MOOSE WINTER FOODS IN THE INTERIOR OF BRITISH COLUMBIA: A PRELIMINARY ANALYSIS

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Preliminary analysis of moose (Alces alces) winter food habits at Revelstoke, B.C. from 1977-1985 is described in this report. Food habits were determined from samples of 242,292 bites at feeding sites, 24 rumen samples, and 864 stations on utilization transects. Major species in the winter diet included Pacific yew (Taxus brevifolia), western red cedar, (Thuja plicata), Oregon boxwood (Paxistima myrsinites), and various deciduous shrub species. Use was largely determined by availability, which was primarily related to snow accumulation. Utilized browse species were ranked in three groups depending on preference by moose over the winter period. There were major differences in food habits among different ecosites used by moose. Bias in the feeding site analysis technique can be reduced by sampling ecosites in proportion to usage patterns.

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Construction of a major hydro-electric dam on the Columbia River at Revelstoke, British Columbia was begun in 1977 by the B.C. Hydro and Power authority, a provincial crown corporation. Moose winter food habits were determined from 1977-1985 as part of a comprehensive series of studies to determine the impact of the energy project.

The importance of moose food habits determination was described by Peek (1974). At Revelstoke, this information was required to assess the impact of habitat loss, related changes in food plant utilization, and moose response to hydro-electric development.

Preliminary findings described in this report are subject to revision pending incorporation of more data. An earlier paper dealing with the Revelstoke moose study described winter population composition (Bonar 1983).

STUDY AREA

Moose winter range includes the Columbia River valley and major tributaries between Revelstoke and the Mica Dam in east-central British Columbia (Fig 1).

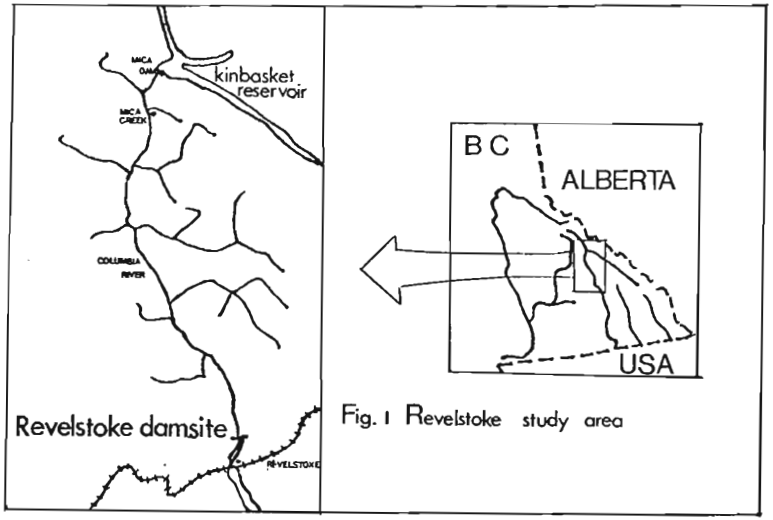

Fig. 1 Revelstoke study area

The area is extremely rugged, with elevations from 349-3076 m and very few areas of shallow slope. The Columbia River flows from north to south in a narrow valley bordered by the Selkirk Range to the east and the Monashee Range to the west. Glacial shaping has strongly influenced the area, leaving hanging valleys and shallow soils of low productivity (Achard 1973).

Annual precipitation averages 105 cm (381 cm snow) at Revelstoke and 146 cm (737 cm snow) at Mica Creek 125 km to the north. Mean annual temperatures are 7.2°C at Revelstoke and 4.2°C at Mica Creek. Maximum and minimum temperatures are 40.6°C and -34.4°C and 35.6°C and -37.2°C, respectively (Environment Canada AES 1971).

Plant names follow Taylor and McBride (1977). California filbert is synonymous with beaked hazel and Cornus sericea with Cornus stolonifera.

