CHARACTERISTICS OF CUTOVERS USED BY MOOSE (*Alces alces*) IN EARLY WINTER

Réhaume Courtois[1], Jean-Pierre Ouellet[2], and Benoît Gagné[2]

[1]Ministère de l'Environnement et de la Faune, Direction de la faune et des habitats, Service de la faune terrestre, 150, boul. René-Lévesque Est, Québec (Québec) G1R 4Y1; [2]Université du Québec à Rimouski, Département de Biologie et des Sciences de la Santé, 300 Allée des Ursulines, Rimouski (Québec) G5L 3A1.

ABSTRACT: We determined the characteristics of cutovers used by moose in January-February to identify the minimum conditions required for maintaining an acceptable winter habitat for moose after cutting. We considered three types of cutovers: (1) recent cuts (2-3 years) with protection of the advanced natural regeneration (CPR) carried out in coniferous stands; (2) recent CPRs done in mixed stands; and (3) 7- to 11-year-old clearcuts without protection of the regeneration. Moose were more selective in CPRs carried out in coniferous stands as compared to the two other types of cutting, suggesting that only some parts of this habitat were suitable. There, moose selected sites supporting more abundant deciduous browse and where mean height of regeneration and lateral cover were higher than those found in control sites. To keep moose in clearcut areas, we suggest maintaining in cutovers a minimum browse density of 10,000 to 15,000 stems / ha. The residual cover should be approximately 2.5 m high, and the lateral cover should reach about 50 % at 15 m. These minimum criteria were met in CPRs carried out in mixed stands and in 7- to 11-year-old clearcuts, explaining why moose did not seem to choose any particular site in these cuts. Besides moose, other species living in young forests should benefit from such an improvement.

Key words: advanced regeneration, browse, clearcuts, cover, cutovers, guidelines, winter habitat

RÉSUMÉ: Cette étude visait à déterminer les caractéristiques des sites fréquentés par les orignaux en hiver dans des coupes forestières afin d'identifier les conditions minimales à rencontrer pour préserver un habitat hivernal acceptable après exploitation forestière. Les analyses ont porté sur trois types d'interventions forestières: (1) des coupes récentes (2-3 ans) avec protection de la régénération (CPR) réalisées dans des peuplements résineux, (2) des CPR récentes effectuées dans des peuplements mélangés et (3) des coupes totales de 7 à 11 ans effectuées dans des résineux. Les orignaux étaient plus sélectifs dans les CPR récentes effectuées dans les peuplements résineux que dans les deux autres types de coupes parce que seulement certaines parties de cet habitat étaient propices. Les orignaux choisissaient alors les sites où la régénération était plus dense et de hauteur moyenne plus élevée que dans les témoins. Dans les sites choisis, le couvert latéral était également plus élevé et le brout feuillu y était plus abondant. Pour maintenir l'orignal dans les aires coupées, nous suggérons de conserver une densité minimale de brout en essences feuillues de 10 000 à 15 000 tiges / ha. La régénération résiduelle devrait avoir en moyenne 2,5 m de hauteur et le couvert latéral devrait être d'environ 50 % d'obstruction à 15 m. Ces seuils étaient rencontrés dans les CPR réalisées dans les peuplements mélangés et dans les coupes totales de 7 à 11 ans. Aussi, dans ces deux types de coupes forestières, nous n'avons pas noté de sélection d'habitat par l'orignal. Les normes proposées contribueraient à maintenir l'orignal dans les secteurs d'intervention forestière et, vraisemblablement, toute une série d'espèces fauniques inféodées aux jeunes forêts.

Mots-clés: brout, coupe forestière, couvert, guide, habitat d'hiver, régénération

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Mechanized forestry practices used over the last thirty years are being questioned and challenged by many citizens. Management techniques that modify stand composition, structure and shape, such as monocultural plantations (Spellerberg and Sawyer 1996), herbicidal applications (Connor and McMillan 1990) and particularly clearcutting (Joyal 1987, Thompson and Euler 1987, Hundertmark *et al.* 1990, Potvin and Bélanger 1995) are, for the most part, responsible for this negative attitude on the part of the public.

