Shiras moose forage selection in relation to browse availability in north-central Idaho

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Forty-eight feeding site examinations from 1979 to 1981, consisting of 13 653 instances of use, described seasonal diets of Shiras moose (*Alces alces shirasi*) in north-central Idaho. Thirty-three of these sites were in mature, dense conifer stands. Pacific yew (*Taxus brevifolia*), menziesia (*Mensiesia ferruginea*), Sitka alder (*Alnus sinuata*), mountain maple (*Acer glabrum*), and Scouler willow (*Salix scouleriana*) constituted over 90% of the observed diet in all seasons. Menziesia and alder were highly selected during summer. During winter, Pacific yew and menziesia were used in proportion to their availabilities. The extensive use of menziesia, Pacific yew, and alder was considered to be a result of low availability of alternative species and moose dependence on forage under mature canopies during winter when snow depths precluded use of open areas such as clear-cuts.

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L'examen de 48 points d'alimentation utilisés 13 653 fois de 1979 à 1981 a permis de décrire les régimes alimentaires de l'original *Alces alces shirasi* dans le centre nord de l'Idaho. Trente-trois de ces sites étaient situés dans des forêts denses, à maturité, de conifères. L'if occidental (*Taxus brevifolia*), le menziesia (*Mensiesia ferruginea*), l'aune de Sitka (*Alnus sinuata*), l'érable nain (*Acer glabrum*) et le saule (*Salix scouleriana*) constituent plus de 90% du régime alimentaire en toutes saisons. Le menziesia et l'aune sont les aliments préférés de l'orignal en été. En hiver, l'if occidental et le menziesia sont utilisés selon leur disponibilité. L'utilisation considérable du menziesia, de l'if occidental et de l'aune semble résulter d'une part de la rareté des autres espèces et, d'autre part, de l'obligation qu'ont les orignaux de se nourrir en forêt en hiver lorsque la couverture de neige est trop profonde dans les terrains ouverts, par exemple où il y a eu de la coupe à blanc.

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The association of moose and browse and the phenomenon of superabundance of forage biomass with overstory removal (Dyrness 1973; Bendell 1974; Wittinger *et al.* 1977; Irwin and Peek 1979) has led to the generalization that moose are best adapted to early seral communities created by fire and logging (Taber 1966; Krefting 1974; Peek *et al.* 1976; Kelsall *et al.* 1977; Franzmann 1978; Doerr 1983). However, in areas with prolonged periods of deep snow, mature dense conifer stands with abundant shrubs in the understory receive substantially more use by moose than nearby cutover areas (Telfer 1974; Ritchie 1978; Peek *et al.* 1982; Pierce 1983). Additionally, in areas depauperate of palatable early seral shrub species, moose may rely more heavily on late successional species.

Diets of Shiras moose inhabiting grand fir (*Abies grandis*) forests of north-central Idaho have not been previously studied. The recent increase in timber management in this area has increased the need to understand the role that logged sites play in providing forage for moose under deep snow and low shrub diversity conditions. This investigation was initiated to examine whether or not timber harvest in north-central Idaho would benefit resident moose populations as it has in other areas (Doerr 1983; Peek *et al.* 1976; Krefting 1974).

Study area

The 118 000 - ha study area was located on the Nez Perce National Forest, Idaho, in the Elk City (45°50′ N, 115°28′ W) vicinity. Elevations ranged from 600 m to 2700 m. Three mountain lakes occurred above 2000 m on the study area. Numerous gold dredge ponds, created in the 1950's, were scattered along roads in the bottoms of major tributaries of the South Fork of the Clearwater River.

Most of the forest occurred within the grand fir and subalpine fir (*Abies lasiocarpa*) vegetation zones (Steele *et al.* 1976). Other major tree species on the study area were ponderosa pine (*Pinus ponderosa*), Douglas-fir (*Pseudotsuga menziesii*), western larch (*Larix occidentalis*), lodgepole pine (*Pinus contorta*), and Englemann spruce (*Picea englemannii*). Pacific yew, a major component on grand fir – ginger (*Asarum caudatum*) habitat types (Steele *et al.* 1976), reached heights of 10 m and canopy coverage was frequently greater than 50%. Menziesia, huckleberry (*Vaccinium globulare*), Sitka alder, mountain maple, rose (*Rosa* spp.), spiraea (*Spiraea betulifolia*), honeysuckle (*Lonicera utahensis*), and snowberry (*Symphoricarpos albus*) were common shrub species present on the study area. Plant nomenclature follows Hitchcock and Cronquist (1973).

