WINTER HABITAT SELECTION BY MOOSE IN NORTHERN BRITISH COLUMBIA

Louise A. Goulet

Ecological Reserves, Parks Program
Ministry of Lands, Parks and Housing,
Victoria, B.C., V8W 2Y9

Abstract: This study reports a 3-year field investigation of the relationships between moose (*Alces alces andersoni*) and their winter habitat in the Liard River valley in northern British Columbia. Sixteen browse species accounted for 97 percent of all browse utilization by moose, with willows alone contributing 35 percent. Habitat selection by moose appeared to be largely based on the availability of these 16 browse species. Browse utilization was greatest in sub-alpine and alluvial habitats, intermediate in bog lowlands and upland deciduous and mixed habitats, and lowest in burns and upland coniferous types. Moose pellet density was greater in sub-alpine (44 groups/ha), burns (33), bog lowland (26) and alluvial types (21), and was lower in the upland deciduous/mixed (10) and coniferous (4) types. Moose density was measured at 0.7 moose/km² in February 1981, ranging from 0.1 moose/km² in upland coniferous forests to 1.1 in burns, 1.2 in alluvial habitats and 3.0 in sub-alpine shrubland. Strong correlations were found between moose density, browse utilization and pellet density. Burns, sub-alpine and alluvial habitats were consistently selected by wintering moose, whereas upland deciduous, mixed and coniferous habitats were generally avoided. Bog lowlands were selected in proportion to their availability.

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Moose (*Alces alces*) throughout North America are generally confined to boreal forests where important habitats are produced in the early seral stages of plant succession (Krefting 1974). Moose are relative newcomers to British Columbia (Kelsall and Telfer 1974), where logging and wildfire associated with opening up the country may explain the invasion by moose during the past century (Hatter 1950).

The purpose of this study was to document habitat selection by moose wintering in the Liard River valley in northern British Columbia.

STUDY AREA

The study area (roughly 13,000 km²) includes the Liard River valley, which traverses the northeastern corner of British Columbia (60° latitude; 129° longitude). The valley is characterized by gentle slopes, with the exception of a section which traverses the terminal section of the Rocky Mountains. Terraces, alluvial fans and riparian floodplains are present within the mainstem valley and larger tributaries.

Most of the Liard valley falls within the boreal Black and White Spruce biogeoclimatic zone, whereas areas located in the Rocky Mountain foothills fall within the sub-alpine Spruce-Willow-Birch zone (Krajina 1969). Upland coniferous and mixed forests alternate with large burned areas in the valley, whereas alluvial, bog lowland and shrubby habitat types occupy smaller areas.

A cold, dry, continental climate prevails in the valley. The mean annual temperature at Watson Lake is -3.0°C, with a mean maximum of 21°C in July and mean minimum of -31°C in January (British Columbia Department of Agriculture, n.d.). The mean annual precipitation for the area is 432 mm, almost equally divided between snow and rain (British Columbia Water Investigations Branch 1971). A mean annual maximum snow depth of 76 cm is given for the Liard area (Canada Department of Mines and Technical Surveys 1957). Snow depth in April 1981 varied from 41 ± 10 cm at 450 m ASL to 55 ± 8 cm at 600 m ASL (B.C. Hydro 1985).

METHODS

Ground fieldwork was completed from 16 June - 31 August 1978, 14 May - 10 August 1980, and 8 June - 20 August 1981, for a total of 600 man-days. A winter aerial survey was flown between 9 to 25 February 1981.

Ground Surveys

A total of 2393 plots were distributed 50 m apart along 200 transects located at random in given vegetation types (modified from Smith et al. 1969) to sample vegetation and to measure winter pellet density, and browse availability and utilization.

Vegetation was described on one or two plots in each transect, for a total of 350 vegetation plots. Vegetation types were classified according to criteria of vegetative structure and physiognomic characteristics, floristic composition and species cover. The floristic composition and areal cover of herbaceous plants, shrubs and trees (DBH >5 cm) were recorded within a 2.5 m, 5.6 m and 10 m radius respectively from the center of each vegetation plot. Cover, i.e. the percentage of plot area enclosed within the vertical projection of a given species or group of species, was index rated as follows: 1. 0-5%, 2. 5-25%, 3. 25-50%, 4. 50-75%, 5. 75-95%, and 6. 95-100%. Separate estimates were

obtained for tall shrubs (>1 m in height) and low shrubs (<1 m). Since snow depth does not ordinarily exceed 1 m in the Liard area, tall shrubs should be available even during the most rigorous winters.