Moose are mainly confined to the Interior Western Hemlock (Tsuga heterophylla) Zone (Krajina 1969) below 1000 m in winter by extreme snow accumulations at higher elevations. Mature forests are dominated by western hemlock and western red cedar. White spruce (Picea glauca) and black cottonwood (Populus trichocarpa) are common on floodplains. Seral stages following fires and forest harvesting contain a mix of tree species including the above as well as paper birch (Betula papyrifera), western white pine (Pinus monticola), Douglas fir (Psedotsuga menziesii), and trembling aspen (Populus tremuloides).

Riparian understories are dominated by dense thickets of California filbert (Corylus cornuta), red-osier dogwood (Cornus sericea), and willows (Salix spp.). Mature confiferous forests on upland sites have sparse to thick shrub layers of Pacific yew, devil's club (Oplopanax horridus), and Oregon boxwood. Disturbed sites usually contain dense regrowth of willows, Oregon boxwood, Rocky Mountain maple (Acer glabrum), and saplings of the various tree species.

METHODS

Feeding Site Examinations

Moose were trailed from November-April and instances of browse plant use or 'bites' were tallied by species and ecosite following the feeding site examination method of Cole (1956). A minimum of 500 bites per trailing session in 1 of 10 ecosites was counted. Ecosites were defined as follows: 1. CEDHEM - mature coniferous forests dominated by western red cedar and western hemlock; usually sparse shrub understory; 2. CEDSPR - mature forests on floodplains dominated by western red cedar and white spruce; black cottonwood also common; shrub layer of red-osier dogwood, California filbert, and common snowberry (Symphoricarpos albus); 3. RIPSLG - selective logging of CEDSPR type, usually older than 10 years; shrub community extremely thick; 4. UPLSLG- selective logging of CEDHEM type, older than 10 years; dense shrub layer of Oregon boxwood, California filbert, and Rocky Mountain maple; 5. RIPLOG - clearcut logged CEDSPR site, varying ages; shrub

community of red-osier dogwood, California filbert, and willows as main species; 6. UPLLOG - clearcut logged CEDHEM site, varying ages; shrub community dominated by willows, black cottonwood and Oregon boxwood; 7. IMMFOR - immature mixed forest, mixed tree species; varying canopy closure depending on site; understory of Oregon boxwood, tree saplings; 8. ROADRW - road right-of-way, usually older than 10 years; shrubs dominated by black cottonwood and willows; 9. ALDWIL - thin-leaved mountain alder (Alnus tenufolia) and riparian willows on wet bottomland sites; usually adjoining CEDSPR type and water margin; 10. SLIDES - avalanche paths; shrubs dominated by Sitka mountain alder (Alnus sinuata); willows and black cottonwood also common.

Use of each plant species along the path selected by moose was estimated based on 6 categories: 0 - no use; 1 - <5% of available twigs browsed; 2 - 5-25% of twigs browsed; 3 - 25-50% browsed; 4 - 50-75% browsed; and 5 - >75% of twigs browsed. Data were summarized by month and ecosite following the aggregate percentage method (Martin et al. 1946).

Twig weight-diameter relationships for browse species were developed following methods described by Peek et al. (1971), and Telfer (1969). Diameter at point of browsing (dpb) (Shafer 1963) was measured for random samples of browsed twigs and used to estimate mean dry matter intake by species using the following equation:

$$Wp = e^{A} D^{B}$$

Wp is the predicted weight of a twig of diameter D where A and B are constants.

Rumen analysis

Rumen samples were analyzed following techniques used by Eastman (1974). Mixed samples were washed on a 4.0 mm mesh seive and the material remaining on the screen was separated by species using a dissecting microscope. Components of each sample were oven-dried at 50°C to constant weight.

Utilization Transects

Transects on moose winter range were arranged on a stratified random sampling basis perpendicular to the axis of the Columbia River (Smith et al. 1969). Measurements of categories at each station along transects included density of shrubs <1m height, shrubs >1m, trees (> 5 cm dbh), and moose pellet groups (Batcheler 1971, 1973, 1975). Species, size category, and number of browsed and unbrowsed twigs within reach of moose were counted for each stem chosen for density estimation purposes at each station.

RESULTS

Twig Weight-Diameter Relationships

A summary of browse species weight-diameter relationships is presented in Table 1.

