HABITAT SELECTION BY MOOSE IN THE YAAK RIVER DRAINAGE, NORTHWESTERN MONTANA

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Abstract: Logging began during the 1950's and is now the primary land use in the Yaak River drainage. The relationships between timber management and moose habitat were evaluated using 669 locations of 12 radio marked moose (*Alces alces shirasi*) collected between January 1982 and September 1983. Harmonic mean home ranges were used as a tool to delineate available habitat for selection analyses. On a yearlong basis, moose use was greater than expected in: clearcuts, logged areas less than 12 ha in size, areas logged 15-30 years ago, or within 100 m of a cutting unit. Moose selected elevations below 1067 m in winter and above 1524 m in summer. Moose used logged areas more in early winter than during mid and late winter when densely timbered sites were selected. Thirty percent of spring and summer locations were in clearcuts. Cows used thicker vegetation than bulls, but bulls were found more often in timbered areas. Cows with calves and bedded moose used security type habitats more than cows without calves and active moose. Maintaining a mosaic of small, 15-30 year-old logged areas intermixed with mature, closed canopy, timbered stands will provide productive moose habitat in the Yaak valley.

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Moose are well adapted to early successional vegetation that is associated with periodic natural fires. Montana's moose populations increased after the widespread fires of 1910 and continued to increase after fires in the early 1930's. Closed moose hunting seasons between 1897 and 1945 also promoted population increases (Schladweiler 1974). Today, fire is less important in maintaining moose habitat because of the efficient fire suppression capabilities of land management agencies.

In place of periodic natural fires, logging can create and sustain productive moose habitat (Peek et al. 1976). Although logging activities are virtually certain to increase the amount of available forage, other requirements of moose may be compromised by poorly planned cutting operations. Pockets of moist, shaded habitat seem to be important in summer and dense conifer stands are utilized for shelter and feeding during winter (Kelsall and Telfer 1974, Peek et al. 1976, Pierce 1983, Pierce and Peek 1984).

This study was conducted from June 1981 to September 1983 and is the first intensive work to be done in northwestern Montana. Jonkel (1963) completed some preliminary investigations in the Whitefish range of northwest Montana, but the Yaak valley possesses different habitat components.

Pacific coast weather patterns moderate temperatures and produce 100 cm of precipitation each year in areas of the Yaak. The abundant moisture and low rolling terrain combine to produce dense, continuous forests in the absence of disturbance. The study site of Pierce (1983) in north-central Idaho was similar to the Yaak. However, his study area contained a significant amount of Pacific yew (*Taxus brevifolia*) which was rarely found in the Yaak.

In contrast, much of the moose range of southwest Montana and northwest Wyoming contains extensive willow (Salix spp.) flats, aspen (Populus tremuloides) stands, mountain parklands, and sagebrush (Artemesia spp.) and bunchgrass communities. These vegetation types are not found in northwest Montana. The majority of Montana's moose research was conducted in the southwest quarter of the state (McDowell and Moy 1942, Schultz and McDowell 1943, Knowlton 1960, Peek 1961, 1962, and 1963, Stevens 1965, 1966, 1967, and 1970, Dorn 1969, 1970, Schladweiler and Stevens 1969 and 1973, Schladweiler 1974).

The presence of a well established moose population, the dissimilarity of the mesic Yaak valley with other study sites, and the opportunities that logging presents for moose habitat management prompted the U.S. Forest Service and the Montana Department of Fish, Wildlife, and Parks to request and support this study. The Kootenai National Forest harvests timber from several thousand acres each year. The effects of logging on moose habitat are not clear and guidelines are needed to effectively manage moose habitat and maintain timber productivity.

This manuscript has 2 objectives; 1) describe a method to delineate available habitat for habitat selection analyses and 2) describe moose habitat use and selection in the Yaak valley.

STUDY AREA

Two drainages of the Yaak River, Spread and Pete Creeks, served as the initial study area (Fig. 1). The study area boundaries were ultimately defined by movements of radioed moose which encompassed over 500 km^2. The Spread Creek drainage had fewer cutover areas than the intensively logged areas in the Pete and Lap Creek drainages. Rolling hills made up this part of the Purcell Mountains and slopes rarely exceeded 40%. Elevations on the study area ranged from 850 to 1825 m.

Logging is the major land use, but recreation is also important. Clearcutting prevails, but selection, sanitation, and overstory removal cuts are also prescribed. Intensive logging began in the 1950's with efforts concentrated on stands infected with spruce bark beetle (Dendroctonus rufipennis). During this time, many roads were built into high spruce-fir basins. This road system has since been expanded and now, few points on the study area are more than 1 km from a road. Recent and present logging activities are concentrated on mountain pine beetle (D. ponderosae) infestations of lodgepole pine.

