Characteristics of moose (*Alces alces*) winter yards on different exposures and slopes in southern Quebec

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Forty-two moose (*Alces alces*) wintering yards were located in February 1970 in southern Quebec. The yards were established without preference for a particular exposure, and no significant difference ($p > 0.05$) in mean areas existed between yards with southern and northern exposures. However, yards with greater slopes tended to be smaller. The average winter yard slope (12.9 ± 8.8%) was significantly ($p < 0.05$) smaller than that of control blocks (18.2 ± 9.6%). Fifty percent of the yards were located on slopes ≤10%. The number of winter yards with gentle (0–≤10%), intermediate (>10–≤20%) and steep (>20%) slopes was significantly ($p < 0.005$) different from that of control blocks. Independent of exposure and slope classes, moose winter yards were mosaics of mature and young coniferous, deciduous, and mixed stands.

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Quarante-deux ravages d'orignaux (*Alces alces*) ont été localisés en février 1970 dans le Sud du Québec. Les ravages sont établis indépendamment de l'exposition et les surfaces moyennes des ravages d'exposition Nord ne sont pas significativement (p >0,05) différentes de celles des ravages d'exposition sud. Cependant, les ravages à pentes abruptes sont plus petits en superficie. La pente moyenne d'un ravage (12,9 ± 8,8%) est significativement ($p < 0,05$) plus petite que celle de zones témoins (18,2 ± 9,6%). Cinquante pourcent des ravages sont situés sur des pentes ≤10%. Le nombre de ravages à pentes douces (0–≤10%), intermédiaires (>10–≤20%) et raides (>20%) est significativement ($p < 0,005$) différent de celui des zones témoins. Indépendamment de l'exposition ou des pentes, les ravages d'orignaux correspondent à des mosaïques de peuplements résineux, feuillus et mélangés, mûrs et jeunes.

Introduction

Moose (*Alces alces*) are important economically and recreationally. In Quebec, the sale of 98 438 hunting licences in 1978 gave rise to direct and indirect economic impacts totalling 34 million dollars (Lacasse and Pelletier 1979). Also, the mystique of the moose makes it one of the most challenging and rewarding subjects for naturalists and photographers (Fraser 1978). However, the moose resource depends on the presence of year-round habitats, the adequacy of which is especially tested during the winter months when snow restricts the movements of the animals (Proulx 1978).

Prescott (1968) reported that south-facing slopes are favoured winter habitats. Telfer (1978*a*) pointed out that ideal moose ranges were shrublands interspersed with patches of coniferous forest. Proulx and Joyal (1981) concluded that both physiographic and floristic characteristics of a site were important constituents of moose winter yards and suggested that mosaics of mature and immature stands, situated on slopes of less than 10%, without regard to any particular exposure, be protected from logging.

The use of any directional exposure by moose in winter is a controversial subject (Prescott 1968; Telfer 1968; Proulx and Joyal 1981) and a gap in knowledge about the importance of the protection layer of each exposure still exists. According to Crête (1977), the presence of moose on gentle slopes is due to a greater abundance of conifers. On the other hand, Proulx and Joyal (1981) stated that the advantage of gentle slopes was in reduced energy expenditures. Also, previous researchers do not agree because of a lack of information on the forest cover of those sites. Therefore, the aim of this study was to determine if moose establish their winter yards with respect to the floristic composition of an area only or also according to the physiographic characteristics of this area.

Study area

The study was carried out near La Tuque, approximately 200 km northeast of Montreal (Fig. 1). The relief is undulating with latitudes ranging from 300 to 500 m. This area is at the junction of the Boreal and the Great Lakes – St. Lawrence Regions (Rowe 1972) and belongs to forest zone 3 of Brassard *et al.* (1974). This zone is considered to be the best zone for moose in Quebec (2.6 animals/10 km^2; Brassard *et al.* 1974). The climax of forest zone 3 is defined as a white birch (*Betula papyrifera*) – balsam fir (*Abies balsamea*) – white spruce (*Picea glauca*) association (Lafond and Ladouceur 1968; Brassard *et al.* 1974).