Such attitude is probably exaggerated because the forest can recover over time and early stages are frequently more diversified and more favourable to certain animal species than old forests. For example, in boreal forests, the greatest densities of moose are found in young stands (15-30 years), stemming from fires, cutting (Spencer and Hakala 1964, Franzmann and Schwartz 1985, Hundertmark *et al.* 1990, Loranger *et al.* 1991, Crête *et al.* 1995), insect epidemics and windfalls (Germain *et al.* 1990). Consequently, forest cutting which replaced fire as the principal rejuvenating agent of the forest in recent decades, is now deemed indispensable for the management of moose habitat, by increasing available food (Telfer 1978, Girard and Joyal 1984, Crête 1988). However, the positive impact of forest cutting is normally only medium-term, as moose seldom frequent recently cut areas (Brusnyk and Gilbert 1983, Courtois and Potvin 1994), probably because the cover is lacking or food availability is reduced. Moreover, the removal of vegetation cover and an increased accessibility likely render moose more vulnerable to hunting and predation (Girard and Joyal 1984, Crête 1988, Timmermann and McNicol 1988, Colin and Walsh 1991).

Nevertheless, recently cut areas are not entirely deserted by moose, particularly in early winter when snow depth and hardness do not impede movements. Such conditions generally exist between December and mid-February in most areas in eastern North America. Track networks and signs of presence observed during aerial (Connor and McMillan 1990, Germain *et al.* 1990, Courtois and Potvin 1994) or terrestrial (Santillo 1994) surveys indicate that certain cutovers are used. Previous studies (Proulx and Joyal 1981, Girard and Joyal 1984, Courtois *et al.* 1996) have shown that in early winter, moose look for a mosaic of coniferous and deciduous stands, offering both food and cover. Hence, we hypothesised that sites used in winter by moose in cut areas are characterized by more abundant browse and denser forest cover as compared to control sites. Characteristics of sites used in recently cut areas will give a reasonable approximation of the minimum conditions that should be maintained after cutting to favor their utilization by moose.

STUDY SITES

The study was conducted in five 60-100-km^2 study blocks of northwestern Québec, located 20 to 75 km southeast of Rouyn-Noranda. The study area is situated in the fir-white birch ecozone of the boreal forest (zone 3 of Brassard *et al.* 1974). Prior to cutting, coniferous stands dominated four blocks. They occupied between 34 and 46 % of the area, whereas mixed and deciduous stands covered approximately 30 and 10 % of these blocks, respectively. The fifth block was dominated by mixed (52 %) and deciduous (13 %) stands, whereas coniferous stands represented 7 % of the block area. The dominant coniferous trees found in the five study blocks were black spruce (*Picea mariana*) and jack pine (*Pinus divaricata*), whereas the dominant deciduous trees were paper birch (*Betula papyrifera*) and trembling aspen (*Populus tremuloïdes*) (Courtois and Potvin 1994). After forestry intervention, cutovers (≤11-

year-old) occupied 29 to 68 % of the surface area of each study block.

Because of changes in forestry practices during the last decade, three types of cutovers were present in the study blocks: (1) recent cuts (2-3 years) with protection of advanced natural regeneration (CPRs) carried out in coniferous stands; (2) recent CPRs done in mixed stands; and (3) 7- to 11-year-old clearcuts carried out in coniferous stands without protection of advanced regeneration. In these three types of cuts, all commercial (diameter at breast height (DBH) ≥9 cm) coniferous and trembling aspen trees were removed. Residual trees, usually white birch, were sparse. Red maple (*Acer rubrum*) was also found after cutting in mixed stands. In CPRs, about 50% of the advanced natural regeneration and shrubs were maintained after cutting. The general appearance of CPRs carried out in coniferous stands was a series of stripes comprising young coniferous and deciduous trees 1-1.5 m high and shrubs alternating with paths, spaced about 20 m, and denuded of live vegetation due to the intensive use by forestry machinery. The general aspect of the CPRs done in mixed stands was similar to the previous one except that the protected regeneration was denser and higher (1.5-2.5 m high). The 7- to 11-year-old clearcuts contained no mature trees but were generally uniformly regenerated with diverse species of young trees 2-3 m high.

METHODS

The five blocks were covered by aerial survey in February 1994 with the help of transects spaced 500 m apart, permitting the delineation of all moose track networks located in the cutovers. The track networks were numbered, and five were randomly selected for habitat survey within each of the three categories of cutovers. In addition, we surveyed habitat in five control sites (i.e., cut areas where no tracks were recorded during the aerial survey) in each cut category.