A diverse vegetation pattern is found in the Yaak. Burns in 1910 and the early 1930's have regenerated predominantly to lodgepole pine. High basins logged in the 1950's are slowly regenerating into subalpine fir (Abies lasiocarpa) and spruce (Picea engelmannii) and have a dense shrub cover composed of menziesia (Menziesia ferruginea), honeysuckle (Lonicera utahensis), and alder (Alnus sinuata). Bare ground to dense vegetation on cutover areas has resulted from more recent cuts. Douglas fir and larch (Larix occidentalis) are preferred timber regeneration

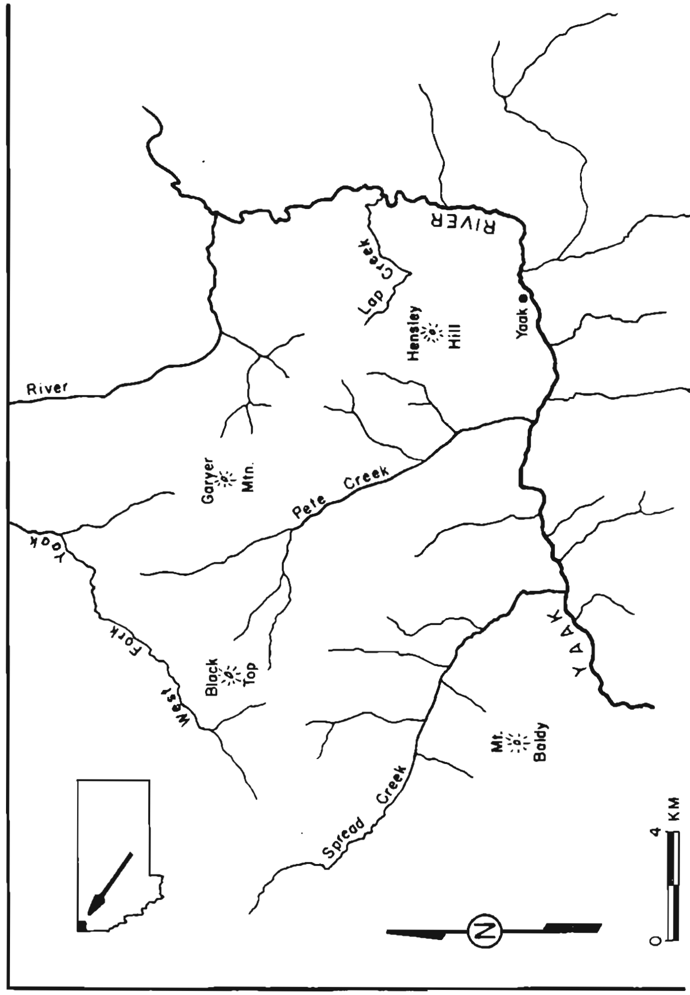

Fig. 1. Yaak River moose study area.

stock and are often planted. Natural regeneration of lodgepole pine, spruce, hemlock, and cedar is also common.

Browse species in cutover areas included; redosier dogwood (Cornus stolonifera), shiny-leaf ceanothus (Ceanothus velutinus), serviceberry (Amelanchier alnifolia), pachistima (Pachistima myrsinites), menziesia, cottonwood (Populus trichocarpa), willow, and aspen. Occasional moose browsing was noted on cedar, Douglas fir, lodgepole pine, buffalo berry (Shepherdia canadensis), huckleberry (Vaccinium spp.), alder, and honeysuckle. Moose often ate old man's beard (Alectoria spp.), an arboreal lichen, in winter.

Timbered sites at upper elevations characteristically have an overstory of subalpine fir, spruce, or lodgepole pine with moderate to dense shrub understories. Mid-elevation timbered sites contain overstories of hemlock and cedar or lodgepole pine, Douglas fir, and larch. Hemlock and cedar stands often have little understory vegetation, but downfall may be extensive. Lodgepole pine, Douglas fir, and larch stands often contain moderate to dense understories of shrubs and cedar and hemlock saplings. Low elevation sites usually have Douglas fir and larch components and open ponderosa pine (Pinus ponderosa) stands are found on some southern slopes.

METHODS

Capture and Radio Telemetry

Twelve moose (8 cows and 4 bulls) were captured and fitted with radio collars (Telonics, Mesa Arizona). Free ranging moose were immobilized with 7 mg of M99 (.1% etorphine, Lemmon Company, Sellersville, PA) using standard CAP-CHUR equipment. One moose was immobilized with 5 mg of M99. The effects of M99 were reversed with 14-28 mg intramuscular injections of M50-50.

