WINTER USE OF POWERLINE RIGHTS-OF-WAY BY MOOSE (*ALCES ALCES*)

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ABSTRACT: The objectives of this study were to determine the influence of a powerline right-of-way on moose abundance and to characterize winter food availability and use by moose (*Alces alces*) in rights-of-way. Moose tracks and trails observed in six 120 km long by 500 m wide plots including a right-of-way were compared to those on 6 similar plots which did not have a right-of-way (control). Helicopter surveys were done from mid-March to mid-April 1990 and 1991. Four variables were retained to describe the habitats. In May 1990 and 1991, after snowmelt, browse surveys were conducted in 16 randomly selected yards (8 each year) located in rights-of-way. Between 70 and 90 $4 m^2$ circular sampling plots were located in the right-of-way itself, while 90 sampling plots were located in the adjacent forest. All available and browsed twigs of all species generally used by moose were tabulated. A total of 95 signs of moose presence were observed in the 6 right-of-way linear sampling plots while 89 were observed in the control plots. The difference was not significant. In both the right-of-way and control plots, more than 75% of yards were located in habitats where the slope was gentle or absent. Half the yards were oriented between the southeast and the west. In right-of-way plots, winter yards were mainly located within 300 m of the closest water body. In the control areas, the majority of yards were located between 300 and 1,000 m from water. Finally, the majority of yards were located in mature mixed forest stands. The average browse production in rights-of-way was 43,495 twigs/ha while that of the adjacent forest was 115,020 twigs/ha. These means are significantly different. On average, 3,081 twigs/ha were browsed in rights-of-way while 1,193 twigs/ha were browsed in the adjacent forest. These means are not significantly different. The presence of rights-of-way did not seem to affect winter habitat selection or regional moose abundance. Results indicate that although rights-of-way studied were used by moose in winter, they did not offer very good feeding habitat, but neither did the adjacent forest habitat.

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Hydro-Québec operates a network of approximately 33,000 km of high voltage powerlines. Large portions of these rights-of-way are located in forested areas in Québec. This network requires a major vegetation control program on 135,000 ha of rights-of-way in forested lands. Most of these are located within moose (*Alces alces*) distribution in the province. From a management point of view, vegetation control represents repeated treatments of the vegetation in the rights-of-way in order to maintain adequate clearance between the conductors and the ground. Ecologically, it results in the maintenance of a linear patch of habitat in which the woody vegetation stratum is maintained in a pioneer state of one form or another, depending on the type of treatment. The ultimate outcome is that, within a right-of-way, the browse available to moose is variable in terms of abundance and quality (species). In impact assessment studies, opinions, albeit speculative, are usually centered on the position that rights-of-way represent a negative impact on moose. On the other hand, *ad hoc* observations over the years indicate that moose use rights-of-way in Québec.

Few studies have addressed this specific question (Joyal *et al.* 1984), although some authors have reported on the positive aspects of rights-of-way as wildlife habitat (Egler 1957, Garant and Doucet 1995). The present study focused on moose activity in winter habitats associated with high voltage powerline rights-of-way. The objectives of the study were threefold: (1) to compare moose utilization of rights-of-way habitats in winter to that of similar habitat where rights-of-way are absent (control); (2) to compare the characteristics (quality) of these habitats (yards associated with rights-of-way and yards not associated with rights-of-way); and (3) to determine browse availability and use by moose in rights-of-way habitats.

STUDY AREA

The study was conducted in 5 regions of Québec where moose densities were homogeneous (Brassard *et al.* 1974). These areas contain some of the highest moose densities in Québec (0.1 to 0.4 moose/km^2) and are located in good habitats where logging is a dominant land use. A total of 6 high voltage transmission rights-of-way were selected to conduct the study (Fig. 1). These rights-of-way were located in the balsam fir - birch mixed forest (southern region) and in the southern part of the boreal forest (northern region). The vegetation control cycle was at different stages in the rights-of-way studied.