We sampled vegetation within the 15 track networks and the 15 control sites along two transects 75 m apart in control sites and 50 m apart in track networks; 50 m was used in track networks because they were sometimes quite narrow. Fifteen sampling plots (2 m x 50 m) were systematically distributed along the transects. We estimated browse availability (i.e., stems containing at least one twig ≥5 cm long between 50 cm and 3 m in height) by species in a 1 x 10 m sub-plot, located at the beginning of the main plot.

We used five indices to quantify the cover. (1) We evaluated the lateral cover of the lower vegetation using a 2-m high vegetation profile board upon which white and red bands alternate at 50 cm intervals (Nudds 1977). The board was placed at the beginning and at a distance of 15 m from the beginning of the plot, while an observer standing at 15 m estimated the proportion, by class of 20 %, of each 50-cm band hidden by the foliage. The mean of the eight measurements was kept as the lateral cover indices. (2) We estimated the basal area of trees ≥9 cm at the beginning of each plot with the help of a factor 2 prism (Grosenbaugh 1952). (3) We counted the number of saplings (deciduous and coniferous trees <9 cm DBH and shrubs ≥2 m in height) by species in each plot. (4) The mean height (m) of regeneration was visually estimated in a 20-m radius around the beginning of the plot; this estimate excluded the few large trees ≥10 m left untouched during the cutting because they provide no protection. (5) Using 1:20,000 forestry maps, we determined *a posteriori*, the shortest distance between the sample plot and the forest margin. Finally, we counted the pellet groups in each plot (2 x 50 m) to obtain an index of site utilization by moose.

We used the analysis of variance, followed by *a posteriori* tests (procedure GLM of SAS statistical software, SAS Institute Inc. 1985) to identify habitat differences (1) among the three categories of cutovers, and (2) between the track networks and the control sites within each category of cutovers. The general linear model included the category of cutovers, the presence of moose (track networks, control site), the interaction between these variables and the site nested in the interaction as independant variables. The between-sites mean square was used as the error term of the model. Data were transformed to their natural logarithms (ln x+1) when the residues of the model were not normally distributed or if their variance was not homegenous. The null hypothesis rejection level was set to 0.05. Mann-Whitney tests were used to compare browse density per species between track networks and control sites. Finally, Spearman's rank correlations were used to verify the potential relations between the moose abundance index and the studied parameters (Scherrer 1984). These analyses were carried out separately for each category of cutovers by using all of the study sites.

RESULTS

The comparison of the three categories of cutovers indicated major differences, particularly between the CPRs carried out in the coniferous stands and the other two types of cuts (Table 1). Deciduous sapling density, mean height of regeneration, lateral cover and deciduous browse density were lower in the CPRs carried out in coniferous stands than in those done in mixed stands or in 7- to 11-year-old clearcuts. Furthermore, there were no significant differences for any of the variables considered between CPRs carried out in mixed stands and 7- to 11-year-old clearcuts.

In the CPRs carried out in coniferous stands, the characteristics of sites where track networks were found differed from those of the control sites for five of the 11 variables studied. Based on pellet group density, moose abundance was approximately 12 times greater in track networks than in control sites. The density of deciduous saplings was greater in the track networks. An analysis per species showed that these differences could be explained by a higher density of paper birch and speckled alder (*Alnus rugosa*) in track networks than in control sites ($P < 0.001$). Moreover, track networks had both a higher mean regeneration height and a higher lateral cover than did the control sites. Finally we found a higher deciduous browse density in the track networks, beaked hazel (*Corylus cornuta*) and trembling aspen being more abundant in track networks ($P \leq 0.001$).

In the case of CPRs carried out in mixed stands, the number of pellet groups did not differ between track networks and control sites. Moreover, no significant difference was observed between the characteristics of track networks and the control sites.

We did not detect any difference for the variables considered between track networks and control sites in the 7- to 11-year-old clearcuts. However, a detailed analysis of browse per species revealed that beaked hazel was more abundant in track networks than in control sites (7,000 vs. 1,300 stems / ha; $P = 0.002$). Moreover, with respect to saplings, alder density was greater in track networks than in control sites (3,000 vs. 1,200 stems / ha; $P = 0.001$).