During field seasons, radio locations were obtained 2-3 times each week by triangulation of signal azimuths from the ground (Tester 1971, MacDonald and Amlaner 1979, Springer 1979). A Telonics TR-2 receiver, H (RA-2A) antenna, headphones, and Silva Ranger compass were used to establish signal directions. Because of the extensive road network, it was often possible to obtain many signal azimuths at distances less than 300 m from several angles in less than 20 minutes. A minimum of 4 accurate readings were required before plotting the coordinates on 7.5 min ortho-photo maps. Indication of moose activity or inactivity was inferred from the radio signal. Inactivity was assumed when the signal strength was non-fluctuating. Moose were considered active when the signal strength fluctuated - faded in and out.

Habitat Use and Selection

Radio locations were assumed to adequately represent proportional habitat use. Habitat data for moose locations were collected from U.S. Forest Service files and from 7.5 min ortho-photo maps. Data included; slope, aspect, elevation, habitat type, stand size class, year of stand origin, the dominant tree species (its abundance and size), and distances to nearest cutover area, nearest water, and nearest drivable road. Habitat type classifications followed Pfister et al. (1977). For logged stands, the year of logging, type of cut, size, and site preparation treatments were noted.

In itself, the proportional amount of moose use that a habitat receives is meaningful. To put that habitat use in perspective, this study compared (2 X N Chi-square) the proportions of habitats used by moose to proportional habitat availability as estimated by random points (Marcum and Loftsgaarden 1980, Byers et al. 1984). Habitat descriptions were collected for 400 random points on the general study area in the same manner as for radio locations. These comparisons provided a basis for interpreting habitat selection where the null hypothesis was that moose used habitats in proportion to their availability. Selection was assumed when use of a habitat was greater than availability (Chi-square $P \leq 0.05$ and Bonferoni confidence intervals $P \leq 0.05$ for individual categories).

The delineation of available habitat is crucial to traditional habitat selection analyses. Available habitat has often been considered as the general study area where the animals were studied (e.g. Pierce and Peek 1984). These areas are usually arbitrarily defined. This study attempted to use moose location data to define available habitat. Johnson (1980:69) stated that "the components available depend upon the order of selection being considered". Available habitat in this study varied depending on the level of selection being studied.

Johnson (1980:69) defined first-order selection as "...the selection of physical or geographical range of a species", e.g. moose habitat selection relative to the entire state of Montana. He defined second-order selection as determining "...the home range of an individual or social group", e.g. moose habitat selection in northwest Montana or habitat selection in the Yaak drainage. Johnson (1980:69) described third-order selection as pertaining "...to the usage made of various habitat components within the home range". In the broadest sense, available habitat for second-order selection was defined with the following procedure.

1. Calculate one harmonic mean home range (Dixon and Chapman 1980, Samuel et al. 1983) for all 669 radio locations (75 X 75 grid and 1:48000 scale).
2. Consider the area within the 99% contour of the utilization distribution as available habitat.
3. Estimate the proportional habitat availability with the random points that fell within the 99% contour.

The purpose of using a harmonic mean home range (HHR) was intended only as a tool to draw a boundary around areas used by moose in order to define available habitat. An alternative was to consider the general study area as available. HHR's were used instead of minimum convex polygons (Dalke 1942, Mohr 1947) because they can be manipulated to

closely or generally follow a distribution of locations. Polygons usually include areas with little or no known animal use. Calculating a composite HHR for multiple animals has no intuitive meaning as a 'home range' description, but it is useful as a tool to delineate areas that were used by moose.

As grid density increases in HHR calculations, the contours more closely follow the distribution of locations. The contour percentage, grid density, and scale used in this study were arbitrarily chosen. I am unaware of any completely non-arbitrary way of establishing grid density (including Samuel et al. 1985). This study used the densest grid and largest scale that was reasonably possible for the available program and computing facilities.

This approach to defining available habitat seems an improvement over previous, often vague, delineations of available habitat. Habitat selection results and interpretations will vary greatly depending on the habitat considered as available. If this study's approach is to be used in the future, we need to establish guidelines for HHR descriptions of available habitat.

Two levels of yearlong, second-order habitat selection were examined; coarse and fine. In the broadest sense, all locations were compared with the 369 random points within the 99% contour (566 km^2) of a total, combined HHR. Step 3 above excluded 31 of the 400 random points that were plotted on the general study area. This definition of available habitat was synonymous with Johnson's (1980) second-order definition.

