

## MOOSE WINTER DIET SELECTION IN CENTRAL ONTARIO

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**ABSTRACT:** This paper documents moose (*Alces alces*) winter diets in the northern portion of the Great Lakes-St. Lawrence forest region of Ontario. Seventeen of 20 species available along 2,890m of moose foraging path were browsed. Striped maple (*Acer pensylvanicum*), eastern hemlock (*Tsuga canadensis*), balsam fir (*Abies balsamea*), and red maple (*Acer rubrum*) comprised a combined 74 and 56 % of the browse dry weight consumed and available, respectively. Moose used balsam fir, eastern hemlock, and red maple proportionally more than their availability, used sugar maple (*Acer saccharum*), yellow birch (*Betula alleghaniensis*), and mountain ash (*Sorbus americana*) proportionally less than their availability, and used striped maple, beaked hazel (*Corylus cornuta*), and mountain maple (*Acer spicatum*) proportional to their availability. The important contribution of striped maple and eastern hemlock to moose diets contrast with other studies. These results may be used to assist in the evaluation of moose winter habitat.

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Dietary information about moose (*Alces alces*) during winter can be used to explain local distribution patterns (Telfer 1978), to evaluate habitat suitability (Crête and Jordan 1982, Crête 1989, Crête and Courtois 1997), and to provide information for habitat enhancement (Peek et al. 1976, Lautenschlager et al. 1997). Moose winter food habits have been documented widely across their primary range in the boreal forest region (Crête and Bedard 1975, Cumming 1987, Crête 1989). Composition of moose winter diets have also been reported in the southern extent of their range in eastern North America, represented by the transitional mixed coniferous-deciduous forest of the Great Lakes-St. Lawrence (GL-SL) and Acadian forest regions (Rowe 1972), from Maine (Ludewig and Bowyer 1985, Lautenschlager et al. 1997) and southwestern Quebec (Joyal 1976, Crête and Jordan 1982) to northeastern Minnesota

(Peek et al. 1976). The purpose of this paper is to report results from a survey of the winter food habits and browse preferences of moose in the northern portion of the GL-SL forest region of Ontario. The unusually low snow depth for this area (< 20 cm; Environment Canada 1995) combined with a low moose density (0.18 per km<sup>2</sup>; Scott Jones, Ontario Ministry of Natural Resources, personal communication), provided an opportunity to determine moose winter browse preferences without the constraint of deep snow conditions in an area with minimal browsing activity in past years.

### STUDY AREA

A moose yarding area was located 19 km north of Sault Ste. Marie, Ontario (46°42'N, 84°24'W) in mid-January 1995. The area varied in elevation from 200 to 230m and was dominated by mature sugar maple (*Acer saccharum*), with yellow birch

(*Betula alleghaniensis*), red maple (*Acer rubrum*), eastern hemlock (*Tsuga canadensis*), and white spruce (*Picea glauca*) occurring at a lower density. Mean daily temperatures during January and February 1995 were  $-6$  and  $-12^{\circ}\text{C}$ , respectively, ranging from  $-30$  to  $+4^{\circ}\text{C}$  (Environment Canada 1995).

## METHODS

Moose were tracked in the snow to determine their diet composition from mid-January through mid-February 1995 by counting all browsed twigs along a minimum 50 m of foraging path at each foraging site (Wetzel et al. 1975, Histol and Hjeljord 1993). Tracks were intercepted in the yarding area by walking ( $> 800$  m) in a southerly direction from a forest access road (Thielman Road). If multiple foraging sites were located along the same track, they were separated by  $> 400$  m. All tracks surveyed were clearly identified as being made by one individual. Browsed and unbrowsed twigs, between snow surface and 3m in height, were counted in  $4\text{m}^2$  circular plots (radius = 1.13 m) located at 10m intervals along the foraging paths to measure browse availability ( $\geq 6$  plots per path).

Diameters at points of browsing (DPB) and diameters of unbrowsed twigs (DUT) were randomly measured for each plant species represented by browsed twigs. DUTs were measured at the proximal end of twigs  $> 5$  cm in length where they forked from a larger branch (Crête 1989). The portion of the twig distal to the DPB or DUT, which could contain more than the current annual growth (CAG), was converted to biomass using equations for regression lines relating fresh diameter (Y) and dry weight (X) of twigs (Telfer 1969, Potvin 1981). Twigs were collected in the study area representing the range of DPBs and DUTs for commonly browsed species.