In CPRs carried out in coniferous stands, the number of pellet groups was significantly correlated ($P < 0.05$) to four of the 10 variables studied: sapling density, lateral cover, average height of regeneration, and available browse density (Fig. 1). However, in the CPRs carried out in mixed stands and in 7- to 11-year-old clearcuts,

Table 1. Mean (± standard error) of variables surveyed in control sites and sites used by moose in cutovers carried out in northwestern Québec.

Variables	CPR - Coniferous (R)			CPR - Mixed (M)		7- to 11-year-old clearcuts (Ct)		Differences among cut categories*
	Control		Moose tracks	Control	Moose tracks	Control	Moose tracks	
Pellet groups / ha	9 ± 5	*	101 ± 26	11 ± 5	21 ± 7	24 ± 8	33 ± 10	-
Sapling stems / ha								
Coniferous	368 ± 66		893 ± 112	1 644 ± 328	1,564 ± 311	1,802 ± 304	1,756 ± 210	-
Deciduous	297 ± 108	*	2,757 ± 381	1 825 ± 208	2,161 ± 265	4,032 ± 600	5,609 ± 655	R < M = Ct
Distance from forest (m)	202 ± 11		168 ± 7	250 ± 22	150 ± 10	152 ± 8	282 ± 20	-
Height of regeneration	1.3 ± 0.1	*	2.5 ± 0.2	2.0 ± 0.1	2.3 ± 0.1	2.1 ± 0.1	2.5 ± 0.1	R < M = Ct
Lateral cover (%)	29 ± 2	*	48 ± 3	49 ± 3	57 ± 3	53 ± 3	65 ± 2	R < M = Ct
Spruce shrubs / ha	213 ± 99		0 ± 0	13 ± 13	173 ± 116	93 ± 34	573 ± 195	-
Stems of browse / ha								
Coniferous	2,440 ± 518		3,440 ± 653	5,253 ± 1,028	5,520 ± 1,277	6,960 ± 1,642	6,840 ± 1,242	-
Deciduous	4,160 ± 970	*	10,853 ± 2,412	17,693 ± 2,791	15,080 ± 2,331	10,893 ± 1304	16,373 ± 2,408	R < M = Ct
Basal area (m^2 / ha)								
Coniferous	0.1 ± 0.1		0.3 ± 0.1	0.2 ± 0.1	0.1 ± 0.1	0.1 ± 0.1	0.3 ± 0.1	-
Deciduous	1.0 ± 0.2		1.4 ± 0.4	2.0 ± 0.3	2.2 ± 0.4	1.4 ± 0.3	2.3 ± 0.3	-

* $P < 0.05$

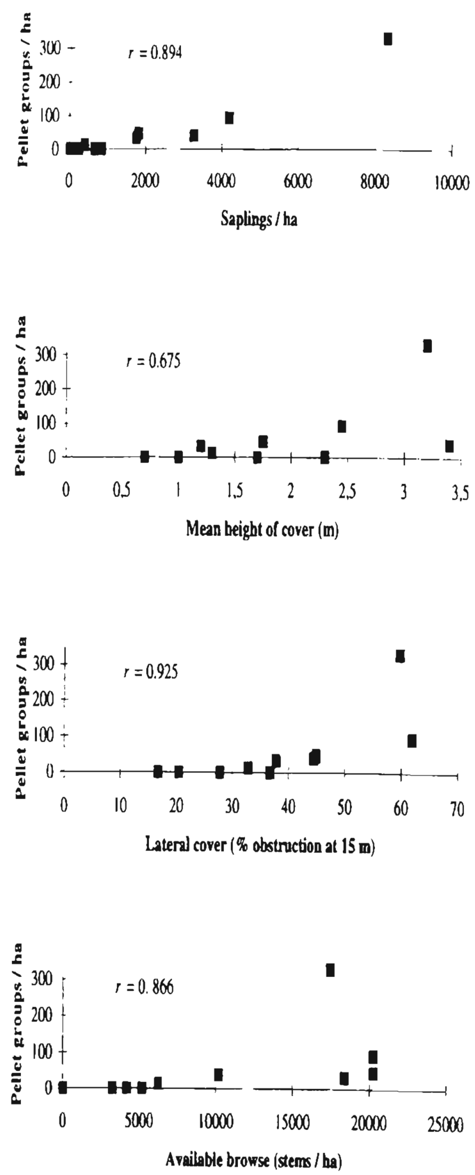

Fig. 1. Relation between moose abundance index and cover and browse index in 2- to 3-year-old CPRs carried out in coniferous stands of northwestern Québec.

the number of pellet groups was not significantly correlated to any habitat characteristics considered.

