WINTER UTILIZATION OF HABITAT BY MOOSE IN RELATION TO FOREST HARVESTING

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Abstract: Patterns of use as shown by three survey procedures suggests that in winter moose select habitat at several different scales. Macrodistribution changes over winter in relation to major cut and uncut blocks. In each of these major habitat types moose select on the basis of topography and forest cover types. Within cutover areas distribution is influenced by forest harvesting patterns and cut history.

Winter selection of habitat by moose has long been of interest to wildlife biologists (Murie 1934, Hickie 1936). Good moose range is usually associated with disturbance and the presence of shrub-rich early seral communities is generally regarded as integral (Dodds 1960, Bergerud and Manuel 1968, Krefting 1974, Crête 1977). Logging, as well as natural phenomena like fire and flooding, has historically been thought to be beneficial. More recently though the value of conventional forest harvesting witn large scale clearcuts has come into question.

As the wildlife managers opportunities for input into forest management plans increase there is a growing need to be able to accurately characterize range quality and to predict the effect of silvicultural activities. To date there have been numerous studies of winter browse patterns (Pimlott 1963, Des Meules 1964, Telfer 1967, Peek 1971) and descriptions of winter yarding areas (Telfer 1967, Brassard et al 1974, Peek et al 1976) but much less attention has been given to characterizing those areas not occupied by moose. Poliquin et al (1977), have shown that habitat variables can be used with high success to discriminate between winter yarding and non-yarding areas in western Québec.

To learn more about natural and anthropogenic variables that would assist in predicting intensity of moose winter use of habitat we undertook three separate but interrelated studies. One based on track counts along ground transects, examined forest harvesting as well as natural variables, another using aerial block censuses of moose concentrated on the use of large cutover and uncut blocks, and a third based on aerial transect track counts examined major changes in distribution patterns over winter.

Our basic objectives were to demonstrate that habitat selection occurs, to quantify the use of different habitats, and to develop procedures for identifying habitats before harvesting that will have high value for moose after cutting.

STUDY AREA

All three studies were conducted in northeastern Ontario in the northwest corner of the Chapleau Crown Game Preserve, about 100 km south of

Hearst. The study area was centered on Mildred Township, a 14.5 x 14.5 km freehold block located at 48°42'N and 83°53'W. All work was done in Mildred and the eight townships surrounding it. Hunting in the Game Preserve has been prohibited since its inception in 1922.

The land is moderately rolling with elevations of 325 to 450 m. The acid igneous bedrock is mostly granite of Archean origin (Ontario Department of Mines, Geological Compilation Map 2116). The whole area is covered by a ground moraine of varying composition and thickness. In general soils are silty to sandy till with occasional concentrations of coarser material. A small part of southeastern Mildred Township, along the Fire River, has lacustrine deposits of fine sand and silt with some varved clays.

The forest is in the Missinaibi-Cabonga section of the Boreal Forest (Rowe 1972). Most stands are mixed wood with components of black spruce (*Picea mariana*), white spruce (*Picea glauca*), balsam fir (*Abies balsamea*), trembling aspen (*Populus tremuloides*), balsam poplar (*Populus balsamifera*), and white birch (*Betula papyrifera*). Many stands are overmature and of mixed age composition. Spruce budworm (*Choristoneura fumiferana* Clem.) has recently ravaged most white spruce and balsam fir and birch dieback is severe in many areas. The opening of the canopy has favoured shrubs and mountain maple (*Acer spicatum*) and beaked hazel (*Corylus cornuta*) frequently form a dense understory. Pure stands of jackpine (*Pinus banksiana*) and black spruce and mixtures of the two do occur on well-drained alluvial and aeolian plains. Black spruce dominates lowlands and river valleys where it sometimes occurs with larch (*Larix laricina*) on site type and eastern white cedar (*Thuja occidentalis*) on another.

Intensive logging in the area began in 1946 with pulpwood cutting of a few stands in the township north of Mildred. Newaygo Timber Co. Ltd., the owner of Mildred Township, began cutting sawlogs and pulpwood in the northwest corner in 1955 and has systematically harvested in a clockwise progression since then so that 85% of the township is now cutover. All merchantable trees have been harvested resulting in clearcut valley bottoms and plains where all conifers were removed and selectively cut mixedwoods where conifer sawlogs, pulp, and veneer quality hard woods have been cut. The largest clearcuts are < 400 ha. but contiguous cuts with only a few hardwoods left cover thousands of hectares. The pattern of cutting has resulted in an intricate patchwork of various sizes of cuts of different cut intensity and age.