Methods

In 1970, 42 winter yards were delineated by helicopter by the staff of the Ministère du Loisir, de la Chasse et de la Pêche

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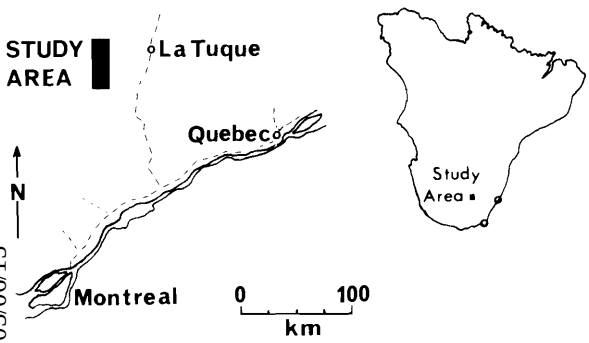

FIG. 1. Location of the study area in southern Quebec.

du Québec. The inventory was done according to the method described by the Quebec Inventory Committee of the Ministère du Loisir, de la Chasse et de la Pêche du Québec (1973); i.e., the outline of the area covered by the network of moose tracks was traced with the help of topographic characteristics. The inventory was done between 19 and 22 February when the average snow depth was 76 cm. The study of the yards was done on forestry maps (1976) at a scale of 1 : 20 000. Those maps provided a detailed description of forest stands and were usable for the present study because the floristic composition of the area did not change markedly from 1970 to 1976, even if a few forest cuts might have occurred (R. Bilodeau, personal communication, 1982). The exposures of winter yards were based upon four orientation classes (NW, NE, SW, and SE). When more than half of a winter yard had a particular exposure, this exposure was recorded. In some cases, it was possible to recognize two orientation classes for the same winter yard. The slopes were calculated in percentage using Proulx and Joyal's (1981) method. The formula used was $S = (M - m)/H$, where M and m are the maximum and minimum altitudes of the winter yard, respectively, and H is the length of the horizontal line drawn perpendicularly between M and m. To know whether moose utilized the range randomly, the 42 winter yards were compared with 42 control blocks chosen randomly on a grid. The control blocks were situated outside the winter yards and were squares 380 m to a side.

The study of the protection layer in diverse exposure and slope classes was done according to the classification of the Ministère des Terres et Forêts du Québec (1975) on forestry maps with a scale of 1 : 20 000. Sixteen variables were used to describe the vegetation within the following categories: cover type, stand density, height indices, stand structure, and growth stages. A Bruning aerograph (No. 4850) was used to determine, by the dot-count method, the surfaces covered by the forest-stand characteristics within a winter yard, with a percentage error equal to 5% (Proulx and Joyal 1981). The protection layer of a winter yard was calculated for several exposure and slope classes. Only conifers were considered to provide cover in winter (Proulx and Joyal 1981). In mixed stands dominated by deciduous species, conifers can cover between 25 and 50% of the basal area. In mixed stands dominated by coniferous species, conifers can cover between 50 and 75% of the basal area (Ministère des Terres et Forêts du Québec 1975). Considering this, the minimum and maximum relative areas of a winter yard possibly covered by conifers were estimated.

Results

Physical characteristics of moose winter yards

Twenty-four (44%) of the 55 exposures recorded in the 42 winter yards were located on north-facing slopes and there were as many yards with a NE slope as there were with a SW one. The frequencies of the control blocks relative to any exposure were also similar (Fig. 2). A chi-square test showed that the frequency distribution for the winter yard exposures ($\chi^2 = 2.244$) was like the one obtained for the control blocks ($\chi^2 = 1.163$), i.e., a theoretical distribution for each aspect ($p > 0.05$). South-facing slopes were not significantly more frequent in the winter yards; moose appeared to establish their yards without regard to exposure. Also, the mean area covered by winter yards of different exposures ranged from 0.08 to 0.11 km^2 (Table 1). No significant difference ($p > 0.05$) in mean area existed between yards with northern and southern exposures.

