native people and outdoor recreationists (Courtois and Beaumont 1999, Hénault et al. 1999, Potvin et al.1999), is essential in order to transform forest harvesting into a sustainable development activity. Potvin et al. (1999) suggested a 3-scale approach. First, at a regional scale ($\geq$ 10,000 km^2), the objective should be the protection of biodiversity through the maintenance of interconnected protected areas (species and rare ecosystems approach). Second, at a forest landscape level (1,000-5,000 km^2), the objective should be the maintenance of a dynamic mosaic of forest stands in terms of composition, age, and spatial configuration (ecosystem management) through adequate planning of forest harvest, appropriate repartition of cuts in time and space, and judicious use of diversified harvest techniques (Bergeron et al. 1999). Finally, a local scale (50-500 km^2) would take into account the specific needs of the general public (integrated forest management). Guidelines previously suggested for grouse, marten, and moose are examples of management at a local scale that would favour not only the needs of the given targeted species but also satisfy the public through the maintenance of wildlife harvesting.

As suggest by Dussault (2001), our results suggest that food and edge between food and cover could be the most important criteria to explain moose density changes between areas. In such a case, these variables should be considered a priority in moose habitat models.

ACKNOWLEDGEMENTS

We would like to thank Michel Crête and François Potvin from Société de la Faune et des Parcs du Québec (FAPAQ), Jean-Pierre Ouellet and Luc Sirois from Université du Québec à Rimouski (UQAR), Christian Dussault from Université Laval, and two anonymous referees for providing helpful comments on earlier versions of this paper. Alain Caron of UQAR assisted in the preparation of habitat maps. We also thank Luc Bélisle, Claude Brassard, Nicole Blanchette, Nancy DeLahaye, André Gaudreau, Jean-Pierre Hamel, Louis Jourdain, Alain Lachapelle, Marcel Paré, and Mario Poirier from FAPAQ for assistance in fieldwork.

REFERENCES

BERGERON, Y, B. HARVEY, A. LEDUC, and S. GAUTHIER. 1999. Stratégie d'aménagement forestier qui s'inspire de la dynamique des perturbations naturelles: considérations à l'échelle du peuplement et de la forêt. Forestry Chronicle 75:55-61.

COURTOIS, R. 1991. Résultats du premier plan quinquennal d'inventaires aériens de l'orignal au Québec, 1987-1991. Ministère du Loisir, de la Chasse et de la Pêche du Québec, Direction de la gestion des espèces et des habitats, Report 1921.

_______, and A. BEAUMONT. 1999. The influence of accessibility on moose hunting in northwestern Québec. Alces 35:41-50.

_______, _______, L. BRETON, and C. DUSSAULT. 1998a. Réaction de l'orignal et des chasseurs d'orignaux face aux coupes forestières. Ministère de l'Environnement et de la Faune du Québec, Service de la faune terrestre, Report 3875.

_______, J.-P. OUELLET, and A. BUGNET. 2001. Moose hunters' perceptions of forest harvesting. Alces 37:19-33.

_______, _______, and B. GAGNÉ. 1998b. Characteristics of cutovers used by moose (*Alces alces*) in early winter. Alces 34:201-211.

CRÊTE, M. 1977. Importance de la coupe forestière sur l'habitat hivernal de l'orignal dans le sud-ouest du Québec. Canadian Journal of Forest Research 7:241-257.

_______. 1989. Approximation of *K* carrying capacity for moose in eastern Québec. Canadian Journal of Zoology 67:373-380.

_______, and F. GOUDREAULT. 1980. Les bois, la tache vulvaire et la couleur du museau pour déterminer le sexe des orignaux (*Alces alces americana*) en janvier dans le sud-ouest du Québec. Proceedings of the North American Moose Conference and Workshop 16:275-288.

_______, and H. JOLICOEUR. 1987. Impact of wolf and black bear removing on cow: calf ratio and moose density in southwestern Québec. Alces 23:61-87.

DALTON, W.J. 1989. Use by moose (*Alces alces*) of clear-cut habitat where 100% or 50% of the production forest was logged. Ontario Ministry of Natural Resources, Report COFDRA 32001.

DUSSAULT, C. 2001. Influence des contraintes environnementales sur la sélection de l'habitat par l'orignal (*Alces alces*). Ph.D. Thesis, Université Laval, Québec, Québec, Canada.

_______, R. COURTOIS, and J. FERRON. 1998. Impact à court terme d'une coupe avec protection de la régénération sur la gélinotte huppée (*Bonasa umbellus*) en forêt boréale. Canadian Journal of Forest Research 28:468-477.