METHODS

Activity

To determine if moose activity (number of winter yards) in or near rights-of-way was similar to that in similar nearby habitat where no rights-of-way were present, we compared the activity (tracks and trails) on 6 120 km long transects in rights-of-way (treatment) to that on 6 similar transects (control) located parallel to, and at least 2 km away from the right-of-way in the adjacent forest. Along each of these 120 km transects we sampled a 500 m wide strip on the ground, thus each sampling plot was covering an area 60 km^2. The distance between treatment and control plots ensured that a given wintering area was not counted twice. On each of these plots, we counted moose tracks and trails using helicopter surveys in winter. The 12 transects were sampled twice between 26 March and 5 April 1990 and 20 March and 4 April 1991. Data were noted on topographic maps (1:50, 000). Data were classed either as winter yards (concentration of tracks) or single track. Winter yards were considered different if they were separated by at least 2 km. A Mann-Witney U test (comparison of means) was used to determine differences in yards and tracks between rights-of-way and forest at the 0.05 significance level.

Quality of Winter Yard

Data on presence/absence in the 12 transects were plotted on forestry maps (1:20,000). For each of the winter yards observed, the habitat was characterized according to 4 variables: (1) slope; (2) orientation; (3) distance to a water body; and (4) woody vegetation types (dominant and sub-dominant). These variables were grouped in classes and comparisons were made using a χ^2 test at the 0.05 significance level after doing a Bartlett homogeneity of variance test (Scherrer 1984). The sample sizes were 69 yards in the rights-of-way transects and 75 in the forest transects.

Browse

In late May 1990 and 1991, 16 winter yards (8/yr) located in rights-of-way were selected at random to conduct browse sur-

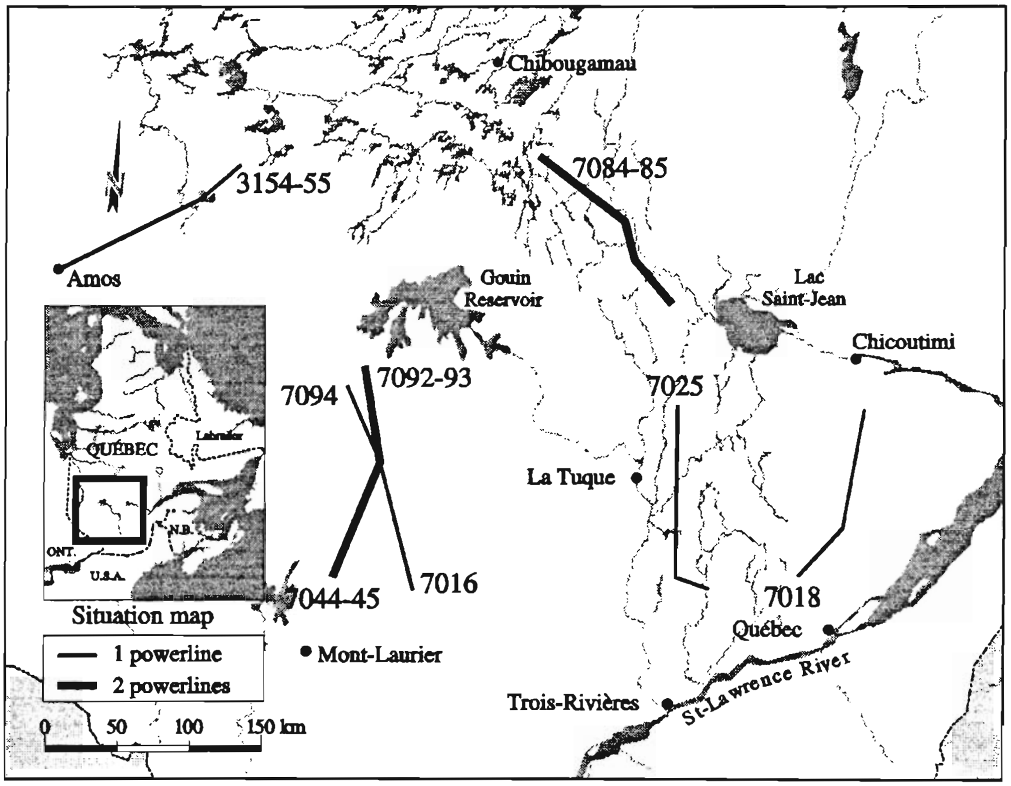

Fig. 1. Study area and locations of rights-of-way and moose yards studied in 1990 and 1991.

veys (Fig. 1). These were only accessible by helicopter. Each survey site was located near the center of the yard mapped during the winter surveys. Each survey site was centered in the right-of-way and covered an area 200 x 200 m. A browse survey was done using a systematic sampling plan in the right-of-way itself (treatment) and adjacent forest (control) to compare results. Circular plots 4m^2 were distributed in a checkerboard design and spaced by 20 m on transects which were 10 m apart. In the adjacent woods, the number of plots was always 90, while it fluctuated between 70 and 90 in the right-of-way due to the width of the latter.