Published equations were used for species minimally browsed (Table 1). Diet composition was estimated by converting twig counts along foraging paths to dry weight. Browse availability was estimated by converting counts of browsed and unbrowsed twigs in the circular plots to dry weight and summing browsed and unbrowsed dry weight. Bonferroni confidence intervals were used to determine which species were consumed relative to their availability (Byers et al. 1984). A measure of browsing intensity was calculated for each species by dividing the biomass consumed into the biomass available at each foraging site for which a particular species was present.

## RESULTS

Diet composition was determined from 9,183 instances of use (IU) along 2,890 m of foraging path (mean  $\pm$  SD,  $206.4 \pm 102.7$  m) at 14 foraging sites. Browse availability was determined from 289  $4\text{-m}^2$  plots. Regression equations relating fresh twig diameter and dry weight of twigs were computed for the 9 most important browse species (Table 1). Published equations were used for chokecherry (*Prunus virginianus*), northern red oak (*Quercus rubra*), paper birch (*Betula papyrifera*), and serviceberry (*Amelanchier* sp.) (Table 1). Due to low availability and use, the latter species were grouped together for analyses. Eastern white cedar (*Thuja occidentalis*), fly honeysuckle (*Lonicera canadensis*), Canada yew (*Taxus canadensis*), and willow (*Salix* spp.) were not included in the analyses because they were uncommon and browsed minimally. Ash (*Fraxinus* sp.), red elderberry (*Sambucus pubens*), and white spruce were removed because they were not consumed. Mean DPBs were significantly larger than DUTs for all species ( $t$ -tests;  $P < 0.01$ ) except for mountain ash, where the DUT was significantly larger ( $t_{2,60} = 4.57$ ;  $P < 0.01$ ), and for yellow birch where the

Table 1. Regressions<sup>1</sup> relating fresh twig diameter (mm) and twig dry weight (g) and mean DUTs and DPBs for common browse species.

Species	a	b	R <sup>2</sup>	SEE/Y <sup>2</sup>	n	DPB (sd) <sup>3</sup>	DUT (sd) <sup>3</sup>
Balsam Fir	-3.33	4.30	0.641	0.179	56	1.81 (0.78)	1.30 (0.47)
Beaked Hazel	-4.12	3.64	0.677	0.205	60	2.69 (0.98)	1.55 (0.62)
Eastern Hemlock	-1.93	3.72	0.657	0.215	43	1.89 (0.81)	0.75 (0.27)
Mountain Ash	-7.04	4.86	0.614	0.065	80	3.76 (1.00)	5.35 (1.75)
Mountain Maple	-4.64	3.70	0.686	0.093	93	3.64 (0.95)	2.19 (0.67)
Red Maple	-4.09	3.04	0.866	0.084	96	3.57 (0.99)	2.46 (0.88)
Striped Maple	-4.97	3.94	0.639	0.090	100	4.10 (1.29)	2.56 (0.62)
Sugar Maple	-4.86	3.51	0.773	0.068	47	2.66 (0.67)	1.84 (0.62)
Yellow Birch	-2.92	2.64	0.808	0.148	83	2.31 (0.63)	2.03 (0.78)
Northern Red Oak <sup>4</sup>	-3.00	2.80	0.988		20		
Paper Birch <sup>5</sup>	-2.66	2.21	0.750		99		
Serviceberry <sup>6</sup>	-0.90	0.56	>0.750		50		

<sup>1</sup> Prediction equation:  $(\ln \text{weight}) = a + b \times (\ln \text{diameter})$ ;  $\text{weight} = a + b \times \text{diameter}$  for serviceberry.

<sup>2</sup> Standard error of estimate divided by mean of dependent variable, twig diameter (Zar 1996:328).

<sup>3</sup> Diameter at point of browsing (DPB) and diameter of unbrowsed twig (DUT). DPB significantly different from DUT for all species ( $t$ -tests;  $P < 0.01$ ) except for yellow birch ( $P > 0.05$ ).

<sup>4</sup> Based on air-dry twig diameter (Telfer 1969).

<sup>5</sup> Crête (1989).

<sup>6</sup> *Amelanchier* sp.; equation also used for *Prunus virginianus* (Lyon 1970).

DUT and DPB did not differ ( $t_{2,43} = 1.15$ ;  $P > 0.05$ ) (Table 1).