At a finer level, the 143 unique random points that were enclosed by a union of the 99% contours of individual HHR's served to estimate yearlong habitat availability (257 random points were excluded). For this second level, HHR's were calculated for individual moose (99 X 99 grid density and 1:24000 scale), then the contours were connected (a union) to form a more limited description of available habitat. This level of selection was considered second-order, but it approaches third-order. Both the coarse and fine delineations of available habitat are diagrammed in Figure 2.

Seasonal habitat availability was defined by 99% HHR contours of combined seasonal locations (Fig. 3). Seasonal periods were defined by time sequence analysis of harmonic mean centers of activity (Matchett 1985). Seasonal dates were; winter - 1 January to 15 March, spring - 16 March to 19 May, and summer - 20 May to 1 September. Random points included in these contours totaled 179 in winter, 44 in spring, and 169 in summer. The respective number of moose locations and available area for each season was; 184 and 207 km^2 in winter, 109 and 64 km^2 in spring, and 308 and 464 km^2 in summer. The size differences between seasonally available areas resulted from differences in grid density and moose movement patterns. The densest possible grid was used in all 3 seasons to restrict the area considered available.

Changes in seasonal habitat use patterns were analyzed with Chi-square and Bonferoni simultaneous confidence intervals. The null hypothesis for seasonal comparison was that moose use of habitats did not differ between seasons. This procedure was also used to test for differences between habitat use patterns of males and females, of cows

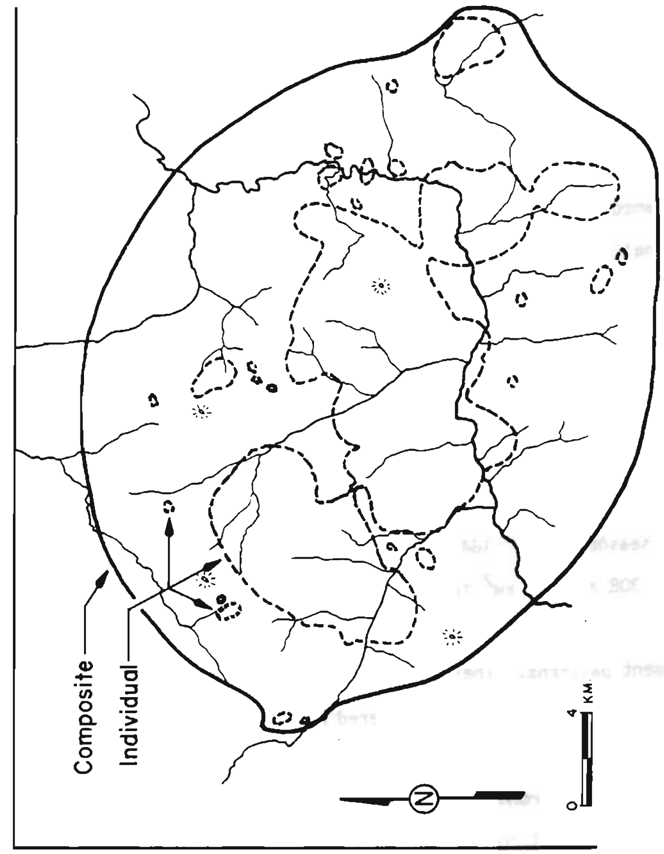

Fig. 2. Areas considered available for second order habitat selection. The composite area was enclosed by the 99% contour of a harmonic mean home range based on all moose locations. The individual area was enclosed by a union of 99% harmonic mean home range contours of individuals.