Table 1. Weight-diameter relationships for browse plant species used as food by moose at Revelstoke during winter, 1977-1985.

Species	N	A	B	Mean Diameter	Coefficient of determination
Red-osier dogwood	99	-2.58	2.30	4.18	0.80
Willows	100	-2.83	2.39	4.64	0.84
Black cottonwood	50	-3.74	2.63	4.91	0.75
Trembling aspen	50	-3.04	2.31	4.48	0.87
Paper birch	99	-2.55	2.22	3.51	0.83
California filbert	99	-2.45	2.17	3.16	0.82
Pacific yew	108	-1.06	2.15	3.74	0.91
Oregon boxwood	114	-1.16	2.06	2.85	0.91
Sitka mountain ash	100	-5.09	3.71	4.80	0.82
Common saskatoon	100	-2.54	2.20	3.34	0.83
Sitka mtn. alder	100	-2.40	2.26	3.49	0.77
Thin-leaved mtn. alder	98	-2.48	2.27	3.57	0.74
Western red cedar	98	-0.72	1.75	2.75	0.67
Rocky Mtn. maple	100	-2.85	2.46	3.69	0.87
Western hemlock	100	-2.44	2.20	2.85	0.90

A and B are constants in the equation for the weight-diameter relationship.

The lower value of the coefficient of determination for western red cedar reflects the difficulty in determining basal diameter for the soft, elliptical twigs of this species (King 1975). These relationships were used to predict mean weight of a browsed twig for each species. The largest mean dpb's were for black cottonwood, Sitka mountain ash, (Sorbus sitchensis), and willows. The greatest dry weight removal per bite was estimated for species such as Pacific yew, western red cedar, and Oregon boxwood which have evergreen leaves or needles that contribute to the twig biomass in winter.

Feeding Site Analysis

A summary of 242,292 bites removed by moose at 154 feeding sites from November - April is presented in Table 2.

Table 2 Summary of browse species aggregate percentage use (dry weight) and rankings for major food plants at Revelstoke, British Columbia

	Nov		Dec		Jan		Feb		Mar		Apr		Total	
Species	Agg. % use	R	Agg. % use	R	Agg. % use	R	Agg. % use	R	Agg. % use	R	Agg. % use	R	Agg. % use	R
Red-osier dogwood	7.7	3	12.9	2	19.7	2	15.1	4	11.3	3	9.5	4	12.7	4
Willows	6.6	4	10.4	3	14.5	3	16.1	3	29.8	1	17.4	2	15.8	3
Black cottonwood	0.4	9	1.5		1.8	8	1.8	8	0.5		t		1.0	9
Trembling aspen	-		0.5		0.6		0.8	9	0.4		-		0.4	
Paper birch	2.0	6	3.0	6	3.6	7	3.3	7	2.8	7	6.6	5	3.6	7
California filbert	4.5	5	4.3	5	4.0	6	7.1	5	3.9	6	5.8	6	4.9	6
Pacific yew	30.1	2	51.2	1	40.0	1	29.8	1	10.9	4	11.3	3	28.9	1
Oregon boxwood	45.6	1	10.0	4	5.0	5	1.0		26.4	2	46.2	1	22.4	2
Sitka mountain ash	1.5	8	0.6		0.3		0.3		0.3		0.4	9	0.6	
Common saskatoon	t		0.1		0.2		0.4		0.1		t		0.1	
Sitka mountain alder	-		0.5		0.7		0.6		0.9	9	0.3		0.5	
Thin-leaved mtn. alder	0.3		0.6		1.2		0.4		0.4		t		0.5	
Western red cedar	-		1.6	9	7.2	4	19.6	2	10.2	5	0.9	8	6.5	5
Rocky Mountain maple	1.7	7	1.7	7	1.7	9	4.0	6	1.8	8	-		1.8	8
Western hemlock	-		1.6	8	0.3		0.4		0.8		-		0.2	
Lonicera involucrata	-		t		t		-		-		2.4		0.4	

R - rank of species by month in biomass removed (dry weight).
t - trace

During late autumn moose selected from a variety of plant species and removed smaller bites. The diet during this period was dominated by Oregon boxwood, the most abundant shrub on the study area. Use of boxwood declined rapidly during December as stems of this species were depressed by snowloading and became less available to moose.