Relative measures of availability and utilization were obtained in each transect for each browse species in each shrub category (i.e. shrubs taller and lower than 1 m in height). Trees having a DBH<5 cm were included in the "shrub" categories. In each transect, availability for a given browse species (0 to 60) was computed as the product of "mean cover (1 to 6) x presence (0 to 10, i.e. number of plots where species present out of 10 plots sampled)". In each transect, utilization for a given browse species (0 to 240) was computed as the product of "availability (0 to 60) x mean browsing intensity (0 to 4)". Browsing was rated as follows: 0. nil, 1. light (twigs browsed to 3 mm in diameter, less than 50% of all shrubs showing only partial browsing), 2. moderate (twigs browsed to 6 mm, nearly all shrubs showing partial browsing), 3. heavy (twigs browsed to 12 mm, all shrubs showing heavy browsing, some hedging), and 4. very heavy (severe hedging, some branches broken, occasional stripping). In each transect, species availability and utilization values were summed for all browse species to obtain browse availability and utilization ratings for that transect. Transect values were grouped and averaged to define ratings for given vegetation types. Full details are given elsewhere (B.C. Hydro 1985).

A pellet group was defined as an assemblage of six or more intact pellets which were judged to have been continuously voided at the place where they were observed (Batcheler 1975). The density of moose winter pellet groups in each transect was measured with a joint-point and nearest neighbour distance technique (Batcheler 1975; Fisher 1979).

A maximum of three measurements to pellet groups (if present) were obtained within a maximum search radius of 10 m in each plot to calculate a transect density value. Transect values were grouped and averaged to define pellet group density for each vegetation type. Full details on the Batcheler technique and the results obtained are given elsewhere (Goulet 1984).

Aerial Survey

A stratified block sampling survey (Gasaway et al. 1979, 1981) was flown in February 1981 to estimate the population of moose wintering in the Liard River valley. A stratification survey was flown first (9-14 February) with a Cessna 185 to record the number of moose present within a 0.4 km wide, 2074 km long transect located within the 8500 km^2 survey area. Zones of high, medium and low moose density were defined. A helicopter (Bell Ranger 206B) census followed between 17-25 February, when 251 plots averaging 1.3 ± 0.4 km^2 in size and covering 330.4 km^2 were distributed among the three moose density strata. The number of moose seen, dominant vegetation type, aspect, elevation, and time of survey were recorded for each plot surveyed. Search intensity averaged 3.7 ± 1.5 minutes/km^2. Additional details regarding this survey are given elsewhere (B.C. Hydro 1985).

Statistical Analysis

A two-staged approach was used to compare the observed distribution of a data set against its expected distribution according to the sample composition. A chi-square test (Zar 1974, page 49) first established if the distribution within a given data set differed from what was expected. If this test was significant ($p \leq 0.05$), Bonferroni normal

statistics (Neu et al. 1974) were then used to test differences at the level of each category within the data set. A confidence interval ($p \leq 0.05$) was calculated around the observed occurrence (i.e. a proportion of the total datum). If the expected occurrence (proportion) lay outside the confidence interval, then the observed category was significantly greater or smaller than expected. A preference index was often calculated by dividing the observed occurrence by the expected occurrence (Cairns and Telfer 1980). A preference index of 1.0 indicates that a given shrub species, habitat, etc. is being used in the proportion in which it is available. Preference indices greater or lesser than 1.0 respectively indicate preference or avoidance.

Differences between data means were established with a parametric approach. An univariate analysis of variance (ANOVA) first established whether or not significant differences existed between the categories of a given data set. If the ANOVA was significant ($p \leq 0.05$), a Newman-Keuls multiple range test was applied (Zar 1974, page 151) to individual pairs of means.

RESULTS

Habitat Types

Thirty-one vegetation types were defined in terms of the species composition and cover of their tree, shrub and herbaceous layers (B.C. Hydro 1985). These 31 types are conveniently grouped here into six major habitat types.

Sub-alpine habitats consist mainly of shrubland vegetation where willows (*Salix* spp.), bog birch (*Betula glandulosa*) and green alder

(Alnus viridis sinuata) are abundant. These species and alpine fir (Abies lasiocarpa) saplings dominate the shrub layers in the semi-open sub-alpine forests.