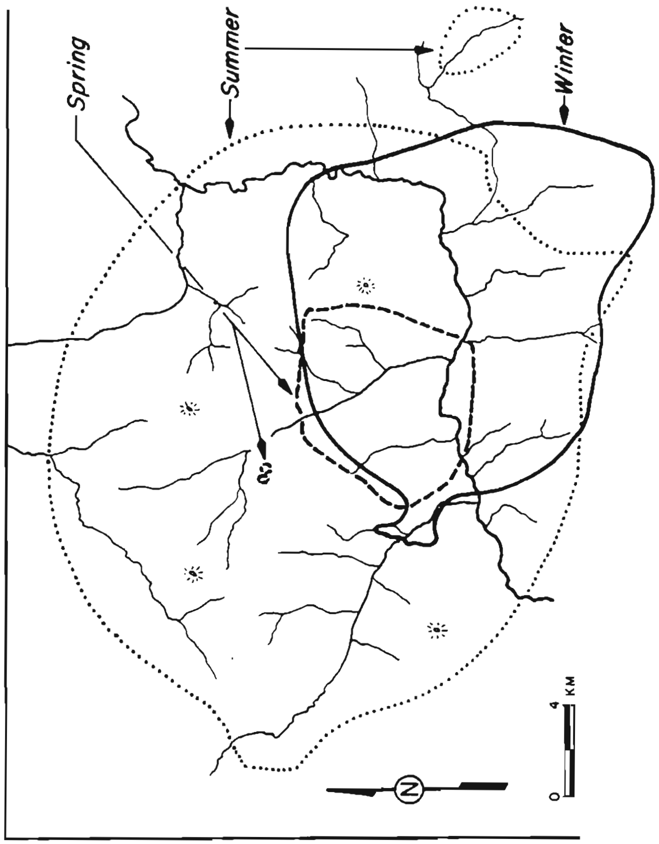

Fig. 3. Areas considered available for seasonal second order habitat selection. The area within the 99% contour of a harmonic mean home range that was based on combined seasonal moose locations was considered seasonally available.

with calves and those without, and of active and inactive moose.

To facilitate discussion about moose use occurring greater or less than availability, an index (I) will be used (Robel et al. 1972). For example;

$$I = \frac{\%USE}{\%AVAILABLE} \quad \text{or} \quad I = \frac{\%\text{ USE BY COWS}}{\%\text{ USE BY BULLS}}$$

This index does not indicate significant differences, only relative differences.

RESULTS AND DISCUSSION

Telemetry

Field work was conducted from June - August 1981, January - March 1982, June - September 1982, and January - September 1983. A total of 669 locations from 12 moose were recorded; 209 in 1982 and 460 in 1983. Eighty-two percent of the locations were mapped to within 1 ha. The remainder were mapped to within 25 ha. Bull and cow locations totaled 166 and 503 respectively. Radio tracking intensity was similar in all seasons (Matchett 1985).

Times of locations ranged from 0800 to 0100 hours with 90% collected between 1000 and 2000 hours. During this portion of the day, activity was greatest in the morning and near dark (Matchett 1985). Minimum activity occurred just after noon, but activity patterns were quite variable. Active moose comprised 67% of the 606 locations where activity status was determined.

Habitat Use and Selection

Determining habitat selection is a difficult problem and has several perspectives. Statements about selection for or against habitats are relative. Underlying mechanisms for habitat 'choices' are not yet fully understood, e.g. social interactions, plant phenology, forage quality or availability, temporal changes, physiological changes, and other factors. Moose use that is greater or less than availability does not mean preference or avoidance, only that there is a relative difference. If a given habitat component is abundant (e.g. 75% of the available area), but only used 50% of the time, avoidance may be implied when in fact 50% use suggests this is an important habitat.

This study was limited in its descriptions of timbered habitat. Data was collected from U.S. Forest Service files of which information on logged areas was good, but information on timbered areas (stage 1 inventories) was often lacking. Small sample sizes limited this study in its ability to detect differences in use of timbered stands, but some patterns were inferred from other habitat parameters.

The following results for yearlong comparisons were based on the composite description of available habitat (Fig 2). Few differences were noted in the results at the 2 levels of second-order selection, but sample **sizes** were frequently small for the finer level. The inclusion of the individual available habitat description was intended to

illustrate the method. Stronger and more precise statements about moose selection patterns could have been made if information for more random points had been collected within the finer definition of available habitat.

Moose usually wintered at low elevations and summered at high elevations. Thus, as might be expected, habitat selection generally corresponded with the different vegetation found from low to high elevations.

Yearlong and seasonal comparisons

Table 1 summarizes habitat selection for several habitat parameters. The western hemlock habitat type series covered more than 50% of the study area and on a yearlong basis, moose used it over 60% of the time. About 30% of the winter locations were in low elevation ponderosa pine or Douglas fir habitat type series that comprised typical winter range in the Yaak valley (I = 2.5). These warmer and drier types were used much more in winter than in spring or summer (Table 2). Subalpine fir habitat type series use exceeded availability in summer (I = 2.3), but this type was rarely used in winter (I = 0.3).

Moose winter ranges in the Yaak should contain a mosaic of 10-30 year-old cutovers and mature, closed canopy, timbered sites. Timbered sites, often draws and creek bottoms, were used extensively by moose in winter after snow conditions restricted mobility. Before snow conditions became limiting, moose frequently used areas logged at least 15 years earlier. Like the findings of Phillip's et al. (1973), use of

Table 1. Habitat selection. The symbols '+++', '++', and '+' indicate use of a habitat category significantly greater than availability using Bonferoni confidence intervals at overall probabilities of; 0.10<P<0.20, 0.05<P<0.10, and P<0.05 respectively. Use less than availability is similarly indicated with '---', '--', and '-'.