The woody vegetation was sampled in each circular plot. All species, except spruce (*Picea* spp.) and alders (*Alnus* spp.) which are usually not taken by moose (Joyal 1976) were included in the data. Balsam fir (*Abies balsamea*) is included although it is a species considered a food of last resort (Brassard *et al.* 1974, Crête 1989). Browsed and unbrowsed stems and twigs were tabulated. Twigs 4 cm and longer were considered in the sample. Twigs browsed by hares were considered as available for moose. Diameters at browse point of a subsample were measured and an average weight was calculated from equations presented in Ricard (1986). These numbers and weights were standardized on a hectare basis to make comparisons. The age of the vegetation in rights-of-way was evaluated from Hydro-Québec's vegetation control program schedule. In the field, it was easy to observe that vegetation control methods are not uniformly efficient and small patches of older woody vegetation were noticeable in some areas in rights-of-way. Browse availability is defined as the percentage of twigs of a species in relation to the total number of all twigs of all species. Use is defined as the percentage of twigs browsed for a given species in relation to the number of twigs of that species. The importance in the diet is the percentage of browsed twigs of a species for a given species in relation to the total number of twigs browsed for all species. These data were compared by comparison of means, non parametric, Mann-Witney U tests at the 0.05 significance level. Simple and multiple correlations were also used (Scherrer 1984).

RESULTS AND DISCUSSION

Activity

A total of 69 yards were observed in rights-of-way transects and 75 in forest transects (Table 1). Twenty-six single tracks were observed in rights-of-way and 14 in forest transects. The total activity signs were 95 in rights-of-way and 89 in forest transects. For the 12 transects surveyed in 1990 and 1991, the test of comparison of means was not significant between the number of presence signs in rights-of-way and in the forest (P = 0.05). In addition, the number of activity signs does not vary in relation to the age of the vegetation in rights-of-way (r^2 = 0.006). These results indicate that the presence of a powerline right-of-way did not influence the choice of winter yard sites by moose in the study area.

Quality of Winter Yards

Both in the rights-of-way transects and in the forest transects, more than 75% of all yards were located on sites with gentle or no slope (< 10%). In the sites studied, moose did not use sites with pronounced slope or hilltops during the winters 1990 and 1991. A frequency test indicated that the distribution of slope classes was similar in rights-of-way transects and forest transects (P > 0.05). About half of the yards were located on a southeast to west exposure, in both rights-of-way and forest transects. About 25% of the yards were on northeast or northwest slopes. A frequency test indicated that there was no significance between orientation classes for the 2 sets of transects (P > 0.05). Brassard *et al.* (1974) indicated that moose yards were often oriented between the southeast and the west. Proulx (1978) and Bourque (1982) concluded that orientation was not important in the Abitibi region. Our data indicate that in the area studied selection of winter yards habitat by moose is based on other criteria than slope exposure.

Table 1. Comparison of moose winter activity in rights-of-way and adjacent forest.

		ROW transects				Forest transects				
	ROW width	Number of tracks		Number of yards		Number of tracks		Number of yards		
ROW number	(m)	1990	1991	1990	1991	1990	1991	1990	1991	Total
3154-55	70	3	3	3	9	4	0	5	6	33
7018	90	3	0	5	0	1	0	7	1	17
7025	90	4	3	12	8	4	3	11	7	52
7016, 7094	90	1	2	10	5	0	0	6	8	32
7044-45, 92-93	140	1	2	5	7	0	1	8	4	28
7084-85	140	3	1	1	4	1	0	4	8	22
Total		15	11	36	33	10	4	41	34	184
Total 1990 and 1991		26		69		14		75		
Number of activity signs		95				89				