The average slope of moose winter yards was 12.9% (±8.8) and was significantly smaller than that of control blocks (18.2±9.6%; $t = 2.638$, $p < 0.05$). Twenty-one or 50% of the 42 slopes determined in the winter yards had an incline of ≤10% (Fig. 3). The number of winter yards with gentle (0–≤10%), intermediate (>10–≤20%), and steep (>20%) slopes was significantly different from that of control blocks ($\chi^2 = 33.678$, $p < 0.005$). The mean area of the 21 winter yards (0.15 ± 0.12 km^2) located on gentle slopes was significantly larger than the mean area of the 7 yards (0.07 ± 0.02 km^2) found on steep slopes ($t' = 2.854$, p

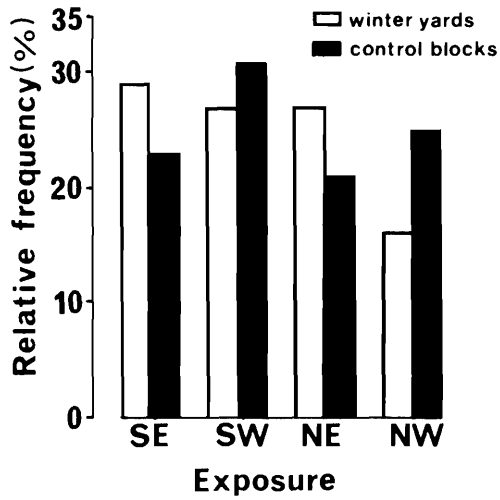

FIG. 2. Relative frequencies of the exposures in 42 winter yards ($N = 55$) and 42 control blocks ($N = 48$) in February 1970 in southern Quebec.

TABLE 1. Relative importance of forest types in the average winter yard of each orientation class in February 1970 in southern Quebec

	Average winter yards slope exposure				Typical winter yard of forest zone 3 (Proulx and Joyal 1981)
	SE	SW	NE	NW	
Area (km^2)					
$\bar{x}$	0.09	0.11	0.08	0.08	
SD	0.08	0.13	0.05	0.06	
Relative area (%)					
Coniferous forest	32.1	27.3	24.0	9.0	18.0
Deciduous forest	21.8	12.7	10.0	14.1	20.0
Mixed forest dominated by:					
conifers	9.5	16.3	21.0	24.2	51.0
deciduous types	27.8	26.4	32.0	39.1	
Nonwoody areas	1.7	2.3	4.0	3.0	4.4
Regeneration	7.1	15.0	9.0	10.6	6.6
Total	100.0	100.0	100.0	100.0	100.0

< 0.05). However, the mean area of the 14 winter yards (0.10 ± 0.09 km^2) with intermediate slopes was not significantly ($p > 0.05$) different than that of yards found on gentle or steep slopes.

Vegetation of winter yards on different exposures

Independent of exposure, mixed stands dominated the average floristic composition of the yards and covered >30% of their areas (Table 1). In south-facing yards, most of the cover was provided by continuous coniferous stands. In north-facing yards, however, conifers were more interspersed with deciduous species. The minimum proportion of conifers in the SE, SW, NE, and NW average floristic compositions was 44, 42, 42, and 31%, respectively. In the same order, the maximum was 53, 53, 56, and 47%. Although the NW exposure provided moose with slightly less cover, the NE-facing yards provided a protection layer as dense as the south yards. Regeneration areas covered between 7 and 15% of the average floristic compositions and the SW yards had the highest proportion (15%) in regeneration (Table 1). Nonwoody areas were unimportant in all yard types.