Burns consist primarily of a thick growth (60-100 percent cover) of tree saplings and shrubs. In dry areas, lodgepole pine (Pinus contorta) saplings dominate whereas in moister areas, willows and trembling aspen (Populus tremuloides) are more abundant.

Upland deciduous and mixed types consist of varied vegetation types, including open slopes, cottonwood (Populus balsamifera) or aspen forests, and mixed forests where the tree canopies support mainly aspen with white spruce (Picea glauca) and lodgepole pine. Shrubs are abundant in these types, with high bush cranberry (Viburnum edule), willows, trembling aspen, common saskatoon (Amelanchier alnifolia) and green alder being the most common species.

Upland coniferous forests are composed mainly of a treed canopy of lodgepole pine with or without black spruce (Picea mariana) and white spruce. The shrub layers in these types are usually sparse, with spruce saplings, alders, high bush cranberry and willows being the most common species.

Bog lowlands support few black spruce and tamarack (Larix laricina) trees and are overall dominated by black spruce saplings, willows and bog birch in the shrub layers.

Alluvial types include riparian edges where willows, thin-leaved alder (Alnus incana) and cottonwood saplings dominate, and alluvial forests where cottonwood and/or white spruce form the tree canopy. Red-osier dogwood (Cornus sericea), high bush cranberry, thin-leaved alder and wild rose (Rosa acicularis) are the most commom shrubs in the alluvial forests.

Browse Preferences and Utilization

Tall shrubs were selected by moose over low shrubs ($p<0.001$). Tall shrubs represented only 40 percent of the browse available, yet they contributed 66 percent of all browse utilization by moose (Table 1).

Although 43 shrub types (species or genera) were differentiated in our analysis, browsing was observed on only 28 types (Table 1). Willows were by far the most utilized species, contributing 35 percent of all browse utilization; yet they represented only 11 percent of all browse available. Willows, red-osier dogwood, mountain ash (Sorbus scopulina), bog birch, trembling aspen, alpine fir, paper birch (Betula papyrifera) and high bush cranberry were preferred by moose, whereas green alder, common saskatoon and cottonwood were taken in proportion to their availability. These eleven species accounted for 87 percent of all browse utilization. Although under-utilized by moose, wild rose, thin-leaved alder, soopollallie (Shepherdia canadensis), Vaccinium spp. and tamarack accounted for another 10 percent of total browse utilization. Overall, the utilization of these sixteen browse species, defined here as "A" species, was correlated to their availability ($r=0.83$).

Browse utilization in sub-alpine and alluvial habitats was significantly higher than that observed in burns and upland coniferous types (Newman-Keuls, $p \leq 0.05$) (Table 2). Browse utilization in upland deciduous and mixed types and in bog lowlands was intermediate between the sub-alpine/alluvial and burn/coniferous browse utilization values,

Table 1. Moose Preferences for Individual Browse Species on the Liard River, Based on Winter Utilization Relative to Availability - Ungulate Utilization Transects, 1978, 1980 and 1981

Browse Species	All Shrubs (>1 m and <1 m) % of Total Availability	% of Total Utilization	Preference Index	Shrub Type
Willows	10.7	34.7	3.24+*1	A
Red-osier dogwood	2.7	8.7	3.22+	A
Mountain ash	0.3	0.8	2.67+	A
Bog birch	2.2	4.1	1.86+	A
Trembling aspen	4.7	8.7	1.85+	A
Alpine fir	2.6	4.5	1.73+	A
Paper birch	3.6	5.6	1.56+	A
High bush cranberry	8.1	10.3	1.27+	A
Green alder	6.0	6.0	1.00	A
Common saskatoon	1.4	1.4	1.00	A
Cottonwood	2.2	2.0	0.91	A
Wild rose	10.2	5.7	0.56-	A
Thin-leaved alder	3.8	1.5	0.39-	A
Soopollallie	4.4	2.1	0.48-	A
Vaccinium spp.	0.8	0.3	0.38-	A
Tamarack	0.6 (0.83)*2	0.2	0.33-	A
Lodgepole pine	3.3	0.8	0.24-	
Ribes spp.	2.1	0.4	0.20-	
Rubus spp.	2.5	0.4	0.16-	
White spruce	5.3	0.7	0.13-	
Labrador tea	2.9	0.2	0.07-	
Black spruce	4.2	0.3	0.07-	
Kinnikinnick	3.1	0.1	0.03-	
Mountain cranberry	4.7	<0.1	<0.01-	
Others*3	7.8 (0.73)	0.3		
Total availability or utilization	28 902	10 205		
% of total availabilty or utilization - tall shrubs	40	66+*4		
- low shrubs	60	34-		