Browse

On average, stem density in rights-of-way was 6,639 stems/ha while it was 8,621 stems/ha in the adjacent forest (Table 2). These differences are not significant. In rights-of-way, these values varied between 715 and 8,862 stems/ha. In adjacent woods, data fluctuated from 667 to 15,749 stems/ha. Stem density increased on a logarithmic scale in rights-of-way following the vegetation control cycle. Crête (1977) observed between 8,000 and 18,000 stems/ha in moose yards in southwestern Québec. Bourque (1982) noted on average 16,291 stems/ha in early winter yards while he observed 3,333 stems/ha in March. Joyal (1983) observed signs of browsing in rights-of-way when the vegetation reached 13,000 stems/ha. Our results indicated that moose will use rights-of-way to browse when stem density is lower than 13,000 stems/ha. Vallée *et al.* (1976) have shown that in mixed stands, stem density increases in cutovers to reach a maximum of 25,000 stems/ha after 5 years of growth. From the logarithmic equation generated in our study, it is possible to calculate that in rights-of-way the number of stems/ha could reach values comparable to those suggested by Vallée *et al.* (1976) after 5 years of growth. Regeneration in rights-of-way is comparable to that in cutovers and the evolution of stem density showed the same tendency, at least in the first years.

We observed a mean of 43,495 twigs/ha in rights-of-way and 115,020 twigs/ha in adjacent woods. These results were significantly different ($P = 0.001$). In rights-of-way, the range was between 5,000 and 114,889 twigs/ha, while in the adjacent woods, it varied between 9,194 and 194,001 twigs/ha. The availability of twigs in rights-

Table 2. Browse available and used by moose in rights-of-way and adjacent forest.

	ROW					Forest				
Browse	Stems /ha	Twigs /ha	Browse production (%)	Browse use (%)	Importance in diet (%)	Stems /ha	Twigs /ha	Browse production (%)	Browse use (%)	Importance in diet (%)
Abies balsamea	180	4,066	9.3	0.0	0.0	1,107	43,342	37.8	0.0	2.9
Acer rubrum	450	2,021	4.7	2.4	1.6	241	1,636	1.4	0.7	1.0
Acer saccharum	125	405	0.9	2.2	0.3	321	2,566	2.2	1.7	3.7
Acer spicatum	1,021	1,620	3.7	3.5	1.9	2,134	23,323	20.2	0.9	18.3
Betula alleghaniensis	0	0	0.0	0.0	0.0	10	96	0.1	3.5	0.3
Betula papyrifera	651	4,908	11.3	8.4	13.3	483	9,158	8.0	3.6	27.4
Corylus cornuta	352	1,288	3.0	1.3	0.6	1,690	18,450	16.0	0.5	7.0
Populus tremuloides	397	4,130	9.5	2.0	2.7	97	592	0.5	0.0	0.0
Prunus pensylvanica	1,960	14,986	34.5	9.1	44.2	153	1,641	1.4	1.3	1.8
Salix spp.	987	6,685	15.4	13.1	28.4	139	1,976	1.7	4.3	7.1
Sambucus pubens	21	104	0.2	1.7	0.0	45	155	0.1	0.0	0.0
Sorbus americana	158	597	1.4	36.1	7.0	368	2,102	1.8	5.3	9.3
Viburnum alnifolium	19	102	0.2	0.0	0.0	703	3,255	2.8	2.4	6.6
Viburnum cassinoides	318	2,583	5.9	0.0	0.0	1,130	6,728	5.9	2.6	14.6
Total	6,639	43,495	100.0	7.1	100.0	8,621	115,020	100.0	1.0	100.0

of-way was lower than that in the forest. Twig density in rights-of-way increased according to a logarithmic scale (Fig. 2). Bourque (1982) observed in early winter yards slightly more than 125,000 twigs/ha while this density was reduced to 22,000 in yards used in March.

An average of 3,081 twigs/ha were browsed in rights-of-way while 1,193 twigs/ha were browsed in the adjacent forest. This difference was not significant (P = 0.71). While 7.1% were browsed in the rights-of-way, 1.0% of twigs were browsed in the forest. This difference was not significant (P = 0.68). The absence of significance between means, even if moose appeared to browse more twigs in rights-of-way than the forest, could be the result of the wide variation in results and the small sample size. Overall the results seem to indicate that moose browse just as much in rights-of-way as in the adjacent forest.