Habitat parameter	Category	Overall Composite	Winter	Spring	Summer
HABITAT[a]	AQUATIC				
TYPE	PIPO-PSME	--	++		-
(series)	PICEA	---			-
	TSHE-THPL				
	ABLA	+			+++
SLOPE	0-15	+	+++		
(%)	15-30		-		
	30-45				
	> 45	---	-		
ELEVATION	855-1220		+++		---
(m)	1220-1525		---		
	1525-1830				+++
	> 1830				
STAND	Seedling		---		
SIZE	Sapling	+++	+++		++
CLASS	Pole-multiple			+	
	Sawtimber	-			
YEAR	< 1950				++
LOGGED[b]	1950-1965		+++		
	1965-1976		---		
	1976-1983				---
TYPE	Clearcut	+++			++
OF	Shelterwood				-
CUT	OSR-salvage[c]	++		+++	+
	Not logged[d]	---		-	--

[a] Habitat types follow Pfister et al. (1977). The first 2 letters of the dominant tree genus and species were used to indicate each series.

[b] The year of logging parameter incorporates only those points situated in logged areas. The type of cut habitat parameter incorporates all points.

[c] OSR stands for overstory removal cut.

[d] Unlogged sites were usually forested sites.

Table 2. Seasonal habitat use comparisons. Symbols and nomenclature are the same as in Table 1.

Habitat parameter	Category	% Win locs	% Spr locs	Sig	% Win locs	% Sum locs	Sig	% Spr locs	% Sum locs	Sig
HABITAT	AQUATIC	0.0	4.2		0.0	7.8	---	4.2	7.8	
TYPE	PIPO-PSME	33.9	8.5	+++	33.9	1.3	+++	8.5	1.3	+
(series)	PICEA	1.8	0.0		1.8	1.3		0.0	1.3	
	TSHE-THPL	62.5	84.5	---	62.5	62.6		84.5	62.6	+++
	ABLA	1.8	2.8		1.8	27.0	---	2.8	27.0	---
	N	**56**	**71**		**56**	**230**		**71**	**230**	
SLOPE	0-15	70.2	43.1	+++	70.2	42.9	+++	43.1	42.9	
(%)	15-30	24.0	49.0	---	24.0	50.4	---	49.0	50.4	
	30-45	5.8	7.8		5.8	5.9		7.8	5.9	
	> 45	0.0	0.0		0.0	0.8		0.0	0.8	
	N	**121**	**102**		**121**	**238**		**102**	**238**	
ELEVA-	855-1220	95.1	72.2	+++	95.1	33.5	+++	72.2	33.5	+++
TION	1220-1525	4.3	27.0	---	4.3	44.2	---	27.0	44.2	---
(m)	1525-1830	0.6	0.9		0.6	21.6	---	0.9	21.6	---
	> 1830	0.0	0.0		0.0	0.6		0.0	0.6	
	N	**164**	**115**		**164**	**310**		**115**	**310**	
STAND	Seedling	4.5	4.8		4.5	10.1		4.8	10.1	
SIZE	Sapling	59.1	46.8		59.1	40.8		46.8	40.8	
CLASS	Pole-mult.	15.9	29.0		15.9	17.9		29.0	17.9	
	Sawtimber	20.5	19.4		20.5	31.3		19.4	31.3	-
	N	**44**	**62**		**44**	**179**		**62**	**179**	
YEAR	< 1950	0.0	0.0		0.0	3.6	--	0.0	3.6	--
LOGGED	1950-1965	50.0	17.2	+++	50.0	45.3		17.2	45.3	---
	1965-1976	13.6	39.7	---	13.6	38.1	---	39.7	38.1	
	1976-1983	36.4	43.1		36.4	12.9	+++	43.1	12.9	+++
	N	**44**	**58**		**44**	**139**		**58**	**139**	
TYPE	Clearcut	16.3	29.7	---	16.3	29.2	---	29.7	29.2	
OF	Shelterwood	10.2	9.0		10.2	4.0	++	9.0	4.0	
CUT	OSR-salvage	3.4	13.5	---	3.4	13.4	---	13.5	13.4	
	Not logged	70.1	47.7	+++	70.1	53.4	+++	47.7	53.4	
	N	**147**	**111**		**147**	**298**		**111**	**298**	

timbered and open areas in winter was related to varied snow conditions (Matchett 1985).

Phillips et al. (1973), Eastman (1974), Peek et al. (1976), Thompson and Vukelich (1981), and Davis (1982) also observed moose in relatively open stands during early winter. They observed a steady increase in the use of tall, mature timber as winter progressed. Winter range in north-central Idaho had an extensive pacific yew component in old-growth grand fir (Abies grandis) stands that was considered critical (Pierce and Peek 1984). Only 1 small area was found in the Yaak that contained Pacific yew and that site was used intensively by 1 radioed moose during winter 1983.