*1 Indicates statistically significant preference (+) or avoidance (-) of a browse species by ungulates. For the Bonferroni statistics (Neu et al. 1974) ($p \leq 0.05$), n equals the sum of the numbers of plots in which browsing was observed for each species, i.e. 5327 total instances of browsing for all shrub species.

*2 Coefficient of correlation between availability and utilization for A-species only, and all species.

*3 Light utilization was observed on silverberry, western choke cherry, shrubby cinquefoil and black crowberry.

*4 Chi-square tests ($p<0.001$) established utilization greater (+) or lesser (-) than expected.

Table 2. Relative Browse Utilization and Habitat Selection by Moose Wintering on the Liard River, Relative to the Availability of Sixteen "A" Browse Species in Different Habitat Types - Ungulate Utilization Transects, 1978, 1980 and 1981

Habitat Types and Groups	Mean Browse Utilization ± S.D. *1 Tall Shrubs	Low Shrubs	All Shrubs
SUB-ALPINE (14)*2	76 ± 36 +*3	14 ± 10	90 ± 48 +
Willow Shrubland (2)	64 ± 10	31 ± 16	95 ± 26 +
Deciduous Shrubland (5)	108 ± 33 +	11 ± 8	119 ± 52 +
Fir, White Spruce-Fir F. (7)	56 ± 34	12 ± 7	68 ± 41
BURNS (30)	29 ± 28	16 ± 16	45 ± 39
Pine Regrowth (9)	15 ± 15	16 ± 15	31 ± 29
Deciduous Regrowth (21)	35 ± 30	16 ± 17	51 ± 42
UPLAND DECIDUOUS AND MIXED (43)	32 ± 25 -	19 ± 26	51 ± 44 -
Open Slope Type A (7)	5 ± 4	13 ± 13	18 ± 15 -
Open Slope Type B (2)	68 ± 13 +	113 ± 34 +	181 ± 21 +
Dry Aspen Slopes (5)	22 ± 28 -	14 ± 19 -	36 ± 45 -
Aspen F. (5)	44 ± 21	17 ± 20 -	61 ± 37 -
Cottonwood Upland F. (2)	73 ± 30	23 ± 12	96 ± 42
Mixed Upland F. (22)	33 ± 20 -	14 ± 14 -	47 ± 28 -
UPLAND CONIFEROUS (50)	18 ± 25 -	14 ± 17	32 ± 37 -
Pine F. (6)	9 ± 14 -	15 ± 9	24 ± 18
Pine-White Spruce F. (14)	35 ± 36 +	24 ± 21 +	59 ± 52 +
Pine-Black Spruce F. (8)	10 ± 19 -	11 ± 21	21 ± 35 -
Spruce-Pine F. (10)	10 ± 8 -	7 ± 12	17 ± 18 -
Spruce (± Aspen) F. (12)	16 ± 16 -	8 ± 10 -	25 ± 22 -
BOG LOWLANDS (15)	30 ± 35	17 ± 16	47 ± 34
Sedge Meadow (2)	4 ± 4	42 ± 8 +	46 ± 4
Bog Birch Shrubland (5)	57 ± 45 +	20 ± 18	78 ± 34 +
Black Spruce Bog (8)	20 ± 19	8 ± 7 -	28 ± 24 -
ALLUVIAL (48)	46 ± 30 +	20 ± 17 +	66 ± 42 +
Riparian Edge (9)	64 ± 24 +	37 ± 26 +	101 ± 47 +
Cottonwood F. - poor type (8)	29 ± 34	10 ± 6 -	39 ± 38 -
- rich type (4)	72 ± 23 +	26 ± 7	98 ± 16 +
White Spruce-Cottonwood F. (11)	34 ± 20	17 ± 14	51 ± 27
White Spruce-Fir F. (8)	48 ± 35	11 ± 10 -	59 ± 43
White Spruce F. (8)	44 ± 30	21 ± 12	65 ± 39

*1 Mean utilization for all browse species is calculated from presence, cover and browsing values. *2 Number of transects. F. = forest(s).