On average, there were 46,034 twigs/ha available in rights-of-way in the southern part of the study area and 42,365 twigs/ha in those in the north. In the adjacent forest, browse availability values reached 135,372 twigs/ha in the south and 62,196 twigs/ha in the north. In the south, moose browsed 1,476 twigs/ha in rights-of-way and 806 in the adjacent forest. In the north, moose browsed 6,750 twigs/ha in rights-of-way and 1,917 in adjacent woods. In the south, moose browsed an average of 2.3% of available twigs in rights-of-way and 0.7% in adjacent woods. In the north, moose browsed an average of 10.0% of available twigs in rights-of-way and 6.5% in adjacent woods. Browse availability is similar in rights-of-way in the north and in the south, while moose use right-of-way browse 4 times more in the north than in the south. In the adjacent woods, the number of twigs available is half that in the north while the use is twice as high. A possible explanation could be that the deciduous twigs are less abundant in the coniferous forest of the northern region. The availability of deciduous twigs in rights-of-way could make them more attractive for moose. In the south, in the mixed forest, the availability of deciduous twigs in rights-of-way is not markedly different than that found in the adjacent forest stands.

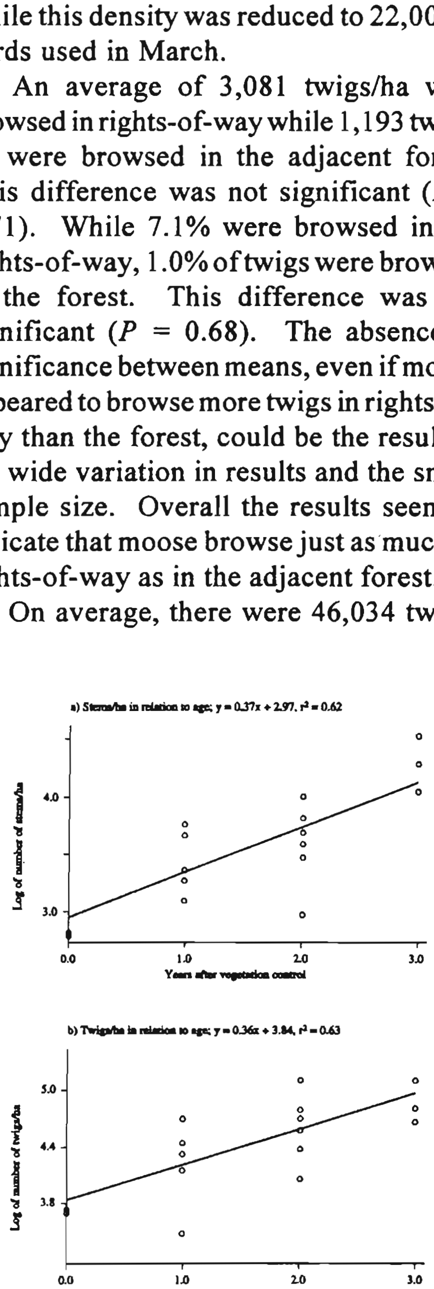

Fig. 2. Number of stems/ha (a) and twigs/ha (b) in relation to the number of growth seasons after the last vegetation control in rights-of-way.

Total browse availability of each browse species varied greatly from one site to another. In general, species contributing the greatest number of twigs in adjacent woods were balsam fir (*Abies balsamea*), beaked hazelnut (*Corylus cornuta*), and striped maple (*Acer spicatum*). In rights-of-way, the most abundant species were pin cherry (*Prunus pensylvanica*), willows (*Salix* spp.), and white birch (*Populus papyrifera*). The main species browsed in the adjacent woods were mountain ash (*Sorbus americana*), willows, and white birch. In the rights-of-way studied, the main species browsed were mountain ash, willows, and pin cherry.

In the south, pin cherry, willows, trembling aspen (*Populus tremuloides*), and balsam fir were dominant in rights-of-way, while in adjacent woods, balsam fir, striped maple, and beaked hazelnut provided the most twigs. In the north, rights-of-way were dominated by willows, pin cherry, and white birch, while adjacent woods offered mainly balsam fir, beaked hazelnut, and white birch. Joyal (1983) observed that in rights-of-way, pin cherry and trembling aspen dominated greatly in southern regions of Québec, while white birch dominated in the north.