Winters were characterized by cold temperatures (20-year average minimum daily temperature was −10°C) and deep snow (average annual snowfall was 360 cm). Summers were generally cool (average maximum daily temperature was 24°C) and dry (average summer precipitation was 3 cm).

Methods

Most of the species fed upon by moose on the study area were shrubs. Occasional use of forbs and graminoids amounted to less than 5% of all recorded use (Pierce 1983). Quantitative diet analyses were restricted to shrub species.

The availability of each shrub species was determined at 177 randomly located 375-m^2 plots, established independently of feeding site locations. Fifteen 4-m^2 circular microplots were sampled at 80 of these random locations. The total number of current annual twigs produced by each species in each microplot was tallied. Only twigs within 4 m of the ground were recorded, since browsing was not observed above that height. Shrub canopy cover in each microplot was determined by estimating the percentage of the area within the circle that was covered by foliage of each shrub species. The average percent cover of each species was estimated by eye (Pfister *et al.* 1977) at the remaining 177 random plots. An additional 77 clear-cuts were systematically selected and sampled since they were poorly represented ($n = 4$) in the 177 random plots. Cover estimates were placed into one of six percent classes: <1, 1–5, 6–25, 26–50, 51–75, 76–100%.

The average number of twigs per square metre in each cover class was determined for Pacific yew, huckleberry, menziesia, mountain maple, rose, spiraea, honeysuckle, and snowberry. The average num-

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TABLE 1. Browse availability estimates based on number of twigs per square metre for different shrub canopy cover in north-central Idaho, 1979–1981.

Species	% of plots on which species occurred	Average % cover on plots	No. of twigs/m² for cover estimates in column 3	Availability: No. of twigs/m² available on all plots[a]	Availability: Rank
Huckleberry	85	14	18(5)[b]	15	1
Menziesia	59	9	13(2)	8	2
Pacific yew	33	11	22(5)	7	3
Sitka alder[c]	29	8	20	6	4
Spiraea	55	4	5(1)	3	5
Snowberry	47	2	4(1)	2	7
Honeysuckle	67	2	3(1)	2	7
Serviceberry[c]	52	2	3	2	7
Scouler willow[c]	18	5	3	1	11.5
Mountain maple	33	4	3(1)	1	11.5
Currant[d]	33	3	4	1	11.5
Rose	71	3	2(1)	1	11.5
Ceanothus[d]	21	3	4	1	11.5
Elderberry[c]	3	9	20	1	11.5
Red osier dogwood[d]	1	8	13	0	15

[a]Availability estimates were obtained by multiplying column 4 by column 2 and dividing by 100.
[b]Confidence intervals (95%) are reported only for twigs of species that were counted.
[c]Twig estimates for mountain maple were assigned to these species.
[d]Twig estimates for menziesia were assigned to these species.

ber of twigs for each species estimate was multiplied by each species constancy value (percent of plots where species occurred) to determine the availability of these shrub species over the entire study area. Availability of other shrub species on the study area was derived using the twig estimates for either menziesia (for species of medium height) or mountain maple (for tall species).

Forage use patterns of moose were determined using a feeding site technique (Cole 1956; Knowlton 1960). Free-ranging radio-collared and unmarked moose were first observed and then allowed to leave a site before examination for fresh use on vegetation. During winter, fresh tracks were followed when the animal was not seen. Data collection at a feeding site was terminated if the feeding trail entered a different vegetation type. A complete tally of instances of use encountered on the site was recorded. One instance of use was defined as a fresh bite on one twig, forb, or blade of grass. During summer moose stripped leaves off branches. Each stripped twig was counted as one instance of use.

The seasonal total instances of use of each browse species in all feeding sites was multiplied by the proportion of feeding sites where use was recorded. These products were summed across all species in order to calculate an aggregate percent use for each species by season (Martin *et al.* 1946).

Relative forage preferences were examined by comparing the average difference in the rank of percent use of a species from the rank of the species' availability (Johnson 1980). Species rarely used in seasonal diets were grouped and treated as one forage type. The relative abundance of low-growing shrubs (e.g., huckleberry, rose, snowberry) during winter was arbitrarily set at 0% to simulate the effects of deep snow on forage availability. Both measures of availability (i.e., snow and no snow) were used to determine relative winter forage preferences, following Johnson (1980).