METHODS

Aerial transect routes (Fig. 1) were set up in a square pattern to sample distribution and density of moose in relation to Mildred Township. The five lines, lettered A B C D E, were located parallel to the township edges at 6.5, 13(0.8 km inside), 16(0.8 km outside), 22.4, and 28.8 km from the centre. The 251 km of transect were marked on an aerial photograph, then divided into 149 segments at readily identifiable topographic features. The transects were flown 8 times at approximately monthly intervals in the winters of 1977-78 and 1978-79. Two backseat observers each recorded the number of fresh tracks transecting an imaginary survey line about 50 m from the flight path on each side of the aircraft. The totals for each segment were averaged. All surveys were flown at approximately 120 km per hour and 100 m altitude. Small single engine Cessna aircraft (170-B, 172, 180, 185) were

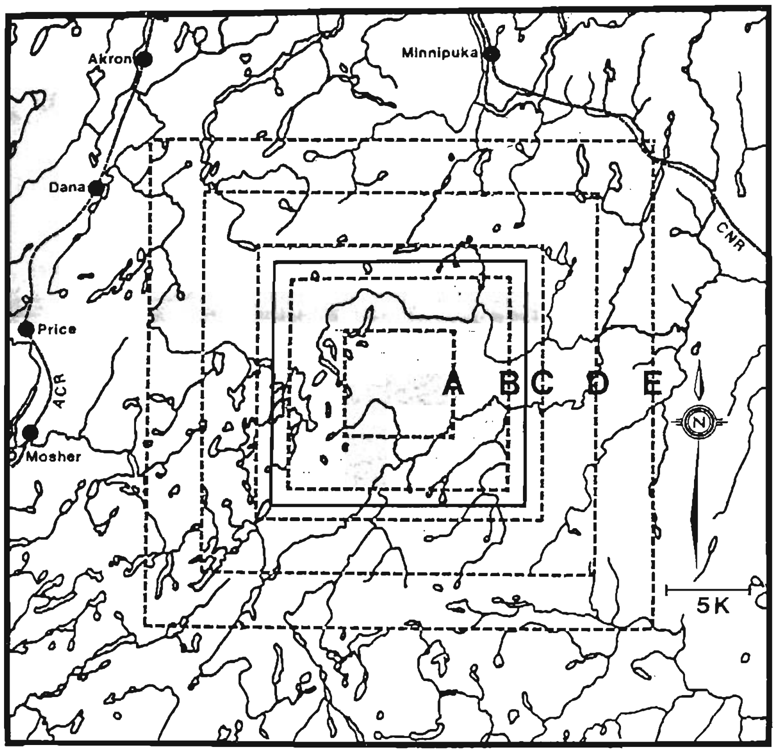

Figure 1. Aerial transect line locations centred around Mildred township.

used for all surveys except January 1978 when a Turbo-Beaver was used. Lines A and D were not surveyed on that date. For the purpose of this paper track number is assumed to accurately reflect relative density.

Aerial survey plots (Fig. 2) of 25 km^2 (2.5 x 10 km) were strategically located to sample a variety of cut and uncut features in Mildred Township and in Makawa Township directly south of it. The 8 plots were oriented in a north-south direction and fitted to the UTM grid to conform with standard provincial practice. Plots were surveyed approximately monthly during the winters of 1976-77, 1977-78, and 1979-80. On each of the 17 surveys the position of all sighted animals was recorded on large scale (6.35 cm = 1 km) aerial photographs.

Six flight lines (the two long boundaries and four lines between at 0.5 km separation) were flown on each plot at approximately 120 km per hour and 150 m altitude. Lines were followed until moose or fresh tracks were found at which time the aircraft circled until the animals position was precisely recorded or it was clear they had left the plot. An effort was made to fly 24 to 48 hours after new snow but this was not mandatory. All surveys were flown between 10:00 and 15:00 hours EST. A right front and single rear seat observer were used. In 1976-77 a Cessna 170-B, Cessna 172, and Cessna 180 were used, in 1977-78 and 1978-79 only a Cessna 185 was used. Each plot was flown until the observers were confident that all moose present had been observed. Full survey details are given in Thomas and Oswald (1979). A numbered grid with 250 x 250 m squares was superimposed over the plot photo in such a way that there was 125 m overlap on all sides (451 squares/plot). All moose locations were coded to the grid block they occurred in.

Ground transect routes (Fig. 3) were selected to sample representative components of different types of cut and uncut forest stands. The 144 km of transect were sampled over a period of a few days by snowmobile on 10 occasions approximately once per winter month in 1976-77 and 1977-78. Transects included some main unplowed roads but for the most part were routed on old skid and haul roads and some specially cleared trails. The proportion of different habitat units sampled by the ground routes was very similar to that sampled by the aerial survey plots and was representative of the township. All tracts crossing the transect and entering or leaving the adjacent habitat were precisely marked on an aerial photograph (6.35 cm = 1 km). Routes were only run when the snowfall history was such that the exact period over which tracks occurred was known (normally during 24-72 hours). A linear numbered grid of 250 x 250 m blocks was superimposed over the transect aerial photographs and all tracks were coded to the 1/4 km section they occurred in. Since track accumulation periods varied within and between months the track collection period was mathematically adjusted to 48 hours for all blocks to facilitate comparisons (ie. tracks accumulated during a 72 hour period were totalled, then divided by 1.5).