*3 Indicates that browse utilization is significantly greater(+) or lower(-) than expected ($p \leq 0.05$). The proportion of total utilization contributed by a given vegetation type or group is compared to the proportion of "A" shrubs available in that same vegetation type or group.

not differing significantly from any habitat group in that regard. Given the availability of the sixteen "A" browse species, sub-alpine and alluvial habitats were preferred by moose. Burns and bog lowlands were utilized in proportion to the availability of their browse, whereas upland deciduous, mixed and coniferous types were under-utilized.

Moose Pellet Distribution

No attempt was made to use pellet density data to estimate moose populations as there are many sources of error in using such counts to census ungulate populations (Van Etten and Bennet 1965). Rather, pellet-group data were used to define the distribution of moose, although pellet distribution does not always give an accurate representation of habitat use (Collins and Urness 1981).

A total of 2393 plots were surveyed for the presence of pellets. Moose pellets were found in 613 of these plots, i.e. 26 percent of the total sample, and were present in all vegetation types except in the pine forest where 53 plots were sampled (Table 3). Pellets were sometimes found in the sedge meadow type, but no density measurements were obtained as pellets were often covered by water.

Given the sample composition, proportionally more plots with moose pellets than expected were located in the deciduous shrubland, burn with deciduous regrowth and riparian edge ($p \leq 0.05$). Sub-alpine, burn and alluvial habitats were preferred. Preference here indicates that these habitats were probably used by moose for feeding and/or resting. However, ungulates are also known to defecate while travelling (Collins and Urness 1981). Upland coniferous forests were consistently avoided, although moose may travel or seek cover in such habitats with-

Table 3. Moose Pellet Density and Winter Habitat Selection on the Liard River Based on the Distribution of Pellet Groups Relative to the Availability of Habitat Types - Ungulate Utilization Transects, 1978, 1980 and 1981

Habitat Types and Groups	% of Plots with Pellet-groups	Pellet-group Density (no./ha ± S.D.)
SUB-ALPINE (168)*[1]	12.9+*[2]	44 ± 39
Willow Shrubland (36)	0.7	12 ± 9
Deciduous Shrubland (54)	7.5+	86 ± 30
Fir, White Spruce-Fir F. (78)	4.7	33 ± 31
BURNS (383)	26.1+	33 ± 45
Pine Regrowth (101)	5.2	18 ± 21
Deciduous Regrowth (282)	20.9+	39 ± 52
UPLAND DECIDUOUS AND MIXED (540)	16.0-	10 ± 17
Open Slope Type A (85)	0.7-	2 ± 11
Open Slope Type B (22)	2.8	70 ± 50
Dry Aspen Slopes (54)	1.3	10 ± 12
Aspen F. (74)	1.0-	6 ± 1
Cottonwood Upland F. (28)	0.3-	4 ± 2
Mixed Upland F. (277)	10.0	9 ± 14
UPLAND CONIFEROUS (532)	6.9-	4 ± 8
Pine F. (53)	0	0
Pine-White Spruce F. (173)	3.6-	7 ± 10
Pine-Black Spruce F. (76)	1.3-	8 ± 11
Spruce-Pine F. (108)	0.8-	2 ± 3
Spruce (± Aspen) F. (122)	1.1-	2 ± 5
BOG UPLANDS (156)	6.0	26 ± 66
Sedge Meadow (30)	-*[3]	-*[3]
Bog Birch Shrubland (35)	3.3	92 ± 96
Black Spruce Bog (91)	2.8	8 ± 8
ALLUVIAL (614)	32.1+	21 ± 23
Riparian Edge (140)	13.7+	41 ± 24
Cottonwood F. - poor type (118)	3.6	12 ± 26
Cottonwood F. - rich type (38)	1.6	13 ± 10
White Spruce-Cottonwood F. (106)	5.5	21 ± 20
White Spruce-Fir F. (99)	1.6-	5 ± 4
White Spruce F. (113)	6.0	24 ± 25

*[1] Number of plots. F. = forest(s).

*[2] Indicates statistically significant habitat preference (+) or avoidance (-) ($p \leq 0.05$), based on proportion of plots sampled (n=2393) in a given habitat compared to the proportion of plots with moose pellets (n=613) observed in that same habitat.