Moose also fed in dredge ponds and in high elevational lakes. However, no attempt was made to quantify diets of moose in aquatic environments. Qualitative observations were made in an effort to determine what plant species were eaten.

Results

Forage availability

Huckleberry was the most available browse to moose on the study area (Table 1). Its high constancy (85%), combined with its relatively high cover on sites where it occurred (14%), resulted in an average of 18 twigs/m² over the entire study area. Other species commonly available to moose for browsing were yew, menziesia, and alder. Most of the other shrub species were either uncommon (e.g., elderberry (*Sambucus racemosa*) and red-osier dogwood (*Cornus stolonifera*)) or else were common but had little canopy cover (e.g., honeysuckle and snowberry), resulting in low estimates of availability.

TABLE 2. Constancy[a] and average percent canopy coverage (the latter in parenthesis) of five common shrub species according to overstory cover type in north-central Idaho, 1979–1981

Species	Old-growth sites[b] (n = 24)	Mature mixed-age sites[c] (n = 67)	Even-aged sites[d] (n = 39)	Clear-cut sites[e] (n = 81)
Pacific yew	80(25)	40(5)	20(5)	20(5)
Mountain maple	70(5)	45(5)	15(1)	20(5)
Menziesia	80(10)	60(5)	65(5)	45(10)
Sitka alder	30(1)	20(5)	35(5)	50(10)
Huckleberry	70(10)	90(10)	90(15)	90(5)

[a](Number of plots of occurrence/total number of plots sampled) × 100.
[b]Grand fir overstory, dbh larger than 40 cm.
[c]Grand fir overstory, dbh between 20 and 40 cm.
[d]Lodgepole overstory, dbh less than 20 cm.
[e]Average age since disturbance = 14 years.

The occurrence of shrub species on a plot was associated with overstory characteristics (Table 2). Pacific yew, mountain maple, and menziesia were most common under old-growth grand fir canopies. These same species were least likely to occur on clear-cuts. Huckleberry and Sitka alder were found most often in clear-cuts and least often in old-growth stands.

Forage use

A total of 48 feeding sites, comprising 13 653 instances of use were examined from 1979 to 1981. Most of the feeding sites were located in old-growth and mature forest (Table 3).

The spring (May–June) diet was dominated by menziesia

TABLE 3. Instances of use (IU), number of feeding sites (NFS), and aggregate percent use (APU)[a] of browse species by moose at 48 feeding sites and their percent availability[b] in north-central Idaho, 1979–1981

	May–June			July–September			October–November			December–April			Availability (%)	
Species	IU	NFS	APU	IU	NFS	APU	IU	NFS	APU	IU	NFS	APU	No snow	Snow
Pacific yew	48	2	3	5	1	0	615	3	42	1427	13	41	18	35
Menziesia	336	5	48	4727	14	80	74	3	5	1030	13	29	14	26
Scouler willow	285	4	35	87	2	0	519	4	48	312	8	5	2	4
Sitka alder	7	1	0	1975	9	19	14	1	0	190	6	3	6	11
Huckleberry	67	4	8	173	6	1	4	2	0	82	5	1	23	0
Mountain maple	18	2	1	0	0	0	0	0	0	756	10	17	3	7
Currant	66	1	2	0	0	0	159	1	4	382	4	3	3	0
Spiraea	0	0	0	0	0	0	0	0	0	16	1	0	8	0
Rose	27	4	3	0	0	0	0	0	0	45	4	0	5	0
Snowberry	2	1	0	0	0	0	0	0	0	4	2	0	6	0
Ceanothus	27	1	0	0	0	0	7	1	0	7	1	0	2	4
Elderberry	9	1	0	0	0	0	0	0	0	1	1	0	1	2
Serviceberry	38	2	1	40	1	0	0	0	0	23	4	0	5	9
Red osier dogwood	0	0	0	61	1	0	0	0	0	0	0	0	1	2
Honeysuckle	0	0	0	0	0	0	11	1	0	21	2	0	3	0
Total IU	930			7107			1403			4297				
NFS in mature overstory[c]		5			9			2			16			
NFS in pole timber		0			4			0			0			
NFS in clear-cuts		2			4			2			4			
Total NFS		7			17			4			20			

[a]APU was calculated by the following formula: $IU_i(NFS_i/\text{total NFS})/\sum_{i=1}^{n}(IU_i(NFS_i/\text{total NFS}))$.

[b]Percent availability was calculated using the above formula, substituting number of twigs and percent species occurrence from Table 1 for IU and NFS, respectively.