A number of habitat variables was described for every 1/16 km^2 grid block on ground (476 blocks) and aerial plot (3567 blocks) surveys. These included a comparison of several indices of topographic relief based on the number of topographic lines (15 m contour) within a circle or doughnut centred on the block. Six indices were studied for circles of different radii (0-250 m, 250-500 m, 750-1000 m, 0-500 m and 500-1000 m), to determine which ones best describe moose response to topographic relief. The original forest stand of each block was also described (percent species composition, age,

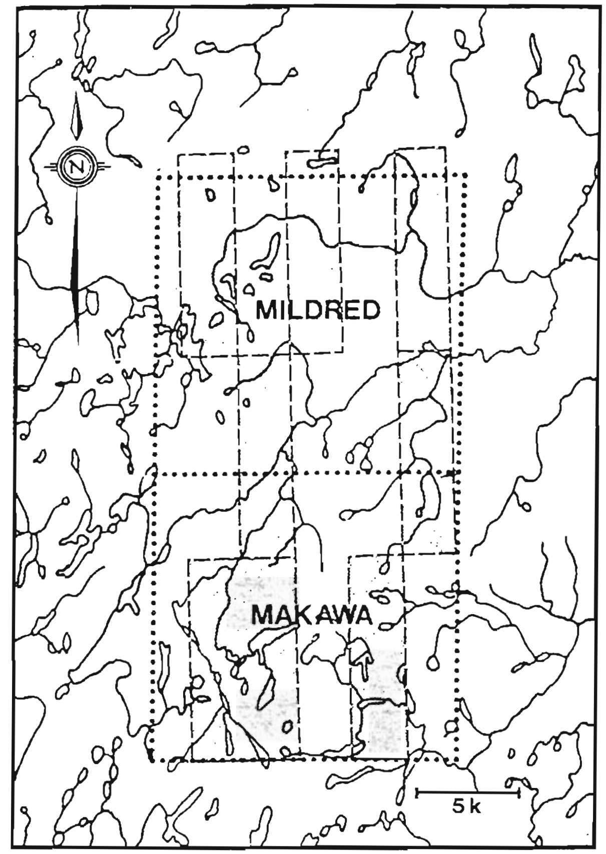

Figure 2. Aerial survey block locations in Mildred and Makawa townships.

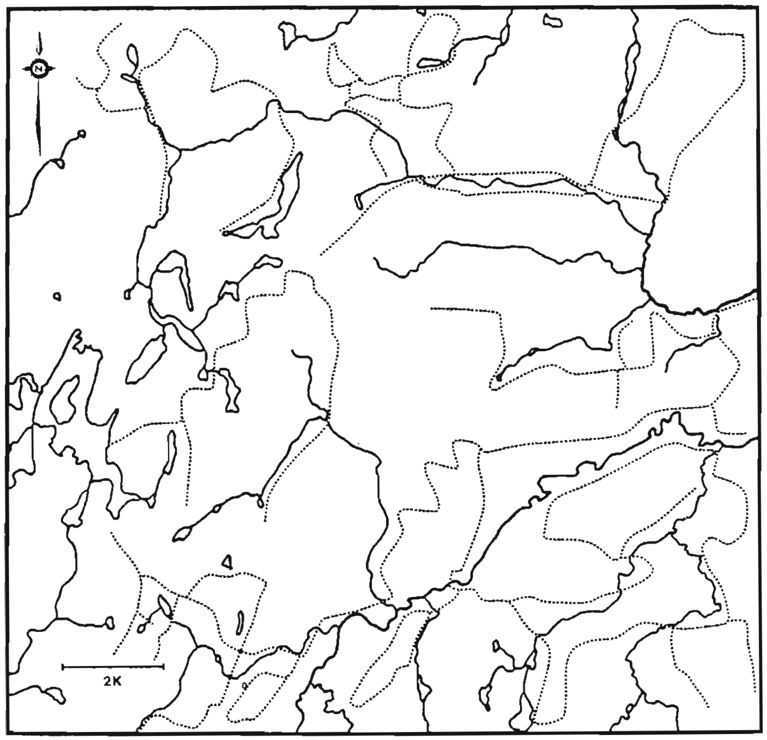

Figure 3. Mildred township ground transect routes.

height and stocking of tree layer) on the basis of forest resource inventory maps.

For those stands that have been harvested, cut variables were described. The cut variables were interpreted from recent aerial photographs or taken from company records. These included year of cutting, intensity of cutting in 3 classes (Selective 1 with 1-40% original stand removed, Selective 2 with 41-80% removed, and Clearcut with > 80% removed), number of primary secondary, and tertiary roads (entering and leaving a 250 m radius circle centered on the block) and the degree of revegetation of each road type.