Use of Pacific yew peaked at more than 50% of the diet in December, partly because moose tended to use mature coniferous stands where yew was the dominant browse species. Highly preferred and easily obtained species such as red-osier dogwood and willows were also important items in the early-winter diet. As snow continued to accumulate use of less

preferred species such as alders, western red cedar, and western hemlock started.

There was still some use of Oregon boxwood in January even though no stems of this species were visible above the snow surface. Moose cratered on steep slopes using both hoof and muzzle to obtain boxwood during this period. The usual method involved a moose standing facing uphill and pawing snow downhill away from the plant. The muzzle was then used to grasp the stem and tear upwards, usually removing most of the stem. Craters were extended uphill to obtain more stems in a particular clump.

Pacific yew, red-osier dogwood, and willows dominated the mid-winter diet. By February snow accumulations were at or near maximum and western red cedar constituted nearly 20% of the diet. Use of Pacific yew declined because of snow depression and lack of availability. Most of the above-snow stems of this species were heavily browsed by this time.

As the snowpack started to decline in March Oregon boxwood again became important in the diet. Moose obtained this species in quamaniq depressions (Pruit 1958) under trees and on south-facing slopes where snow first melted. Use of willows peaked as moose took advantage of hard snow crusts to utilize logged habitats where willows are the most abundant shrub.

The rapidly declining snowpack in late winter created conditions of browse availability and utilization similar to the late autumn period of November. Oregon boxwood again dominated a diet that included a wide variety of perferred browse species.

Preference

Average monthly preference scores for 14 browse species are shown in Table 3. There were 3 groups of species, each with similar characteristics. Group I consisted of Oregon boxwood, willows, red-osier dogwood, paper birch, and sitka mountain ash, all species consistently at or above 3 for the entire winter period. Moose selected these species regardless of avialability.

Table 3 Moose browse plant preference score and group rankings at Revelstoke, British Columbia.

Group	Species	Score					
		Nov	Dec	Jan	Feb	Mar	Apr
I	Red-osier dogwood	3.6	4.5	4.4	4.7	4.5	4.3
	Willows	4.5	4.9	4.8	4.8	4.7	4.3
	Paper birch	3.0	4.0	4.5	4.4	3.7	4.0
	Oregon boxwood	4.6	4.6	5.0	5.0	5.0	4.0
	Sitka mtn. ash	2.8	3.5	3.9	4.6	3.5	4.0
II	Pacific yew	4.5	4.7	4.8	4.7	4.6	2.4
	California filbert	3.3	4.0	3.7	4.2	2.7	2.3
	Common saskatoon	4.0	4.4	3.5	4.7	4.0	2.0
III	Black cottonwood	3.0	1.8	2.1	2.5	2.1	1.0
	Rocky mtn. maple	1.3	2.0	2.3	2.4	2.5	0.5
	Western red cedar	0	0.6	1.6	2.2	1.8	0.3
	Trembling aspen	-	3.3	3.6	4.2	4.0	0
	Sitka mtn. alder	0	1.9	1.4	2.0	3.6	0
	Roses	0	0	0.4	1.0	0.5	0
	Thin-leaved mtn. alder	0.6	1.5	1.5	1.3	1.0	0

and sitka mountain ash, all species consistently at or above 3 for the entire winter period. Moose selected these species regardless of availability.

Group II included Pacific yew, California filbert and common saskatoon (Amelanchier alnifolia), species that were highly preferred until April when scores abruptly declined. These can be considered as palatable food plants that were less preferred when there was abundant availability of Group I species.

Group III consisted of species such as rose (Rosa spp), western red cedar, and alders that were not used in early and late winter but were important during periods of deep snow. Western red cedar ranked fifth in terms of biomass in the winter diet but never achieved a mean preference score much above 2, indicating that less than 25% of available twigs were browsed.