EASON, G. 1989. Moose response to hunting and 1-km^2 block cutting. Alces 25:63-74.

_______, E. THOMAS, R. JERRARD, and K. OSWALD. 1981. Moose hunting closure in a recently logged area. Alces 17:111-125.

ELKIE, P.R., R.S. REMPEL, and A.P. CARR.

1999. Patch analyst user's manual. Ontario Ministry of Natural Resources, Northwest Science and Technology, Publication TM-002.

(ESRI) ENVIRONMENTAL SYSTEMS RESEARCH INSTITUTE, INCORPORATED. 1996. ArcView GIS. The geographic system for everyone. Environmental Systems Research Institute Incorporated, Redlands, California, USA.

GIRARD, F., and R. JOYAL. 1984. L'impact des coupes à blanc mécanisées sur l'orignal dans le nord-ouest du Québec. Alces 20:40-53.

HÉNAULT, M., L. BÉLANGER, A.R. RODGERS, G. REDMOND, K. MORRIS., F. POTVIN, R. COURTOIS, S. MOREL, and M. MONGEON. 1999. Moose and forest ecosystem management: the biggest beast but not the best. Alces 53:213-225.

LAMONTAGNE, G., H. JOLICOEUR, and R. LAFOND. 1999. Plan de gestion de l'ours noir, 1998-2002. Société de la faune et des parcs du Québec, Report 3960.

LARIVIÈRE, S., H. JOLICOEUR, and M. CRÊTE. 2000. Status and conservation of the gray wolf (*Canis lupus*) in wildlife reserves of Québec. Biological Conservation 94:143-151.

MCGARIGAL, K., and B.J. MARKS. 1995. Fragstats. Spatial pattern analysis program for quantifying landscape structure. Oregon State University, Corvalis, Oregon, USA.

(MER) MINISTÈRE DE L'ENERGIE ET DES RESSOURCES. 1984. Normes d'inventaire forestier. Ministère de l'Énergie et des Ressources, Service de l'inventaire forestier, Québec, Québec, Canada.

_______. 1989. Modalités d'intervention en milieu forestier. Ministère de l'Énergie et des Ressources, Québec, Québec, Canada.

(OMNR) ONTARIO MINISTRY OF NATURAL RESOURCES. 1988. Timber management guidelines for the provision of moose habitat. Ontario Ministry of Natural Resources, Toronto, Ontario, Canada.

PARÉ, M. 1991. Inventaire aérien de l'orignal dans la zone de chasse 16 en janvier 1990. Ministère de l'Environnement et de la Faune du Québec, Direction régionale de l'Abitibi-Témiscamingue, Report 1928.

_______. 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, editors. Rapport annuel des inventaires aériens de l'orignal à l'hiver 1994. Ministère de l'Environnement et de la Faune, Report 3291.

_______, and R. COURTOIS. 1990. Inventaire aérien de l'orignal dans la zone de chasse 12 en janvier 1988 et dans la zone de chasse 13 en janvier 1989. Ministère de l'Environnement et de la Faune, Direction régionale de l'Abitibi-Témiscamingue, and Direction de la gestion des espèces et des habitats, Report 1764.

POTVIN, F. 1998. La martre d'Amérique (*Martes americana*) et la coupe à blanc en forêt boréale: une approche télémétrique et géomatique. Ph.D. Thesis, Université Laval, Québec, Québec, Canada.

_______, R. COURTOIS, and L. BÉLANGER. 1999. Short-term response of wildlife to clear-cutting in Québec boreal forest: multiscale effects and management implication. Canadian Journal of Forest Research 29:1120-1127.

REMPEL, R.S., P.C. ELKIE, A.R. RODGERS, and M.J. GLUCK. 1997. Timber-management and natural-disturbance effects on moose habitat: landscape evaluation. Journal of Wildlife Management 61:517-524.

(SAS) SAS INSTITUTE INC. 1989. SAS/STAT user's guide. SAS institute Incorporated, Cary, North Carolina, USA.

SEIP, D.R., and D.B. CICHOWSKI. 1996. Population ecology of caribou in British Columbia. Rangifer Special Issue 9:73-80.

TURCOTTE, F., R. COURTOIS, R. COUTURE, and J. FERRON. 2000. Impact à court terme de l'exploitation forestière sur le tétras du Canada (*Falcipennis canadensis*). Canadian Journal of Forest Research 30:1-9.