All variables from aerial blocks and ground transects were individually analyzed by correlation or analysis of variance. Discriminant function analysis (DFA) was also used with some data sets to determine degree of similarity and difference between components of the population.

RESULTS

The density and distribution of moose in relation to a major cutover block (Mildred Township) and the surrounding uncut land changed dramatically during the winter in a similar manner in two successive years. The density of moose inside the township, on Transects A and B, as shown by mean number of tracks per line as a percentage of mean total (Fig. 4) was many times greater early in the season than surrounding uncut (lines C, D and E). As winter progressed the density inside dropped dramatically until by March in 1977-78 and February 1978-79 it was approximately even overall.

Interpretation of all other surveys in the vicinity of the study area suggested that about 300 moose (0.3 - 0.4 moose/km^2) live in the 28.8 x

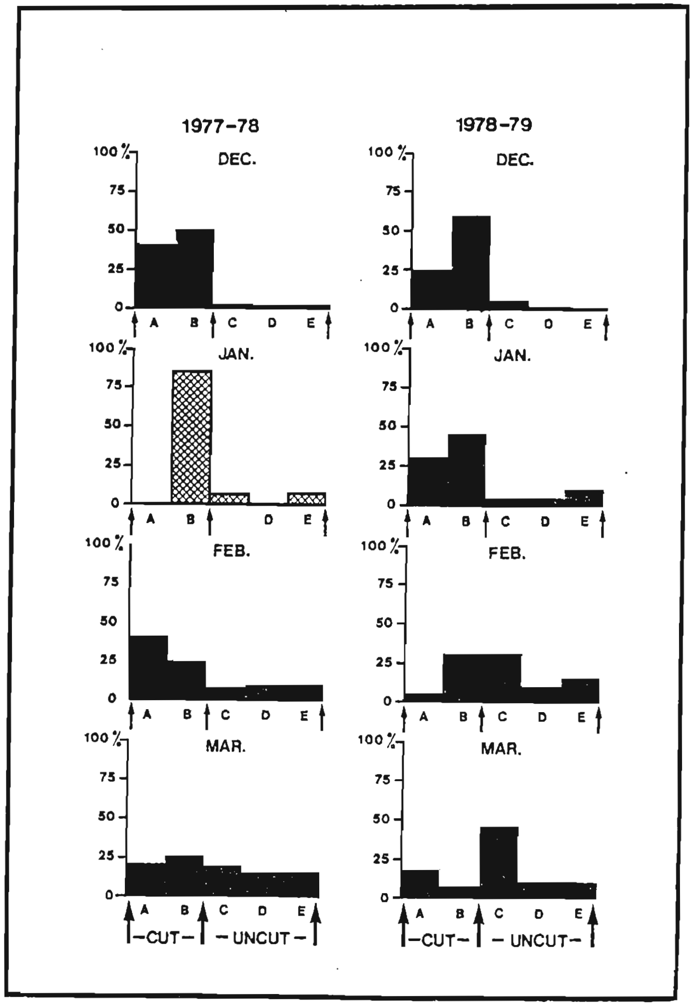

Figure 4. Moose track distribution around Mildred township during the winter shown as percent of total track density/km for each monthly survey for 5 survey lines at different distances from township centre. Based on track counts for aerial transect surveys. January 1978 survey covered only 3 lines. Position of transects is described in text.

28.8 km area encompassed by line E, and that major movements occur within that area rather than between it and surrounding uncut. The strongest evidence for this argument is that in December and January there are 250-275 moose in Mildred Township based on plot and total counts. At that time about 15% of the tracks/km on aerial transect surveys are outside of the township. In February 1978 there were about 145 moose in Mildred Township and track density inside was 45% of the total (Fig. 4). Based on that assumption and accepting that track numbers reflect density Fig. 5 shows clearly that there is a major shift in the distribution of the local population over winter in relation to cut and uncut forest. In the second year there is a higher density at line C just outside the township edge in March.

The relationship between tree species composition of aerial grid blocks and moose track density was examined both species by species and by lumping into groups, such as stands of > 80% black spruce and larch in one class, those with balsam fir and white spruce in another, and so on. In general species values have greater predictive value than groups in multivariate models. For most species the responses are complicated due to changes from month to month. Table 1 presents results demonstrating two overall patterns; firstly, that jackpine is selected against and is unimportant when it composes > 20% of the stand and secondly, that as hardwood (white birch, aspen, balsam poplar) content increases number of tracks increases up to about 80% composition at which point use appears to drop off again.