Browse Utilization In Different Ecosites

There were major differences in percentage utilization of browse species attributable to different vegetation structure in the 10 ecosites (Table 4). Use of browse species groups in each ecosite type reflected availability.

Table 4 Summary of browse plant aggrregate percent utilization in ecosite types during winter at Revelstoke, 1977-1985.

	Ecosite type									
	CEDSPR		UPLSLG		UPLLOG		ROADRW		SLIDES	
	CEDHEM		RIPSLG		RIPLOG		IMMFOR		ALDWIL	
Species	%	%	%	%	%	%	%	%	%	%
Red-osier dogwood	1.9	50.0	41.4	6.6	41.0	7.9	4.1	9.2	25.2	6.6
Willows	2.6	3.5	12.4	15.8	7.3	31.5	23.5	46.7	59.5	41.3
Black cottonwood	0.3	0.3	3.3	2.6	4.1	2.1	2.5	7.2	2.8	5.2
Trembling aspen	2.1	-	-	0.8	-	2.8	2.1	0.4	-	2.7
Paper birch	0.2	0.4	10.4	5.4	12.8	14.2	6.1	17.3	0.3	10.9
California filbert	13.9	9.0	20.5	11.6	14.2	17.0	7.7	4.9	2.0	3.0
Pacific yew	52.9	12.6	-	30.0	0.9	4.2	5.0	1.3	5.3	-
Oregon boxwood	12.3	1.3	2.9	15.8	10.1	6.5	21.9	3.1	-	-
Sitka mountain ash	0.5	0.1	-	0.2	0.8	1.1	0.9	0.2	-	0.4
Common saskatoon	0.6	-	-	0.3	-	0.4	2.0	0.3	-	-
Sitka mountain alder	0.6	0.4	-	1.5	0.3	1.7	1.1	6.1	4.0	13.1
Thin-leaved mtn. alder	0.4	1.9	2.6	0.2	2.1	1.9	1.9	0.5	1.0	9.8
Western red cedar	8.7	19.8	3.1	5.1	6.1	4.2	16.1	0.1	-	5.1
Rocky Mountain maple	5.1	0.5	-	3.9	1.4	3.9	2.5	1.6	-	2.1

ecosite types are described in methods

Rumen Analysis

A summary of dry weight percentage composition of 24 rumen samples is presented in Table 5. These results correspond fairly well with those in biomass units derived from feeding site examinations, indicating that diet determinations derived from the 2 methods may be comparable. Detailed comparison will be undertaken after remaining rumen samples (N = 43) are analyzed and total diet is determined by comparing ecosite use with utilization.

Table 5 Summary of percentage contents (dry weight in gms) of rumen samples collected during winter atRevelstoke, 1977-1985.

	Nov	Dec	Jan	Feb	Mar	Apr	Total
Species	%	%	%	%	%	%	%
Athyrium filix-femina (fern)	0.6	-	-	-	-	1.7	0.4
Willows	8.5	8.5	16.9	27.2	31.1	3.4	15.9
Cornus canadensis	0.1	-	-	-	-	-	-
Sitka mountain alder	1.5	-	-	-	-	-	-
Thin-leaved mountain alder	-	-	13.0	2.6	8.6	-	4.0
Western red cedar	3.4	2.0	37.5	9.6	22.8	-	12.6
Oregon boxwood	34.8	20.9	t	7.2	12.5	73.7	24.9
Pacific yew	2.5	64.2	7.0	18.2	-	2.7	15.8
Red-osier dogwood	29.4	0.1	11.0	12.2	14.0	3.1	11.6
Black cottonwood	-	0.3	4.5	7.6	3.7	-	2.7
Paper birch	17.8	1.2	16.2	4.5	3.9	-	7.1
Lysichiton americanum	-	-	-	-	-	-	4.3
Common saskatoon	-	-	t	-	-	-	-
California filbert	1.2	3.1	6.9	3.6	3.5	-	3.1
Lobaria pulmonaria (lichen)	-	-	-	t	t	-	t
Rocky Mountain maple	t	-	t	7.0	-	-	1.2
Lonicera involucrata	-	-	-	-	-	11.1	1.9

Utilization Transects

A total of 864 stations on 83 transects were measured in 1978 and 1979. Density and biomass estimates have not been completed for these data. Tabulation of use on measured stems is summarized in Table 6. Utilization was highest for Pacific yew, red-osier dogwood, and common saskatoon, among major species in the tall shrub category. For trees, highest utilization was for paper birch, western red cedar, and black cottonwood. The high value for paper birch reflects a single tree that had 85% utilization of available twigs.