Christensen (pers comm., Schlegel and Christensen 1979) noted that some moose wintered at relatively high elevations in north-central Idaho. He noted high forage densities in these areas and moose exhibited limited movements. The few observations of moose at upper elevations in the Yaak usually coincided with snow that had developed a very hard surface crust. This crust was quite supportive and when present, some moose made extensive movements (Matchett 1985).

Use of timbered (unlogged) sites was greatest in winter and least in spring (Table 2). Unlogged, two-storied stands over 12 m tall were particularly important winter habitats. Winter use of these stands was greater than availability (I = 1.4). Spring and summer use was similar to availability (I = 0.9 and I = 0.7 respectively). Use of unlogged, two-storied stands was greater in winter (40%) than in spring (24%) or in summer (18%). Unlogged stands with one-storied canopies over 12 m tall were used less than availability (I = 0.8). Even though use was

less than availability, moose were found in unlogged sites over 50% of the time.

On a yearlong basis, moose use of logged areas with a one-storied residual canopy over 12 m tall exceeded availability (I = 2.0). These areas were used less in winter (10%) than in spring (22%) or summer (18%). Overall, use of clearcuts with at least medium regeneration was greater than availability (I = 2.6). Clearcuts with medium to good stocking levels were used less in winter (15%) than in spring (28%) or summer (23%). When moose were found in logged areas during winter, they tended to occupy older cuts than were occupied at other times of the year (Table 2). At all comparison levels, clearcuts with little or no regeneration were rarely used.

Moose did not seem to select for a particular size of cutting unit relative to availability. They spent about half of the time they were in a cutover area in cuts less than 20 ha and 82% of the time in cuts less than 60 ha.

When moose were in a cutover area, 76% of the locations were in areas logged before 1976 (41% between 1950 and 1965). These sites were generally composed of saplings and shrubs in moderate to dense stands. The highest use of young cuts was observed in spring. The oldest cuts were upper elevation spruce-logged basins that were only used in summer.

Post-logging site treatments were used in proportion to their availability. About two-thirds of the logged areas received a treatment sequence of mechanical scarification, dozer piling slash, and burning of piles (use = 72%). About 20% of the logged areas were broadcast burned, but moose used these sites only 11% of the time.

Regardless of the site preparation treatment, most clearcuts in the Yaak revegetate quickly because of the wet environment. Moose habitat selection of cuts may relate to the influence of site preparation treatments on forage plant regeneration, but this study was inconclusive in demonstrating any relationship. Shiny-leaf ceanothus in clearcuts was commonly browsed by moose during early winter. Shiny-leaf ceanothus seed germination is stimulated by heat and it sprouts under some conditions. Broadcast burning in cuts on winter ranges where ceanothus is present would benefit moose.

Moose were usually located close to logged areas. Seventy-four percent of the locations were within 200 m of a cut (I = 1.4). Moose selected against distances greater than 500 m from a cutting unit (I = 0.3). Spring (68%) and summer (66%) locations were more frequent at distances less than 100 m from a cut than in winter (44%).

Almost 30% of spring moose locations were in low to mid-elevation clearcuts. Other studies also showed high use of relatively open canopy sites during spring and early summer (Knowlton 1960, Houston 1968, Phillips et al. 1973, Peek et al. 1976). Moose use of cutover areas in summer exceeded availability (I = 1.3) and use of timbered stands was less than availability (I = 0.8). In north-central Idaho, moose also used open areas more than availability during summer (Pierce and Peek 1984). However, only 3% of the available area had no overstory in Idaho and moose use was estimated at 11%. Twenty percent of the available summer range in the Yaak had no overstory and use was estimated at 30%.

Pierce (1983) found that moose in north-central Idaho used high elevation lakes and dredge ponds in summer and they travelled from patch to patch of abundant menziesia and alder. Moose in the Yaak also used areas that had thick stands of menziesia and alder in summer, but they travelled to lowland aquatic sites. Moose use of aquatic sites was similar to availability (I = 1.3).

Movements to aquatic sites were relatively long and sometimes very quick. A cow and 1 month-old calf pair were radio tracked over 6 km from a high elevation spruce basin down to the Yaak River in less than 10 hours. They remained in or near the river for several days and then returned to their summer range. These distinct movements to aquatic sites and returns to isolated summer ranges were common (Matchett 1985). This movement pattern over a relatively large area was responsible for the relatively large area considered to be available for summer habitat selection. Once the movement from winter to spring range was complete, moose movements were small (Matchett 1985), hence a relatively small area was considered as available habitat in spring.