The effect of topographic ruggedness as shown by a comparison of six different indices is summarized for bimonthly periods in Table 2. In general use increases with increasing ruggedness. This effect is more pronounced with

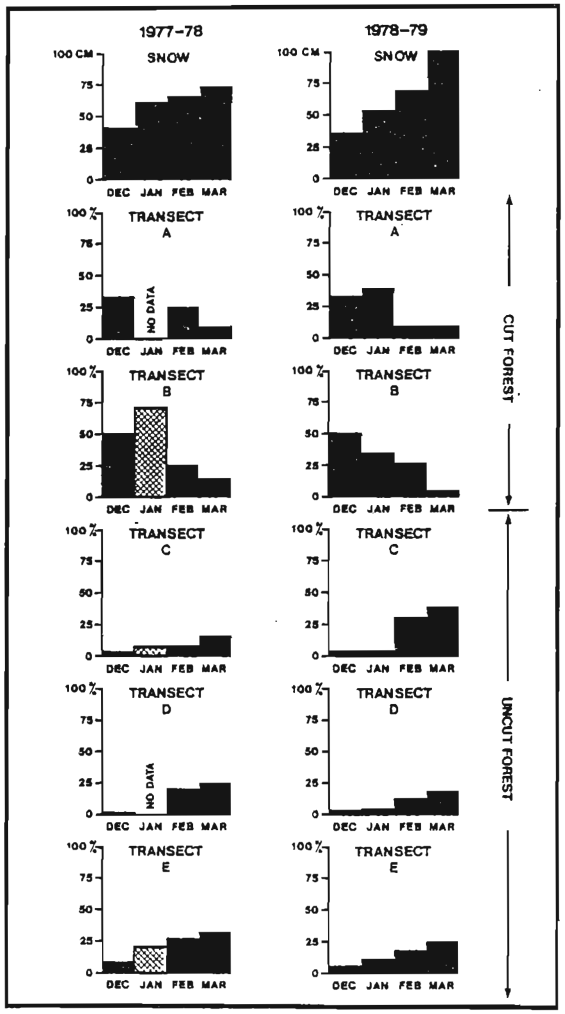

Figure 5. Changing patterns of moose distribution around Mildred township during the winter shown as relative percent of population in areas at different distances from township centre. Based on number of tracks from aerial transect surveys.

Table 1. Winter use of stands of different tree species composition as shown by mean number of moose per grid block for all aerial surveys. Groups are quintiles for species cover based on forest resource inventory maps. Hardwood is a combination of white birch, aspen and balsam poplar.

Group	n	x	
Jackpine			
0	1447	0.4803	
1	1006	0.1978	F prob = 0.0000
2	670	0.0955	
3	405	0.0519	
4	39	0.0513	
5	--		
Hardwood			
0	198	0.2071	
1	1285	0.1790	
2	883	0.1948	F prob = 0.0000
3	689	0.4064	
4	426	0.5305	
5	86	0.3721	

Table 2. Bimonthly winter use of blocks of different topographic relief as shown by a comparison of 6 indices. All indices are based on the number of 15m contour lines at different distance from block centres. Q1 is 0-250m, Q2 is 250-500m, Q3 is 500-750m, Q4 is 750-1000m, Q5 is 0-500m, Q6 is 500-1000m. Use is based on mean number of moose per grid block from aerial surveys, n is the number of blocks in each group.

Index	No. of Topo Lines	n	% of Mean Totals Nov-Dec	Jan-Feb	Mar-Apr	Total
Q1	0	373	10	11	12	11
	1	1703	18	17	10	15
	2	1013	12	21	21	19
	3	385	23	24	28	25
	4	77	20	11	30	18
	5+	16	16	15	--	12
Mean Total			0.3803	0.8072	0.4338	1.6211
Q2	0	91	4	1	7	4
	1	843	25	15	8	15
	2	1306	15	18	15	17
	3	836	26	18	17	20
	4	353	18	28	23	25
	5+	138	12	20	29	20
Mean Total			0.3110	0.8149	0.4454	1.5629
Q3	0	59	--	--	4	1
	1	410	27	15	7	16
	2	1140	20	21	11	19
	3	1042	18	20	18	20
	4	581	31	25	20	26
	5+	335	5	19	20	6
Mean Total			0.3089	0.7268	0.4546	1.3751
Q4	0	57	--	--	--	--
	1	206	30	23	16	23
	2	853	21	21	17	20
	3	1164	20	19	21	20
	4	772	19	18	28	20
	5+	515	11	19	18	17
Mean Total			0.3275	0.7611	0.3281	1.4212
Q5	0	90	4	1	8	4
	1	833	26	14	8	15
	2	1291	16	18	15	17
	3	854	24	19	18	20
	4	359	21	28	23	25
	5+	140	9	19	29	20
Mean Total			0.3062	0.8092	0.4429	1.5576
Q6	0	57	--	--	--	--
	1	180	26	21	9	17
	2	793	23	22	18	22
	3	1111	17	18	24	20
	4	855	25	22	26	24
	5+	571	10	18	22	17
Mean Total			0.3227	0.7478	0.3061	1.3366

		PREDICTED CATAGORY UNCUT	CUT	NO. OF CASES
ACTUAL CATEGORY	CUT	54.6%	45.4%	218
	UNCUT	49.1%	50.9%	159

NO. CLASSIFIED CORRECTLY 53.1%

Table 3. Results of discriminant function analysis of cut and uncut forest based on topographic and uncut forest stand composition variables. Canonical correlation = 0.1708 and Wilke's Lambda = 0.9708