Table 6 Percent utilization of browse plant stems on moose winter range at Revelstoke, 1977-1985.

	Shrubs >1m ht		Trees >5cm dbh	
Species	No. stms measured	% use	No. stms measured	% use
Red-osier dogwood	414	26.6	-	-
Willows	333	6.0	27	2.3
Black cottonwood	50	11.3	95	6.0
Trembling aspen	29	2.6	65	1.2
Paper birch	58	10.9	4	48.3
Pacific yew	14	27.3	-	-
Oregon boxwood	20	0.5	-	-
Subalpine fir	3	2.4	2	-
Sitka mountain ash	9	3.5	-	-
Vaccinium ovalifolium	35	0.8	-	-
Common saskatoon	17	23.7	-	-
Sitka mountain alder	70	5.1	20	1.9
Thin-leaved mountain alder	141	8.0	81	6.6
Roses	3	12.5	-	-
Western red cedar	75	5.9	181	8.5
Rocky Mountain maple	98	6.5	17	3.0
Western hemlock	47	-	73	-
White spruce	16	-	56	-
Lonicera involucrata	71	0.1	-	-
Lonicera utahensis	24	0.9	-	-
Menziesia ferruginea	2	-	-	-
Western white pine	3	-	41	-
Douglas fir	5	-	18	-

DISCUSSION

Composition of and changes in moose winter food habits at Revelstoke reflected a combination of palatability and availability. Preferred species such as Sitka mountain ash and common saskatoon were heavily used by moose but were rare on the study area and did not constitute a large percentage of the winter diet. This was also true for subalpine fir (*Abies lasiocarpa*), a species used heavily by moose in other areas (Cowan et al. 1950, Hatter 1950, Pimlott 1953, Dodds 1960, Eastman 1977), but rare at Revelstoke on low-elevation winter range. Subalpine fir may be important to Revelstoke moose during mild winters or when snow crusts permit moose to use the Engelmann Spruce (*Picea engelmanni*) - Subalpine Fir Zone bordering low elevation range.

Oregon boxwood was highly preferred by moose but was unavailable during mid-winter due to snow depression. This species was also heavily used in Wells Gray Park (Ritcey 1965). Pacific yew was used to the extent that virtually all available twigs above snow level were removed each winter on sites receiving heavy winter use. In eastern North America *Taxus canadensis* was heavily used on Isle Royale (Pimlott 1953).

Willows, red-osier dogwood, California filbert, and paper birch were all important components of the winter diet. Use of these species has been well documented in the literature (Peek 1974, Trottier 1981).

Chronological preference of plant species is mainly influenced by availability. Winter snow depression of browse, mobility limitations, and density of food plants were major factors governing food selection.

Availability of preferred species within ecosite types also had a major effect on food plant selection. Considerable bias in determining winter diet could occur using the bite count technique unless ecosites are sampled in proportion to temporal use by moose. In this study, use of ecosites as determined by telemetry will be used to adjust estimates of total diet.

Moose are generalist herbivores that select a variety of preferred plant species (Miquelle and Gordon 1979). This pattern expands to include a number of less palatable species and increased use of preferred species (greater mean dpb, bark stripping) as availability decreases during winter. It appears that the energy costs associated with procurement of preferred species outweigh any advantages that moose might obtain from such a diet strategy. Use of less preferred browse species apparently satisified moose maintenance requirements when overall dietary quality was low and energy expenditure to obtain preferred species was high. Future analysis will include comparison of food habits determination by the 3 methods described herein and also the fecal analysis technique (Sparks and Malechek 1968).

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