In the southern region, moose browsed mainly striped maple, Appalachian tea (*Viburnum cassinoides*), and mooseberry (*Viburnum alnifolium*) in adjacent woods, while willows, pin cherry, and white birch were browsed in rights-of-way. In the north, in adjacent woods, mountain ash, Appalachian tea, and white birch were browsed, while in the rights-of-way moose browsed mainly willows, pin cherry, and white birch. In the Gaspé region, Crête (1989) observed that important browse species included mountain ash, willows, dogwoods (*Cornus* spp.), trembling aspen, striped maple, and white birch. Moose diet can vary from one area to another (Joyal 1976, Poliquin 1978, Ricard 1986) but a few species such as willows, trembling aspen, and mountain ash are often browsed intensively. When we compared browse availability and use by moose in rights-of-way, willows and mountain ash appeared to be sought, while balsam fir, trembling aspen, and Appalachian tea appeared to be avoided ($r^2 = 0.84$, Fig. 3). In the adjacent forest, all species except white birch (sought) appear to be browsed according to availability ($r^2 = 0.21$). Finally, when we combined rights-of-way and adjacent woods, willows, white birch, and pin cherry seemed to be strongly preferred, while balsam fir appeared to be avoided ($r^2 = 0.19$).

A step-wise regression model indicated that 99% of the variation observed in the browsed biomass in the rights-of-way can be explained by the abundance of white birch, mountain ash (positive), and Appalachian tea (negative) (y = 0.47 [white birch] + 0.69 [mountain ash] - 0.57 [Appalachian tea] + 69.96). In adjacent woods, the abundance of mountain ash (positive), pin cherry, and Appalachian tea (negative) explained 80% of the variation in the diet (y = 0.61 [mountain ash] - 0.49 [pin cherry] - 0.09 [Appalachian tea] + 1,236.0). When we combined rights-of-way and adjacent woods, 83% of the variation in biomass browsed was explained by the abundance of white birch, mountain ash (positive), and balsam fir (negative) (y = 0.51 [white birch]

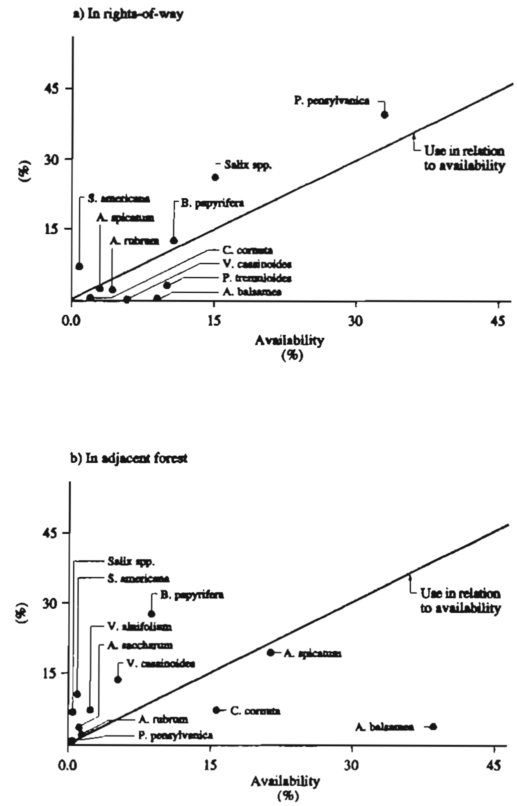

Fig. 3. Relative importance of browse species in moose diet in relation to availability in (a) rights-of-way and (b) adjacent forest.

+ 0.30 [mountain ash] - 0.03 [balsam fir] - 518.7). It thus appears that it is not necessarily preferred species which contribute the most to moose diet. Other species browsed proportionately to availability contribute strongly to the diet in relation to their relative abundance. However, balsam fir appeared to be avoided and possibly rejected (negative contribution) by moose. As suggested by Brassard *et al.* (1974) and Crête (1989) balsam fir is probably a browse species of secondary importance for moose in winter and could have been excluded from biomass estimations. In rights-of-way, the number of browsed twigs varied in relation to the number of twigs available (Fig. 4). In terms of biomass, the relation is stronger ($r^2 = 0.55$). Renecker and Hudson (1986) showed that there was a good relationship between available biomass and that utilized by moose.