Table 4. Winter use of forest stands of different age class by months based on ground transect track counts. Age classes are 2=3-5 yrs, 3=6-11 yrs, 4=12-17 yrs, 5=18-30 yrs, 6=99 yrs (mature), n is the number of blocks in each age class.

n	Age Class	Nov.	Dec.	Jan.	Feb.	E.Mar.	L.Mar.	Total
137	2	24.2	31.6	13.3	16.1	1.6	0	14.4
153	3	23.3	19.7	36.6	25.3	11.9	11.6	30.9
128	4	21.2	27.9	28.8	36.9	19.1	36.0	29.4
119	5	31.2	15.2	20.1	8.9	44.6	23.3	20.2
31	6	0	5.6	1.2	12.8	22.9	29.0	5.1
Mean Total		2.66	7.95	11.80	3.82	0.51	0.88	19.66
F prob.		0.603	0.085	0.003	0.025	0.001	0.000	0.001

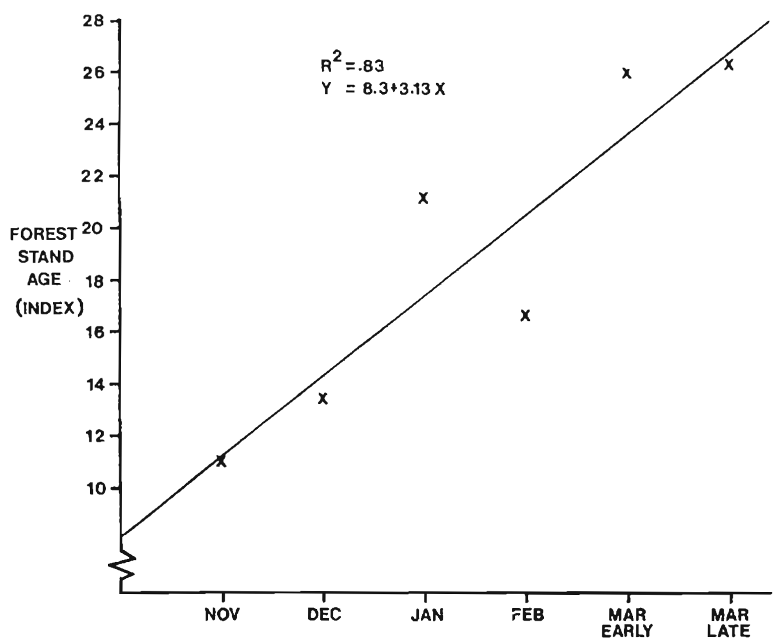

Figure 6. Monthly use of forest stands of different age based on number of tracks per grid block from ground transects. Age axis is a relative scale based on weighted mean of midpoints for 6 age classes.

progression of the winter season. Indices Q1, Q2, Q3, Q5 all suggest an absence of pattern in November-December, greater use with increase in number of topographic lines in January-February, and even more use in March-April of more rugged terrain. Index Q4 appears to have the opposite response. The Q6 value which is a combination of Q3 and Q4 does not have a clear effect.

To determine if the type of habitat used, as shown by topography and original forest cover, in cut and uncut blocks was the same, a discriminant function analysis was run. Table 3 clearly shows that on the basis of topography and original cover type grid blocks with moose in uncut cannot be discriminated from grid blocks with moose in cutovers.

One of the most important characteristics of disturbed habitat is the length of time since disturbance. Although there are a number of complicating factors associated with cut intensity, size and distance to cover, Table 4 indicates a distinct seasonal pattern in the age of stands being used. In November there is little selection by age; in December young stands are used, and as the season progresses moose occupy successively older cutovers. Young cuts were little used late in the winter as were uncut stands early in the year. The general relationship is shown in Fig. 6 which indicates an increasingly older relative mean age of stands used as winter progressed.

Number of primary (r_s = 0.0207, p = 0.27) and secondary (r_s = -0.0486, p = 0.07) roads did not significantly affect the number of moose tracks per block, but track number was highly correlated with number of tertiary roads (r_s = 0.162, $p > 0.000$). The nature of the road surface also affects use and roads with closed vegetation and shrubs experience

significantly more use (gravel surface r_s = 0.026, p = 0.22, open vegetation (< 1 mht) r_s = 0.058, p = 0.037, closed vegetation (> 1 mht) r_s = 0.278, p = 0.001). Table 5 explores the relationship between amount of vegetation on and number of tertiary roads. In general as vegetation and number of roads increase the incidence of use increases.

The overall effect of cutting intensity is shown in Table 6. Regardless of combinations with other intensity classes, as the amount of uncut increases use decreases, and as the amount of Selective 1 increases use increases. Patterns are not as clear with the other two types but it appears that amount of Selective 2 alone does not affect use intensity and that there is reduced use when more than half of the block has been clearcut.