[c]Old-growth and mature mixed-age feeding sites combined.

TABLE 4. Average rank of browse species use by moose in north-central Idaho (1979–1981) at a feeding site and the average difference of this use from the availability rankings of each species according to season (a positive value indicates the average rank of use was greater than the rank of availability)

Species	May–June		July–September		October–November		December–April		
								Average difference	
	Rank of use	Average difference	Rank of use	Average difference	Rank of use	Average difference	Rank of use	Snow[a]	No snow
Pacific yew	—	—	—	—	2.1	+1.9	3.7	−2.2B[b]	−0.2C
Menziesia	2.9	+0.1	1.6	+1.4A	3.4	+0.4	3.7	−2.0B	0.0C
Scouler willow	3.2	+1.8	—	—	2.7	+2.3	4.9	+1.8A	+3.3AB
Sitka alder	—	—	2.2	+1.8A	—	—	5.4	−2.4B	−0.4C
Huckleberry	3.5	−1.5	2.9	−0.9B	3.3	−1.3	6.0	+2.5A	−5.0E
Mountain maple	—	—	—	−0.9B	—	—	4.3	+2.2A	+3.7A
Currant	—	—	—	—	—	—	5.7	+2.8A	+2.3B
Serviceberry	—	—	—	—	—	—	6.1	−1.7B	−0.2C
Rose	3.5	+0.5	—	—	—	—	—	—	—
Other[c]	1.9	+0.9	3.2	−2.2C	3.5	−2.5	5.4	−0.9B	−3.4D
F-statistic		Not tested		78.5		Not tested		25.9	53.8
(Degrees of freedom)				(3,14)				(8,12)	(8,12)
P				0.001				0.001	0.001

[a]Availability of shrubs shorter than 60 cm was assumed to be zero under snow column.
[b]Moose seasonal preferences for species with the same letter were not significantly different.
[c]Species were grouped together when use during a particular season was less than 1%; e.g., alder use was less than 1% during spring and fall and thus was grouped in the "other species" category.

and Scouler willow, comprising over 80% of the recorded use (Table 3). Huckleberry and rose were also used. Nine species each constituted over 1% of the observed spring diet. Use was noted on many forb species during this time (Pierce 1983).

Use was greater than 1% for only three browse species during summer (July through September) (Table 3). Menziesia and alder constituted over 90% of the recorded use. Menziesia was fed on exclusively at five sites. Its use was ranked first on 11 of the 14 sites where it was eaten. Alder use (rarely fed upon in the spring) was ranked first at five summer feeding sites. Huckleberry was the only other shrub fed on regularly. Summer was the one time when moose were observed feeding in pole timber, and most of the recorded use of huckleberry occurred in this cover type.

Animals first started feeding in dredge ponds in mid-May and continued through mid-September. *Nitella* spp. grew abundantly on the bottoms of many dredge ponds and was fed on extensively. Other species used at these sites were sedge (*Carex nebraskensis*), orchard grass (*Dactylis glomerata*), and willow (*Salix* spp.)

Both Pacific yew and Scouler willow dominated the diet during fall (October–December) (Table 3). Other species browsed during the fall were currant (*Ribes* spp.), alder, snihyleaf ceanothus (*Ceanothus velutinus*), and huckleberry.

The dominance of yew in the moose diet continued through winter (Table 3). Menziesia was once again used heavily and mountain maple was fed on regularly. Seven species each constituted over 1% of the observed winter diet. Most of the feeding sites occurred in late successional forests. Four feeding sites were recorded in clear-cuts during early December. Moose fed on beargrass (*Xerophyllum tenax*) at four of the winter feeding sites. Moose clipped blades near the base, consuming some and leaving many blades scattered on the ground, which made quantitative comparisons inappropriate. Most use on beargrass was noted when snow cover was spotty, although occasionally animals had pawed through snow to feed on it.

Forage preference

Species browsed most during summer (menziesia and alder) were also most preferred at this time (Table 4). In contrast, during winter species browsed most (yew and menziesia) were not as preferred as species receiving substantially less use (i.e., Scouler willow, mountain maple, and currant). At best, preferences with no snow effect indicated that yew and menziesia were used in proportion to their availability during winter. Limited spring and fall foraging data suggests that the dominant browse species in the diet at these times may also be preferred.