*[3] Pellets covered by water; no density estimate was obtained.

out defecating. Upland deciduous and mixed types were also used less frequently than expected. Bog lowlands were used in proportion to their availability, but the difficulty of finding pellets in the sedge meadows may have partly reduced the percentage of plots with pellets in that habitat grouping.

When pellet densities are compared between habitat groupings (Table 3), no significant differences can be shown between the sub-alpine (44 groups/ha), burn (33), bog lowland (26) and alluvial (21) types (Newman Keuls tests, $p \leq 0.05$). However, pellet density in upland coniferous types (4 groups/ha) was consistently lower than in other habitats. Pellet density in the upland deciduous and mixed types (10 groups/ha) was intermediate, being significantly smaller than that observed in the sub-alpine, burn and alluvial habitats, and being greater than in the upland coniferous types. Three of the habitat groupings showing the greater pellet densities, i.e. the sub-alpine, burn and alluvial types, are also the three groups shown to be preferred by moose in terms of the percentage of plots with pellets (Table 3).

Moose Distribution

A total of 239 moose were observed in the 330.4 km² area censused, for an overall density of 0.7 moose/km² (Table 4). The distribution of moose numbers in different habitat types (in comparison to the actual areas surveyed for those types) reveals significant preference or avoidance patterns ($p \leq 0.05$). Sub-alpine (3.0 moose/km²), riparian/alluvial (1.2) and burn (1.1) habitats were clearly selected by wintering moose, whereas upland deciduous and mixed forests (0.4 moose/ km²), and coniferous forests (0.1) were avoided. Bogs (0.7) were seemingly

Table 4. Winter Density of Moose in Different Habitat Types Along the Liard River Valley - Helicopter Census Survey, February 1981

Habitat Types	Total Area Sampled (km²)	Mean Moose Density (no./km² ± S.D.)
Alpine Tundra	1.1 (1, 0)*1	0
Sub-alpine (Deciduous Shrubland)	6.2 (5, 17)	3.0 ± 2.2+*2
Burns	98.4 (73, 99)	1.1 ± 1.6+
Upland Deciduous and Mixed Forests	75.1 (60, 28)	0.4 ± 0.8-
Upland Coniferous Forests	62.1 (47, 7)	0.1 ± 0.3-
Bog Lowlands	20.4 (16, 13)	0.7 ± 0.8
Riparian/Alluvial Types	67.1 (49, 75)	1.2 ± 1.8+
Total or Mean	330.4 (251, 239)	0.7 ± 1.4

*1 Number of plots sampled, number of moose observed.

*2 Indicates statistically significant habitat preference (+) or avoidance (-) ($p \leq 0.05$), based on proportion of area sampled in a given habitat compared to the proportion of moose observed in same habitat.

used in proportion to their availability. Only one plot was located in the alpine tundra; no moose were seen there at that time nor at any other time when flying took place over alpine areas.

No preference could be detected for a given aspect or elevation in the 90 plots where moose were observed (Table 5; p>0.05). Moose were distributed according to the sample composition. Mean elevation between those plots with moose (681 ± 109 m) and those without moose (636 ± 167 m) did not differ significantly (t-test, $p \leq 0.05$). According to observations made elsewhere (Des Meules 1964), the snow depth observed on the Liard River during the winter 1981, i.e. from 30 to 65 cm, probably had little effect on moose distribution.

The moose density observed in the six habitat types sampled was strongly correlated to the pellet density (n=6, r=0.94) and browse utilization (r=0.91) measured in these same habitats (Table 6). Similarly, a strong positive relationship is observed between browse utilization and pellet density (r=0.93).

DISCUSSION

The selection by moose of tall shrubs over low shrubs may be attributed to many factors including the presence of snow cover, a different species composition in each shrub group, or the different growth form of various browse species (e.g. Labrador tea or wild rose seldom exceed 1 m in height). The presence of snow should reduce the utilization of the low shrubs since moose do not usually paw the snow aside to obtain food in the manner of caribou (Pruitt 1960).