Vegetation of winter yards of different slopes

Continuous coniferous stands represented the most important forest type of the average composition of winter yards located on gentle slopes. They covered 36.7% of the area. Mixed stands dominated by conifers were poorly represented. Nearly 12% of the mean area was in regeneration (Table 2). Based on the height and density indices from the Ministère des Terres et Forêts du Québec (1975), most of the area of the average winter yard had forest stands with a canopy ranging from 41 to 80% and a height between 9 and 21 m (Table 2). Nearly 15% of the area was covered by mature multilayered stands. The forest types of the winter yards found on gentle slopes provided moose with a dense canopy and with trees and branches at different heights. The stands were mostly young but were also interspersed with mature, multilayered vegetation stands.

Continuous coniferous stands covered only 11.9% of the mean area of yards with intermediate slopes. Mixed stands were predominant (55.5%) in the average composition and those dominated by conifers covered 26.7% of the area (Table 2). Nearly 20% of the area was in regeneration. Most of the area consisted of forest stands with a canopy ranging from 41 to 80% and a height between 9 and 21 m (Table 2). Winter yards corresponded to a mixture of young and multilayered mature stands.

The average composition of winter yards located on steep slopes was rich in mixed stands which represented 63.2% of the total area (Table 2). Nearly one-fourth of the area was covered by deciduous stands, while coniferous stands represented only 11.4% of the area. Regeneration areas were unimportant on steep slopes (Table 2). Forest stands with a canopy ranging from 41 to 80% and a height between 9 and 21 m dominated the average winter yard. Young forest stands were dominant in the yard (Table 2).

According to the relative importance of the forest types in the yards, the continuous coniferous stands were three times more important in the yards located on gentle slopes than in the other winter yard types (Table 2). However, mixed stands dominated by conifers were six times more important in the yards situated on intermediate and steep slopes than they were in yards located on gentle slopes (Table 2). The minimum crown cover provided by conifers of the pure and mixed stands in the winter yards located on gentle, intermediate, and

TABLE 2. Areas and percent relative areas of forest types and structure and age-classes of forest stands in the average winter yard of gentle, intermediate, and steep slopes in February 1970 in southern Quebec

	Gentle slopes	Intermediate slopes	Steep slopes
Area (km^2)			
$\bar{x}$	0.15	0.10	0.07
SD	0.12	0.09	0.02
Relative area (%)			
Coniferous forest	36.7	11.9	11.4
Deciduous forest	14.2	11.1	23.7
Mixed forest dominated by:			
conifers	4.3	26.7	29.0
deciduous types	30.0	28.8	34.2
Nonwoody areas	3.3	2.8	0.0
Regeneration	11.5	18.7	1.7
Total	100.0	100.0	100.0
Canopy closure (%)			
>81	8.7	2.6	0.0
61–80	44.5	53.2	56.0
41–60	21.5	18.9	18.7
25–40	10.5	3.8	23.6
Tree height (m)			
>21	6.7	2.7	13.0
15–21	19.4	12.7	23.9
9–15	56.0	53.6	61.4
9	3.1	9.5	0.0
Growth stage			
Mature multilayered	14.2	14.6	33.3
Young	71.0	63.9	65.0

steep slopes was 46, 32, and 34%, respectively. In the same order, the maximum was 55, 46, and 50%, respectively. Winter yards located on gentle and intermediate slopes were similar in their proportions of deciduous stands and regeneration areas. Winter yards found on steep slopes were markedly richer in deciduous stands but poorer in regeneration areas. In all yard types, tree height ranged mostly from 9 to 21 m and the forest stands had a canopy ranging from 41 to 80%. Also, all yards were mosaics of mature and young vegetation stands.

Discussion

In February, the winter yards were small because of a confinement of the animals due to snow accumulations greater than 75 cm (Telfer 1970; Phillips *et al.* 1973; Crête 1977).