The effect of time of winter and aerial proportion of blocks of cut intensity groupings is demonstrated in Table 7. Selective 1 alone and in combination is the most heavily used type and receives peak use in mid-winter. Uncut stands and uncut with Selective 1 are used increasingly as winter progresses. In general, clearcuts and blocks associated with clearcut are used least, the best clearcut association being with Selective 1. The most intensively cut stands (Selective 2, clearcut, Selective 2 and clearcut) receive reduced use late in winter.

DISCUSSION

Moose winter migrations in North America are well known (LeReshe 1974) but only a few of the studies relate directly to the boreal forest (Van Ballenberghe and Peek 1971, Roussel et al 1975, Addison et al, in press). The aerial transect data show that moose concentrate in Mildred

Table 5. Relationship between number of tertiary roads and surface type for roads within 250 m of centre of ground transect grid block. Values are mean number of tracks for all ground surveys combined with sample size in parenthesis.

		Surface Type			
			Gravel & Forb	Grass	Shrub
		0	1	2	3
Number of Tertiary Roads	0	5.1 (140)	0	0	0
	1	0	3.7 (43)	8.0 (32)	9.1 (58)
	2	0	3.9 (34)	6.8 (33)	10.7 (65)
	3	0	4.5 (17)	5.8 (36)	11.8 (34)
	4	0	4.7 (3)	6.4 (13)	13.2 (29)
	5+	0	0	6.7 (11)	9.8 (33)

Table 6. Winter use of stands of different cut intensity as shown by mean number of moose per grid block for all aerial surveys combined. Blocks are classified according to amount of area in each intensity category, n is number of blocks in each percentage class.

	Cut Intensity											
% Block	Uncut			Selective 1			Selective 2			Clearcut		
	$\bar{x}$	%	n	$\bar{x}$	%	n	$\bar{x}$	%	n	$\bar{x}$	%	n
0	0.6367	25	746	0.3154	7	903	0.4131	11	910	0.5482	19	788
1-20	.4653	19	101	.5238	11	63	.5870	16	92	.6742	23	89
21-40	.4348	17	92	.7174	16	92	.8485	23	99	.4215	15	121
41-60	.4074	16	54	1.0968	24	62	.5079	14	63	.6506	22	83
61-80	.3133	13	83	.9242	20	66	.5309	15	81	.3153	11	111
81-100	.2419	10	277	.9940	22	166	.7315	20	108	.2795	10	161
F prb.	0.0000			0.0000			0.0000			0.0111		

Table 7. Winter use of blocks of different cut intensity for bimonthly periods and total based on mean number of moose per grid block from aerial surveys, n is the number of blocks in the class. Blocks are grouped into 11 classes according to areal composition for cut intensity categories. Cut intensity classes are described in text. Classes 1 to 4 are 80% of intensity class, 5 to 10 are 20% of two named classes and 10% of others, class 11 includes all other blocks.

Class	n	Nov-Dec $\bar{x}$	%	Jan-Feb $\bar{x}$	%	Mar-Apr $\bar{x}$	%	All Winter $\bar{x}$	%	Cut Intensity Class
1	301	0.0266	2	0.0930	3	0.1329	10	0.2525	4	Uncut
2	168	0.2202	15	0.5714	18	0.1964	15	0.9881	17	Selective 1
3	102	0.2157	15	0.4804	15	0.0196	1	0.7157	12	Selective 2
4	109	0.0826	6	0.1009	3	0	0	0.1835	3	Clearcut
5	50	0.1200	8	0.2800	9	0.3600	27	0.7600	13	Uncut+Selective 1
6	33	0.0606	4	0.1212	4	0.0606	5	0.2424	4	Uncut+Selective 2
7	94	0.0426	3	0.1383	4	0.1383	10	0.3191	5	Uncut+Clearcut
8	85	0.2471	17	0.6706	21	0.2353	18	1.1529	19	Selective 1+Selective 2
9	100	0.1400	10	0.3400	11	0.1300	10	0.6100	10	Selective 1+Clearcut
10	147	0.1565	11	0.2041	7	0.0068	1	0.3673	6	Selective 2+Clearcut
11	164	0.1280	9	0.1341	4	0.0610	4	0.3232	5	Edge
F prob.		0.0067		0.0000		0.0000		0.0000		

Township early in the year making use of vast areas of early seral forest with abundant food. As winter progresses they gradually move into surrounding uncut stands.