Striped maple, eastern hemlock, balsam fir, and red maple comprised 73.7% of the browse dry weight consumed at 28.8, 17.1, 16.7, and 11.1%, respectively, and 55.7% of the browse dry weight available (Table 2). Sugar maple, striped maple, mountain maple, and balsam fir were present at 12 or more of the 14 foraging sites (Table 2). An average of 7 browse species was present (range 3 – 11) over the 14 foraging sites. Stem breakage was recorded frequently on striped maple and less commonly on balsam fir. Balsam fir, red maple, and eastern hemlock were used 2 – 14% more than expected ( $P < 0.05$ ); sugar maple, mountain ash, and yellow birch were used 4 – 9% less than expected ( $P < 0.05$ ); and striped maple,

beaked hazel, and mountain maple were browsed in proportion to their availability ( $P > 0.05$ ) (Table 2).

Average browsing intensities ranged as high as 68, 71, and 97% of the available biomass for balsam fir, red maple, and eastern hemlock, respectively, to as low as 6% for yellow birch (Table 2). Browsing intensities for eastern hemlock, red maple, balsam fir, striped maple, beaked hazel, mountain maple, and sugar maple were highly consistent ( $r > 0.98$ ,  $P < 0.0001$ ) from one foraging site to the next (Table 2). At all seven sites where eastern hemlock was present,  $\geq 93.3\%$  of available biomass was removed regardless of its absolute ( $0.3 - 5.9 \text{ kg ha}^{-1}$ ) or relative (1.8 – 13.8%) availability. Fifty percent or less of available sugar maple browse, ranging from 0.5 – 7.9

Table 2. Diet composition, browse availability, and browsing intensity.

Browse Species	Instances of		% of Total	% of Total	Range kg per ha	Mean browsing intensity <sup>2</sup>	
	Use	<i>n</i> <sup>1</sup>	Biomass Consumed	Biomass Available		% (SD)	<i>r</i>
Eastern Hemlock	775	7	17.1 (1.7) <sup>3</sup> +	4.4	0.3 – 5.9	96.8 (1.8)	0.997**
Balsam Fir	2560	12	16.7 (1.7) +	13.9	1.3 – 6.6	67.7 (29.0)	0.935**
Red Maple	982	7	11.1 (1.5) +	8.7	0.3 – 9.5	71.4 (32.0)	0.984*
Striped Maple	1134	14	28.8 (2.1) =	28.7	1.5 – 15.0	59.0 (30.0)	0.999**
Mountain Maple	446	12	7.3 (1.2) =	7	0.1 – 9.2	29.7 (37.1)	0.994**
Beaked Hazel	825	7	6.9 (1.2) =	7.4	0.2 – 8.2	33.4 (43.4)	0.898**
Sugar Maple	1518	14	5.2 (1.0) –	10	0.1 – 7.9	30.9 (21.8)	0.883**
Mountain Ash	196	5	1.5 (0.6) –	10.8	0.1 – 15.1	28.4 (40.8)	0.710 <sup>ns</sup>
Yellow Birch	147	11	1.0 (0.5) –	5	0.1 – 6.0	6.2 (12.0)	0.321 <sup>ns</sup>
Other <sup>4</sup>	600		4.3 (0.9)	4			

<sup>1</sup> Foraging site frequency.

<sup>2</sup> Proportion of a species' available biomass consumed (sample size is the number of foraging sites<sup>1</sup> the species was present at).

<sup>3</sup> Selection of browse more (+) or less than (–) availability ( $P < 0.05$ ), or equal (=) to availability ( $P > 0.05$ ). 95% Bonferroni confidence interval lengths are in parentheses.

<sup>4</sup> Includes *Prunus virginianus*, *Amelanchier* sp., *Quercus rubra*, and *Betula papyrifera*.

\* $P < 0.001$ , \*\* $P < 0.0001$ , ns = not significant.

kg ha<sup>-1</sup>, was consumed in 13 of the 14 sites.

## DISCUSSION

Striped maple, a frequent understory component in mature hardwood stands representative of the study area (Rowe 1972, Rutkowski and Stottlemeyer 1993), comprised nearly one-third of all browse consumed and had a relatively high mean browsing intensity. Only trace amounts were available and consumed in southwestern Quebec, an area also lying within the GL-SL forest region (Joyal 1976, Crête and Jordan 1982). The large contribution of striped maple to moose diets may be partly attributed to the ability of moose to readily break striped maple stems to access twigs that would otherwise be out of their reach.