Prescott (1968) and Audy (1974) concluded that south slopes were important for wintering moose, but the present results indicate that moose use forest stands of any exposure without preference. This agrees with the findings of Telfer (1968) and Proulx and Joyal (1981) and suggests that exposure is not a critical factor in the establishment of winter yards. With respect to the floristic composition of the winter yards established on south and north exposures, there is no indication that moose should favor south-facing slopes. Moose do not overwinter in a forest offering a continuous protection layer (Telfer 1968). Proulx and Joyal (1981), in their description of a typical winter yard of forest zone 3, reported that less than 19% of a typical yard area had a continuous coniferous cover. Considering the proportion of mixed stands in their study, conifers covered between 30 and 50% of the typical yard area. In this study, on any exposure, at least one third of an average winter yard area provided cover to moose. Independent of exposure, all yards were characterized by a diversified floristic composition and moose profited from an interspersion of regeneration areas and coniferous, deciduous, and mixed stands. Furthermore, Proulx and Joyal's (1981) description of a typical yard is even more similar to the one encountered on the north slopes of this study rather than on the south ones. The common belief that south slopes are favoured habitats of

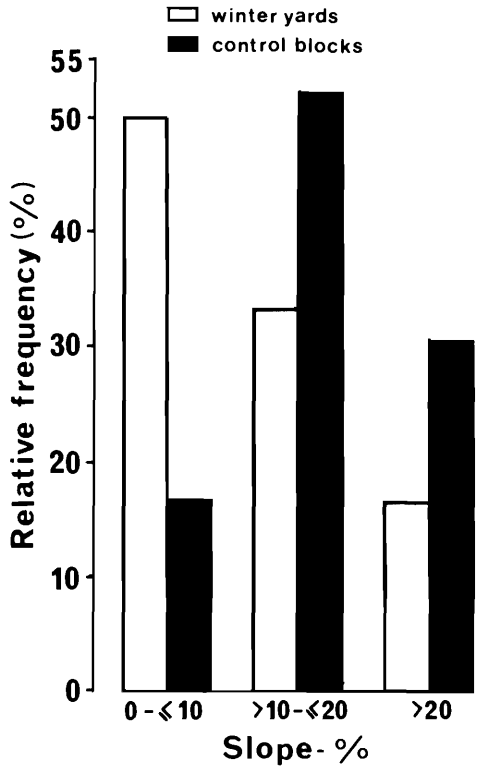

FIG. 3. Relative frequencies of the slope classes in 42 winter yards and 42 control blocks in February 1970 in southern Quebec.

cervids might be applicable to white-tailed deer (*Odocoileus virginianus*) (Telfer 1978*b*), but it appears to be less relevant for moose.

Moose winter yards tended to be situated on gentle slopes. This conforms to the findings of Proulx and Joyal (1981). Previous studies (Audy 1974; Peek *et al.* 1976) were solely descriptive with respect to the physical characteristics of moose winter yards, and slopes were not considered in habitat management considerations. In this study, the mean slope of winter yards was significantly less than the control blocks and gentle slopes were significantly more numerous in winter yards than in control blocks. This suggests that moose did not choose their winter yards at random.

According to Crête (1977), the presence of moose on gentle slopes is due to high soil moisture associated with greater abundance of conifers. Therefore, vegetation would be the factor in the selection of an area by moose. Coniferous stands represented a greater proportion of vegetation in the average composition of a winter yard located on gentle slopes than in the composition of other yard types. However, the needs of moose in winter are minimal with respect to a protection layer. Telfer (1978*a*) pointed out that their large size involves possession of long legs and a relatively low ratio of body surface to body mass. They are thus well equipped to walk in deep snow and resist wind chill. Therefore, unlike white-tailed deer (Telfer 1978*b*), moose do not need a continuous cover to face the harshness of winter. An interspersion of coniferous and deciduous species is considerably more favourable to moose because it provides them with cover and food (Telfer 1978*a*; Proulx and Joyal 1981). Such an interspersion was particularly found on intermediate and steep slopes. Also, in those yards, as well as in the ones located on gentle slopes, at least one third of the area was covered by conifers found either in continuous stands or mixed ones. Therefore, the protection layer found on gentle slopes would not be more favourable to moose and its characteristics do not explain the concentration of winter yards in such areas.