DISCUSSION

Our initial hypothesis stipulated that moose track networks located in recent cutovers would be situated in sites containing more abundant browse and higher cover quality than in control sites. This has only been confirmed for the CPRs carried out in coniferous stands. In the 7- to 11-year-old clearcuts, the characteristics of the sites used during the February 1994 aerial survey did not differ from those of control sites. This finding was predictable because these clearcuts are characterized by a high vegetation cover and browse density. The time period between the cuts and the present study was sufficiently long to permit a substantial regeneration of the forest. Total sapling density (deciduous and coniferous) now reaches 6,000-7,000 stems / ha whereas the deciduous browse is very high, with 11,000-16,000 stems / ha. This corresponds to values generally found in good wintering habitats (8,000-30,000 stems of browse / ha with a mean of ≥15,000 stems / ha; Vallée *et al.* 1976, Crête 1977, Joyal and Bourque 1986, Joyal 1987). Vallée *et al.* (1976) have shown that 5- to 10-year-old clearcuts offered maximum browse density in central Québec. Recent CPRs carried out in mixed stands offer similar characteristics to those found in 7- to 11-year-old clearcuts. Consequently, it is not surprising that no particular habitat selection by moose was observed in recent CPRs done in mixed stands as in 7- to 11-year-old clearcuts; these cutovers represent acceptable habitat for moose in early winter (usually between December and mid-February in our study area).

The impact of forest cutting is more pronounced in the CPRs carried out in coniferous stands. These sites support less deciduous browse, a lower density of deciduous saplings, a lower mean height of regeneration and a lower lateral cover than do the other two categories of clearcuts. The difference between recent CPRs realized in coniferous and in mixed stands is largely due to characteristics of the vegetation prior to cutting, particularly for browse availability which is less abundant in commercially exploitable mature coniferous stands. In these last CPRs, moose selected sites with a better cover, a higher regeneration, and a more abundant deciduous browse than in the control sites. The two main species that were more abundant than expected are beaked hazel which represents more than 40 % of the available stems, and trembling aspen, which constitutes 22 %. These two species are frequently cited as important components of moose winter diet (Joyal 1976, Vallée *et al.* 1976, Joyal and Bourque 1986, Joyal 1987, Timmerman and McNicol 1988, Crête 1989, Jackson *et al.* 1991, Schwartz 1992).

Our results in 7- to 11-year-old clearcuts could suggest that clearcuts without protection of the advanced regeneration (CWP) are more attractive to moose than are the CPRs done in coniferous stands. Forestry practices changed in Québec at the end of the eighties and no recent CWP were available in our study site. The use of 7- to 11-year-old clearcuts was the best compromise to include in our study this previously widespread and criticized logging practice. However the 7- to 11-year-old clearcuts supported a regeneration sufficiently well developed to attract moose, but published information suggest that moose avoided recent clearcuts without protection of the regeneration (Girard and Joyal 1984).

Brassard *et al.* (1974) indicated that a good moose habitat must offer a basal area of coniferous trees from 11 to 16 m^2 / ha. Thompson and Vukelich (1981) estimated that the best habitats are found in 18-year-old stands, offering a basal area of 9.5 m^2 / ha. Such high basal areas are only encountered in well-established forests. However, our data showed that in early winter moose can use sites characterized by a low density of trees, having frequented sites where the tree stratum occupied from 1.7 to 2.6 m^2 / ha. However, we can speculate that the vertical cover offered by trees in the CPRs may not be sufficient for moose in late winter (usually between March and mid-April in our area) especially during the years of deep (>90 cm; Jackson *et al.* 1991) and/or hard (crust) snow conditions. The CPRs will probably be used only in early winter, when moose search for browse more than for protective cover. In late winter, moose usually use mature stands, where the coniferous cover occupies a minimum of 9.5 to 11.0 m^2 / ha (Brassard *et al.* 1974, Thompson and Vukelich 1981, Brusnyk and Gilbert 1983). According to Thompson and Euler (1987), sites with adequate late winter cover may be distant from sites used in early winter as moose may travel up to 20 km to find suitable late winter habitat. Nevertheless, in late winter, moose are sedentary (Courtois and Crête 1988) and would not wander off more than a hundred metres from the cover to feed (Thompson and Euler 1987, Connor and McMillan 1990). Consequently, areas without late winter sites could be abandoned by moose in late winter.