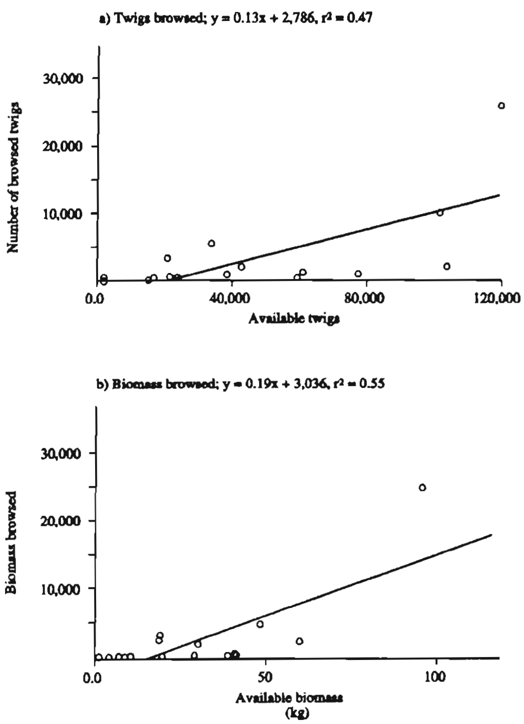

Fig. 4. Twigs (a) and biomass (b) browsed by moose in relation to availability in rights-of-way.

It is possible to use an optimal foraging model (Pyke *et al.* 1977, Hudson and White 1985) to assess rights-of-way in terms of potential feeding areas for moose. According to the premises of these models, the critical biomass for moose in winter is on the order of 150 kg/ha, while the optimal biomass value is about 600 kg/ha. In the present study, feeding areas which offered less biomass than the critical value could be considered of low quality, while those offering a quantity above the critical value could be considered of average quality, and those which offered a quantity above the optimal value could be considered of good quality for moose feeding. In terms of twigs, the critical availability for moose is roughly around 150,000 twigs/ha. The optimal availability is around 600,000 twigs/ha. In comparison to those values, the number of twigs available (including balsam fir) in rights-of-way and most adjacent stands studied is below the critical availability. Towards the end of the vegetation control cycle, after 4 or 5 years of growth, the critical availability is probably reached. Garant and Doucet (1995) observed similar values in rights-of-way located in white-tailed deer (*Odocoileus virginianus*) winter yards in southern Québec.

If we exclude balsam fir, the average twig densities reach about 70,000 twigs/ha (approx. 70 kg/ha) in adjacent woods and about 40,000 twigs/ha (approx. 40 kg/ha) in rights-of-way. All the sites studied showed values below the critical density in deciduous twigs. The quality of feeding areas in adjacent woods appeared low and comparable to that observed in feeding areas in rights-of-way.

In comparison to our biomass values, Crête (1989) observed around 14 kg/ha in deciduous species and around 237 kg/ha in balsam fir in the Gaspésie Park. Crête and Jordan (1982) established, in southwestern Québec, an annual production varying between 20 and 250 kg/ha (balsam fir included). In Alaska, Wolff and Cowling (1981) estimated available biomass in willows (the only species browsed) varying between 40 and 110 kg/ha. Oldemeyer (1974) estimated biomass in Alaska for deciduous species between 36 and 227 kg/ha. On average, the total availability in deciduous species in rights-of-way was similar to those reported for Alaska and for southern Québec.

CONCLUSIONS AND MANAGEMENT IMPLICATIONS

Results indicate that on a regional basis, there was no difference in density indices of presence of moose between rights-of-way habitat and the control habitat located away from rights-of-way. Yards located near, or touching rights-of-way were comparable in orientation, slope, and distance to water to yards located in the control areas.

The browse available is less in rights-of-way than in the adjacent forest. In general, species composition is different, but quantities browsed by moose are similar. None of the sites studied in rights-of-way appeared to offer a biomass high enough for a moose to balance its energy budget and much less to optimize diet requirements. However, moose use rights-of-way, even when the browse available is low. This could be explained by the poor quality of available vegetation in adjacent woods. Results presented provide evidence that the available biomass in deciduous species is comparable in adjacent woods and in rights-of-way. Rights-of-way appear to be poor quality feeding areas for moose, but adjacent woods do not seem to present better quality feeding areas.

According to our results, it is possible that moose browse relatively more intensely in some rights-of-way than in the adjacent woods. However, the variability in results and the small sample size in this study do not permit a conclusion on this issue. From an ecological perspective, it would be relevant to study how moose would react to a lengthening of the vegetation control cycle. This could increase the available biomass, and the critical level of biomass could possibly be reached after 4 or 5 growing seasons.

In the face of these results, albeit from only 16 sites, the large variation observed between sites, and the cost of sampling, we have elaborated a set of simple guidelines (Doucet 1996) to address the moose issue in rights-of-way. At present Hydro-Québec does not manage the vegetation specifically for moose in rights-of-way but remains open to partnerships for vegetation management to attract moose to rights-of-way.

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