The movement from open to closed habitat may be a general pattern in Ontario (Macfie 1961, Addison et al, in press) and has frequently been described elsewhere as movement to conifer cover (Des Meules 1964, Telfer 1968, Peek 1971, Van Ballenberghe and Peek 1971, Eastman 1974, Peek et al 1976). The timing of the movement has often been related to snowfall but there is little agreement about critical thresholds. Phillips et al (1973) and Peek et al (1976) observed movement to conifers at less than 50 cm snow while Telfer (1968) and Prescott (1968) suggest that movement occurs when snow depth is greater than 50 cm. Des Meules (1964) found moose moving to conifer cover at 76 to 86 cm. In Mildred it appears that the move is related to season but may be accelerated by heavy short term snowfall. Moose moved earlier in 1978-79 after a series of storms but with no more total ground accumulation of snow.

LeReshe (1974) has pointed out that the degree of movement in any area is related to degree of interspersion of early and late winter habitat. The present study indicates that size of habitat units involved may be large. The late winter movement was from a cutover township to a large uncut block even though many smaller patches of uncut remained in the township. It may be that moose in the deep snow of northeastern Ontario need uncut conifer valleys with adjacent mixedwood slopes in late winter.

The results presented in Table 1 demonstrate that forest resource inventory maps can be used successfully for moose habitat description. Other work in progress demonstrates monthly changes in response to other tree species. The generalized hardwood result is interesting because it shows that without some conifer component (apparently > 20%) use appears to drop off.

The comparison of topographic index responses in Table 2 suggests that relief from 0 to 250 m (Q1), 250 to 500 m (Q2) and 500 to 750 m (Q3) has a similar pattern but beyond that (Q4 - 750 to 1000 m) the pattern reverses. This is probably an artifact related to the physiography of the area; when there are high hills 750 to 1000 m from a point it is likely to be in the middle of a plain or valley. The Q5 index shows that Q1 and Q2 are additive since the results are slightly clearer for Q5 but there are few topographic lines in Q1 that do not appear in Q2. The degree of similarity between Q5 and Q2 is sufficiently great to make the value of the additional quantification questionable. The negative effects of Q4 are slightly overbalanced by Q3 in Q6 but the value of that index appears slight.

The results in Table 3 clearly show that on the basis of original cover type and topography, habitats selected in cut areas cannot be distinguished from those selected in uncut. Since readily available information bases like forest resource inventory (FRI) maps and topographic maps can be interpreted to yield information of value in describing moose habitat it should be possible to take these tools and with a predictive model delimit important winter moose range before cutting. Poliquin et al (1977) have already demonstrated one approach to this but their model requires field sampled variables, a difficult task before road construction.

The complex nature of the effect of forest cutting on moose has been the subject of a number of studies (Bergerud and Manuel 1968, Telfer 1974, Crête 1977). The combination of different pulp mill and sawmill needs

in different areas coupled with different forest community structure has resulted in a large variety of different cutover patterns making generalizations difficult. Additionally all cut variables are inextricably linked with each other and with topography, original cover type and other ecosystem variables. The complexity of the pattern has made definition and ordering difficult. In our studies we have selected definitions that seemed generally applicable and allowed description. It should be pointed out that a change in definitions may well result in different results.

The age of a stand obviously affects the amount of browse and cover available. Table 4 and Figure 6 demonstrate the importance of seral stages with a well developed shrub community and show that the age of selected stands changes during the winter. The decrease in use of young stands and increase in older stand use is another way of viewing the move from open to closed canopy. Poliquin et al (1977) have shown the same phenomenon in early and late western Québec yards.

The effect of roads on track distribution indicates that only tertiary roads are significantly correlated with moose numbers. This is a reflection of the fact that number of tertiary roads increases with cutting and there are more moose in cut areas than uncut. The surface index shows that roads with vegetation greater than 1 m height have more moose. Obviously this is age related as older tetiary roads have higher more plentiful shrubs. Table 5 shows that the two generally covary such that use by moose increases with vegetation development and number of tertiary roads.

The simplified view of use in relation to cut intensity in Table 6 clearly shows the general avoidance of uncut, while Table 7 indicates that season has an effect and that use of uncut does increase late in the winter. The preference for Selective 1 stands which have both cover and food is consistant and as would be expected other less used classes have increased use when coupled with Selective 1. The reduced use of clearcuts late in the winter has been specifically shown before (MacLennan 1975) and is in general accord with the move to heavier cover discussed earlier.

CONCLUSION

In the boreal forest of northeastern Ontario moose appear to undertake two winter movements; first into generally open cutover habitat early in the winter and second into large uncut predominantly old forest stands later in the winter. Early winter densities in cutover areas are many times greater than late winter levels.

Within both cut and uncut habitat moose appear to select range in a similar manner on the basis of topographic and forest stand variables. In cutovers the intensity of and length of time since cutting affect the selection of habitat which also shows a seasonal pattern.

These conclusions present several issues of interest to managers:

- Large uncut areas in association with cutover habitat may be a necessary component of good winter range. In view of the lower late winter densities these may need to be much larger than the early seral stages providing mostly food.
- It appears possible on the basis of readily available data sources to delimit good winter moose range.
- On the basis of information on response to cut variables harvesting can be manipulated to improve habitat quality.

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