Habitat Management Guidelines

Based on the results of this study there are components of stands which must be retained during timber harvesting to provide immediate suitable habitat for moose. The key characteristic appears to be browse availability which must reach between 10,000 and 15,000 deciduous stems / ha. Furthermore, the height of the cover must reach about 2.5 m, and the lateral cover must attain approximately 50 % obstruction at 15 m. It is necessary to protect the shrub stratum and/or the parts of stands that are rich in deciduous browse species to maximize the chances of meeting these criteria during the cutting process in coniferous stands.

Cutovers meeting these criteria are frequented by moose in early winter, that is until the snow layer reaches between 65

(Brusnyk and Gilbert 1983) and 90 cm (Thompson and Euler 1987, Jackson *et al.* 1991). To remain in the cut areas in late winter, moose must also have access to mature coniferous stands (Brusnyk and Gilbert 1983, Thompson and Euler 1987). Because moose are very sedentary in late winter (Thompson and Euler 1987, Courtois and Crête 1988), small stands of >3-5 ha offering a good protective coniferous cover (9.5-11 m^2 / ha; DBH $\geq$ 9 cm) could be sufficient. As moose density is low in Québec (< 2-3 / 10 km^2), we suggest that two to three 3-5 ha mature coniferous stands / 10 km^2 (shelter patches) would be sufficient to satisfy their late winter needs. These stands should be adjacent to stands offering abundant browse, given that moose movements are limited at that time of the year. Maintaining adequate early and late winter habitats would probably allow moose to use cut areas all year long.

The above guidelines point out the need to keep a minimum habitat quality inside the cutovers themselves to maintain moose in harvested areas. These guidelines are additive to other measures such as the maintenance of buffer strips between cuts and along streams, such reserves occupying around 10 % of an intervention area. Except for mixed stands containing shade tolerant deciduous species, our guidelines are more restrictive than those proposed by other authors which focused only on the minimum forested area to keep after cutting. For Central Québec, Crête (1977) suggested harvesting 40 % of the tolerant deciduous trees and 75 % of the coniferous trees in mixed stands containing tolerant deciduous trees. In mixed stands containing intolerant deciduous trees, he proposed protecting 4 % of the intervention area in stands of 2 to 3 ha, whereas no particular guideline was provided for coniferous stands. North of the 48th parallel, Joyal (1987) suggested conserving 20 mixed stands of 3 to 5 ha / 10 km^2, representing approximately 6 to 10 % of the intervention area. The objective of the guidelines of Crête (1977) and Joyal (1987) was to provide good moose habitat over the medium term (10-15 years) when the cutover itself will be fully regenerated.

Other research carried out on our study sites demonstrated that marten (*Martes americana*; Potvin and Breton 1997), hare (*Lepus americanus*; Ferron *et al.* 1994), and spruce grouse (*Dendrapagus canadensis*; Turcotte *et al.* 1994) avoided or deserted sites that did not meet the minimum habitat quality identified for moose. However, ruffed grouse (*Bonasa umbellus*) density was maintained in stands where less than 50 % of the basal area of the trees was removed (Dussault *et al.* 1998). Similarly Welsh *et al.* (1980) and Eason (1989) observed that the greatest moose densities were found in cutting areas where less than 40 to 50 % of the area was exploited. In the northern boreal forest of Québec Crête *et al.* (1995) showed that biological diversity of passerines and mammals was at a maximum when the shrubs and the young stands were 5-10 m high, had a basal area of 0.8-3.0 m^2 / ha, and where browse reached 730-1,000 stems / ha. Except for deciduous browse, these values are similar to those observed in our sites used by moose.

To maintain moose in harvested areas we suggest maintaining attractive habitats within the cutovers by keeping sufficient browse and lateral cover. An alternative solution would be to limit the cutover size to about 50 to 100 ha and distribute them over the landscape so as to maintain uncut about 50 % of any intervention area and consequently creating a mosaic landscape. The second alternative is probably the more practical one since the first alternative can only be met in sites where the natural regeneration is dense before forest harvesting. These two types of guidelines would help maintain a minimum habitat quality for moose in cut areas and, probably, for many other animals dwelling in young forests.

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