The Kootenai National Forest has a pothole blasting program for sedge-choked swamps as a habitat improvement measure for waterfowl and furbearers. Moose were only observed to feed at aquatic sites that had some open water. This program of creating open water in swamps also benefits moose.

Most of the aquatic sites were surrounded by conifers which provided cover. Logging within 100-200 m of these areas should be avoided. When timber sales are proposed near aquatic sites, logging in winter will minimize impacts on moose use of the area.

Moose selected flat or rolling terrain. Yearlong use of slopes less than 15% was greater than availability (I = 1.3). Moose selected against slopes greater than 45% (I = 0.1). Selection for flat to slightly rolling terrain was most pronounced in winter (I = 1.3 relative to availability and I = 1.6 relative to both spring and summer). Proulx (1983) also found that moose selected slopes less than 10% in winter.

Moose distributed their use evenly across eastern, southern, and western exposures with a total of 74% of the locations occuring on these aspects. Thirteen percent of the locations occurred in flat areas and 13% were found on aspects between northwest and northeast. There was a slight selection for flat, southern, and western aspects in winter. No strong selection for aspects relative to availability was apparent for spring or summer.

Moose tended to select for areas less than 500 m from roads and against areas greater than 500 m. However, less than 8% of the study area was greater than 1 km from a road. Moose were usually found close to cutovers and only 5% of the available area was greater than 600 m from a cut. A prerequisite for logging is road access and this apparent selection for roads probably results from moose selection for logged areas.

Moose selected for close (less than 100 m) proximity to water in all seasons (I = 2.9). Only 16% of the available area was greater than 1 km from a permanent water source and about 53% the area was within 500 m. Distances to water were measured on maps and many water sources are not discernable. Therefore, the above estimates of distance to water are maximums.

Comparisons between sexes, reproductive status, and activity

Comparisons of habitat use patterns were made between; cows and bulls, cows with calves and cows without calves, and active and inactive moose. Sample sizes were sometimes small, especially when broken into seasonal subsets. However, some differences in habitat use patterns were detected.

Radio collared cow and bull moose home ranges overlapped extensively. Cows used eastern and northeastern aspects more than bulls (I = 2.4). Cows calved on eastern aspects and used more thickly vegetated sites than bulls. Vegetation density was greatest on these exposures and it seems that cows used these sites as security areas.

Bulls were found more often than cows in timbered areas (I = 1.4), but when cows were in timbered stands, they used more thickly vegetated sites than bulls. Cows used logged areas more than bulls (I = 1.8). When in logged areas, cows used older cuts than bulls (cuts prior to 1965: I = 2.4).

As might be expected, cows with calves (WC) used older, wetter, and more thickly vegetated sites than cows without calves (WOC). For 1-2 weeks after calving, cows were isolated and relatively sedentary. They were located in thickly timbered sites. Rounds (1978), Thompson and Vukelich (1981), and others have reported that cows with calves may require solitude in comparison with other social classes of moose.

WC use exceeded WOC use of northeast aspects (I = 12.0). WC use of stands with hemlock or cedar as the dominant tree species was greater than WOC use (I = 12.3). WC used stands where the average tree diameter was greater than 48 cm more than WOC (I = 24.0). WC use of cuts logged between 1965 and 1976 exceeded WOC use (I = 2.8).

Inactive (bedded) moose used more secure (thicker, older, wetter, timbered stands away from disturbances) sites than active moose. Inactive moose use of the sawtimber stand size class was twice that of active moose. Sixty percent of the inactive locations were in unlogged sites compared to 20% in clearcuts. Fifty percent of the active locations were in unlogged sites and 31% were in clearcuts.

HABITAT MANAGEMENT RECOMMENDATIONS

1. Maintain a diverse mixture of cuts, cut types, and mature, security type timbered areas.
2. Plan timber sales to produce a continuous mixture of mature timber and small (less than 20 ha) cuts that are 15-25 years-old.
3. Maintain closed canopy, two-storied timbered stands, especially in draws and creek bottoms, on winter ranges in association with small cuts.
4. Maintain at least 100 m of timber between cutting units.
5. Continue and promote road closure program.
6. Continue and promote winter/spring range burning programs and site preparation procedures that promote forage growth and reduce slash accumulation.
7. Maintain coniferous cover around aquatic feeding sites and minimize disturbance in these areas (e.g. winter logging in the vicinity of aquatic sites).
8. The Kootenai National Forest should continue and perhaps expand its pothole blasting program.

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