Discussion

Extensive use of Pacific yew, menziesia, and alder by Shiras moose has not been previously reported. Pacific yew is the western counterpart to Canada yew (*Taxus canadensis*), a species known to be highly palatable to moose (Pimlott 1961; Murie 1934; Aldous and Krefting 1946). Pacific yew was apparently very palatable to Shiras moose, especially during fall and winter. Evidence of extensive use of Pacific yew was observed in all stands where it occurred. Many of the yew trees were severely hedged (following Cole 1959), and evidence of barking on yew trees was pronounced. Pacific yew, a coastal disjunct, is especially abundant in the study area (Crawford 1983). This undoubtedly contributed to its importance in the moose diet.

Menziesia received surprisingly high levels of use. It was the major forage taken during summer and was second only to yew during winter. Menziesia accounted for over 15% of the summer moose diet in the spruce–fir cover types of Jackson Hole (Houston 1968). However, it received little moose use there during winter and its palatability was considered very low (Harry 1957). Menziesia has not been considered a major forage species for ungulates, with the result that biologists excluded it from calculations of available forage biomass (e.g., Orme and Ragain 1982).

The extensive use that menziesia received during this study

was probably related to its abundance on the study area. Normally this species is associated with cool environments, reaching maximum site importance in the subalpine fir – Engelmann spruce zone in northern Idaho (Daubenmire and Daubenmire 1968) and Montana (Pfister *et al.* 1977). Steele *et al.* (1976), however, found menziesia to be abundant on grand fir – clintonia (*Clintonia uniflora*) and grand fir – ginger habitat types as well as an important species in the subalpine fir zone in the study area. The wide distribution of menziesia on the study area made it highly available to moose.

Limited winter use of thinleaf alder (*Alnus incana*, previously *A. tenuifolia*) has been reported for Shiras moose (Houston 1968; Knowlton 1960; Harry 1957). Thinleaf alder grows on the study area but is restricted to stream bottoms and other wet areas. Sitka alder was much more prevalent, occurring throughout the study area at the heads of draws in small openings and under timber canopies. Moose were often seen feeding in these alder patches, stripping leaves. Alder leaves, unlike other browse available, remained green throughout the summer and well into the fall.

Additionally, previous Shiras moose diet studies may have found menziesia and alder to be unimportant because other more palatable browse species were abundant. The highly palatable riparian willow species (*Salix pseudocordata, S. interior, S. drummondiana*) that are major constituents of the reported diets of most other Shiras moose studies (Peek 1974) are virtually nonexistent in the forests of north-central Idaho. Only the upland growing Scouler willow was available in any quantity. Other recognized preferred browse such as redosier dogwood, chokecherry (*Prunus virginiana*), cottonwood (*Populus* spp.), and mountain ash (*Sorbus scopulina*) were uncommon. Huckleberry, a browse species considered to be moderately palatable to big game (Orme and Ragain 1982; Hanley and McKendrick 1983; Irwin 1976), was the most available shrub to the moose on the study area. Yet menziesia and alder were consistently browsed more heavily and were significantly preferred over huckleberry during summer.

Big game forage preferences described for local populations (Harry 1967; Houston 1968; Irwin 1976; Orme and Ragain 1982) can be misleading when extrapolated to areas where availabilities of forage species are dissimilar (LeResche and Davis 1973; Cushwa and Coady 1976). Possible geographic variation in chemical composition of forage species (Hanley and McKendrick 1983; Bryant *et al.* 1983; Bryant and Kuropat 1980; Prudhomme 1983) may have also contributed to the observed forage selection patterns. Comparisons of moose diets among studies with a wide range of biomass and nutrient availabilities are useful for these reasons.

In addition to absolute availability of browse, moose diets in the study area were affected by relative availabilities imposed by substantial annual snowfall. Deep snows have been reported to restrict moose movements and use of habitat in other areas (Kelsall 1969; Formozov 1946; Peek 1971; Telfer 1974; Thompson and Vukelich 1981). Snow depths in clearcuts averaged over 70 cm from December through March (Pierce 1983). During winter, moose in the study area were restricted to mature forests with abundant browse (Pierce and Peek 1984).

Pacific yew, menziesia, and mountain maple dominated shrub understories in old-growth grand fir stands on the study area. These species provided abundant forage during deep snow periods when other shrubs in clear-cuts were unavailable to moose. Pacific yew and menziesia are not favored by timber harvest (Crawford 1983; Stickney 1980; Mueggler 1965). As a result, timber harvest on this study area probably would not favor moose populations, contrary to the general belief that high quality winter moose habitat is characterized by early seral communities.

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