Balsam fir and mountain maple ranked third and fifth, respectively, in their contribution to moose diets, as was found in

southwestern Quebec (Joyal 1976, Crête and Jordan 1982) and northeastern Minnesota (Peek et al. 1976). Red maple was preferred during this study, in southwestern Quebec (Joyal 1976, Crête and Jordan 1982), and northeastern Minnesota (Peek et al. 1976). Balsam fir and red maple were browsed much more intensively than mountain maple, indicating a greater preference.

Eastern hemlock had a low availability, yet ranked second in contributing to moose diets and was the most intensively browsed species. Trace amounts of eastern hemlock have been reported in moose winter diets in Maine (Ludewig and Bowyer 1985, Lautenschlager et al. 1997) and Algonquin Park, Ontario (Peterson 1955). Extensive winter browsing by white-tailed deer (*Odocoileus virginianus*) on eastern hemlock is well documented (Anderson and Loucks 1979, Frelich and Lorimer 1985).

Since the southern extent of moose range in eastern North America overlaps the northern limits of the range of eastern hemlock, the impacts of long-term browsing by sympatric moose and white-tailed deer on eastern hemlock regeneration may be critical. Eastern hemlock saplings provide winter food for white-tailed deer, while mature eastern hemlock stands provide important winter cover (Euler and Thurston 1980). Where locally abundant, striped maple, balsam fir, eastern hemlock, and red maple should be considered important winter browse species in GL-SL forests. Sugar maple, beaked hazel, mountain maple, and mountain ash were not browsed intensively, and should be considered marginal browse species.

Not surprisingly, yellow birch was under-used, probably because it contains a secondary compound that reduces the rate of fermentation by rumen microbes (Belovsky 1981). Although found to be important in other studies of winter diets (e.g., Peek et al. 1976, Snyder and Janke 1976, Cumming 1987), mountain ash was under-used. The large availability of mountain ash, the third highest amongst all browse species, can be attributed to the large mean DUT recorded, which was the only DUT larger than the mean species DPB. Many mountain ash twigs, particularly the leaders, were large, possibly deterring moose from selecting them. Moose may browse twigs at increasingly larger diameters, maximizing biomass consumption, to the point where quality (i.e., digestibility) eventually becomes compromised (Vivas and Saether 1987). This effect may not have been as noticeable if DUTs were measured at the proximal end of the CAG (e.g., Ditchkoff and Servello 1998, Shipley et al. 1998) as opposed to the proximal end of twigs > 5 cm in length where they forked from a larger branch (Crête 1989).

The mean DPB was larger than the

DUT for other browse species indicating that availability was underestimated even though more than the CAG was likely sampled by measuring DUTs using Crête's method (Crête 1989). This indicates that moose may have been removing considerably more than the CAG (Telfer 1969, Shipley et al. 1998). The study area was in mature forest where the length of CAG and subsequent biomass of browse species would be less than in recently disturbed areas where the plants would be exposed to full sunlight. Under this latter situation the CAG on twigs may be much larger in effect decreasing the amount of twig in excess of the CAG that may be browsed. In mature forest, species such as striped maple, may produce minimal stem growth annually (Hibbs et al. 1980), increasing the likelihood that moose will consume multiple year's growth.

White spruce was readily available to moose but was not browsed. Trace amounts of white spruce have been recorded in winter moose diets in Maine (Ludewig and Bowyer 1985) and on Isle Royale even though it had sufficient nutritional quality to be heavily browsed (Belovsky 1981). Snyder and Janke (1976) reported greater densities of white spruce regeneration on Isle Royale in areas of moose browsing versus unbrowsed areas, because competing species such as balsam fir were heavily used.

Browse preferences of moose have generally been expressed through browse use and availability estimates from plots placed throughout wintering areas following the winter-use period and before leaf flush (e.g., Crête and Bedard 1975). Browse preferences determined using the methods in this study may better reflect preferences because only potential browse species encountered by moose were sampled. However, Van Vreede et al. (1989) found little difference in forage preference indices for white-tailed deer in Oklahoma when either

technique was used to estimate forage use and availability. As browse availability was not estimated independent of moose foraging paths, it cannot be determined if the method in this study would yield results similar to random plots placed throughout the wintering area.

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