Proulx and Joyal (1981) found that the majority of stands of all types in the typical winter yards had a canopy ranging from 41 to 80% and a height between 9 and 21 m. Such characteristics of the forest stands were found in the average composition of yards of every slope type. They also found that the typical moose winter habitat was made up of a mosaic of mature and young stands. Such a mosaic was also encountered in all yard types of this study. In fact, with respect to the forest stands, the basic needs of moose (Telfer 1978*a*; Proulx and Joyal 1981) were met on gentle, intermediate, and steep slopes.

Moose choose their habitat more by the food layer than by the protection layer (Kearney and Gilbert 1976; Poliquin *et al.* 1977; Proulx and Joyal 1981). Since the present study was done with the aid of forestry maps, no information relative to the understory is available. However, the average composition of the winter yards of all types had young and multilayered forest stands which supply moose with browse. The average composition of the winter yards of this study had regeneration areas which supply moose with browse along their edges. All winter yards, in particular the ones located on slopes greater than 10%, had mixed stands which, in forest zone 3, are principally made up of balsam fir and white birch (Proulx 1978). Lafond and Ladouceur (1968) stated that in the white birch – balsam fir stands, balsam fir saplings and mountain maple (*Acer spicatum*) were numerous. Those species are important in the winter diet of moose (Joyal 1976) and balsam fir twigs are highly nutritive (Aubry 1980). In the floristically similar Acadian Forest Region, Telfer (1972) reported open and dense mixed wood as the highest ranking forest types in production of winter browse. Since the interspersion of food and cover was particularly strong on steep and intermediate slopes, there is no reason to believe that winter yards located on those slopes would be less suitable to moose than the ones located on gentle slopes.

The mean area of winter yards on intermediate slopes was neither too small to be found significantly different from the yards located on gentle slopes nor too big to be significantly different from yards located on steep slopes. This area was in between two extremes which were, however, significantly different. With respect to forest types, one could expect that yards located on intermediate and steep slopes would be similar in size. Both yards were rich in mixed stands and relatively poor in continuous coniferous stands. This importance of mixed stands on intermediate and steep slopes might have contributed to a reduction of the areas. Moose could have concentrated their feeding activities on relatively small areas. However, if one assumes that forest type is responsible for the size of a yard, a difference should exist between winter yard areas of gentle and intermediate slopes. Indeed, yards on gentle slopes were distinct from other yards in their richness of continuous coniferous stands and their paucity of mixed stands. Alternatively, on the basis of vegetation, if no difference existed between yard areas of gentle and intermediate slopes, no difference should have been found between the mean areas of yards on gentle and steep slopes.

Considering that the vegetation characteristics of all winter yard types were favourable to moose in winter, the slope itself could act on the size of the winter yards. The amount of energy expended by free-ranging animals is unknown because at this time there is no feasible method for measuring it in the field (Moen 1973). However, it is known that the energy cost for some domestic species walking on a vertical gradient is over 10 times greater than that for walking on level ground (Clapperton 1961; Moen 1973). With an increase in the slope a decrease in the winter yard areas might be expected. It is suggested that moose could extend their range on gentle slopes with relatively less effort because less energy expenditure would be involved in movements.

Forest managers must consider the slope of an area in determining the exploitation sites, for the sake of moose. The present study showed that moose established most of their winter yards on gentle and intermediate slopes and those areas should be protected against extensive logging operations. The production of diversified forests, similar to those described by Proulx and Joyal (1981), located on slopes less than 10%, should be promoted in the future in order to provide moose with adequate winter habitats.

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