Table 5. Moose Winter Distribution in Relation to Aspect and Elevation on the Liard River - Helicopter Census Survey, February 1981

	Sample Composition*1 (%)	Proportion of Total Number of Moose Seen*2 (%)
Aspect		
S, SE	27	28
E, NE	12	9
W, SW	21	18
N, NW	13	12
flat	23	31
varied	3	3
Elevation (m)		
400 - 460	1	0.5
461 - 520	4	4
521 - 580	16	20
581 - 640	23	22
641 - 700	21	21
701 - 760	13	13
761 - 820	4	3
821 - 880	7	6
881 - 945	7	6
946 - 1000	3	4
Mean (± S.D.)*3 681 ± 109		

*1 Percentage of plots in a given category. Moose were observed in a total of 90 plots.

*2 239 moose were seen.

*3 Mean elevation in the 161 plots without moose was 636 ± 167 m.

Table 6. Habitat Selection by Moose Wintering in the Liard River Valley, Based on the Distribution of Moose Numbers, Moose Pellets and Browse Utilization - 1978 to 1981

	Preference Indices*1		
Habitat Types	Moose Density (no./km² ± S.D.)	Pellet-group Density (no./ha ± S.D.)	Relative Browse Utilization (± S.D.)
Sub-alpine	3.74+*2 3.0 ± 2.2	1.84+ 44 ± 39	1.40+ 90 ± 48
Burns	1.32+ 1.1 ± 1.6	1.63+ 33 ± 45	0.91 45 ± 39
Upland Deciduous and Mixed	0.57- 0.4 ± 0.8	0.71- 10 ± 17	0.81- 51 ± 44
Upland Coniferous	0.16- 0.1 ± 0.3	0.31- 4 ± 8	0.78- 32 ± 37
Bog Lowlands	0.90 0.7 ± 0.8	0.91 26 ± 66	0.94 47 ± 34
Alluvial	1.60+ 1.2 ± 1.8	1.25+ 21 ± 23	1.12+ 66 ± 42

*1 Proportion of population observed in a given habitat ÷ proportion expected in same habitat = Preference Index.

*2 Indicates statistically significant preference (+) or avoidance (-) ($p \leq 0.05$).

Most browse species recognized in this study as preferred, i.e. red-osier dogwood, mountain ash, bog birch, trembling aspen, high bush cranberry, alpine fir and especially willows, are confirmed as being important to moose elsewhere in North America (Peek 1974). Silver (1976) identified willow, aspen and bog birch as the most important forage species for moose in the boreal White and Black Spruce zone of British Columbia. Willows constitute an important part of moose winter diet in many areas (Berg and Phillips 1974; Ritcey 1965). However, the proportion of the major browse species utilized differs in various regions as a function of their availability. Peterson (1955) noted that the availability of a food species is more important in influencing the actual composition of the diet than palatability or individual preference. This would not be entirely true in the Liard River valley where all browse species but three were utilized by moose in proportions significantly different from their availability. Overall, the correlation between the availability and utilization of all browse species was poor ($r=0.73$). However, the utilization of sixteen "preferred" (or A) browse species was more closely correlated ($r=0.83$) to their availability.

The habitat selection shown by moose as measured from browse utilization and pellet densities was consistent with the moose distribution observed from aerial surveys. Sub-alpine and alluvial habitats were utilized by moose to a greater extent than expected from their availability. Burns were utilized in proportion to their browse availability, but pellet and moose abundance in these types was greater than expected. A detailed analysis of browse utilization in burns showed that on the Liard River, only burns ranging in age from 15 to 38 years were selected by wintering moose (B.C. Hydro 1985). Upland deciduous, mixed and coniferous habitats were generally avoided by moose, whereas bog lowlands were utilized in proportion to their availability.

In Alaska, upland shrubby birch-willow, lowland bogs, riparian/alluvial habitats and especially burns are also the most important wintering habitats for moose (LeResche et al. 1974). The importance of burns (Bryant 1955; Peterson 1955; Peek 1972; Eastman 1976), shrublands (Cairns and Telfer 1980) and riparian/alluvial habitats (Kistchinski 1974; LeResche 1974) has been well documented elsewhere, with willow being identified as a primary food species. Moose in northwestern Minnesota, central Saskatchewan and northeastern Alberta, use mainly lowland willow habitats. These habitats are the ultimate winter refuge of moose in the absence of burns (LeResche et al. 1974).

Habitat selection by moose in the boreal forest in northern British Columbia was similar to that observed elsewhere in North America. Willows were the most important browse species. Sub-alpine shrublands, burns and alluvial habitats were selected by moose. Habitat selection as measured from browse utilization and pellet densities was consistent with the moose distribution observed during aerial surveys.

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