USE OF RESIDUAL STRIPS OF TIMBER BY MOOSE WITHIN CUTOVERS IN NORTHWESTERN ONTARIO

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ABSTRACT: Winter aerial track surveys and spring browse surveys in 1987 and 1988 showed that moose (*Alces alces*) used areas near corridors of residual timber within clearcuts during the winter. Aerial track survey data showed that moose significantly ($P<0.01$) preferred the area within 45 and 90 meters of cover. The area within 90 meters of the corridors was preferred ($P<0.05$) in 7 of 22 cases and used as available in the remaining 15 cases. Analysis of spring browse survey data showed no significant ($P<0.01$) difference between the number of stems available or browsed that was related to distance from the corridor. Significant ($P<0.01$) differences between the number of twigs available and browsed seemed related to availability rather than increasing distance from the corridor. Snow surveys showed significantly ($P<0.05$) lower snow depths within the corridor than in the cutover. Corridors may be used as escape cover, thermal cover or as travelling areas but are not being used specifically for feeding areas.

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Habitat management is an important technique for moose management in northern Ontario (OMNR 1988) and timber harvesting is an important habitat management tool. Logging has historically been thought to be beneficial to moose by creating an interspersion of early and late successional stages needed by moose (Welsh *et al.* 1980) but increased demand for wood and mechanization of harvesting have produced larger, cleaner cuts (Hamilton *et al.* 1980). Optimum habitat provides both disturbed areas for food and retains mature conifers for cover (Hamilton and Drysdale 1975) but large disturbed areas retain little cover and hence are not as useful as smaller ones (Hamilton *et al.* 1980, Telfer 1978). Leaving scattered coniferous cover in cutovers would provide thermal and escape cover in close proximity to large amounts of browse (OMNR 1984).

The Ontario Ministry of Natural Resources Timber Management Guidelines for the Provision of Moose Habitat recommend that shelter patches should be left in clearcuts when the clearcut area exceeds 100 ha and the edge to edge width of the cutover is greater than 400 m (OMNR 1988). The purpose of these shelter patches is to ensure vegetative diversity and still provide for a reasonable timber harvest. One way the guidelines are being implemented is to leave corridors of uncut timber within some clearcut areas.

The main objective of this study was to answer the question:
do moose use corridors of uncut timber left within clearcuts?

Secondary questions were: how do the corridors affect snow depth?, and how do moose use the corridor during the winter?

STUDY AREA DESCRIPTION

Six study sites (Fig. 1) were selected to meet the following specifications: cutover areas had been harvested three to ten years prior to the study, cutovers contained at least one moose corridor and cutovers had not been treated with herbicide. The selected cutover areas ranged from 297 to 4828 ha and the mean cutover size was 1394 ha. All areas were open to hunting.

Vegetation

The study areas were in the Superior section of the boreal forest region (Rowe1972). There was variation in forest types within each area but four of the six corridors were classified as boreal mixedwood forest. This forest type is characterized

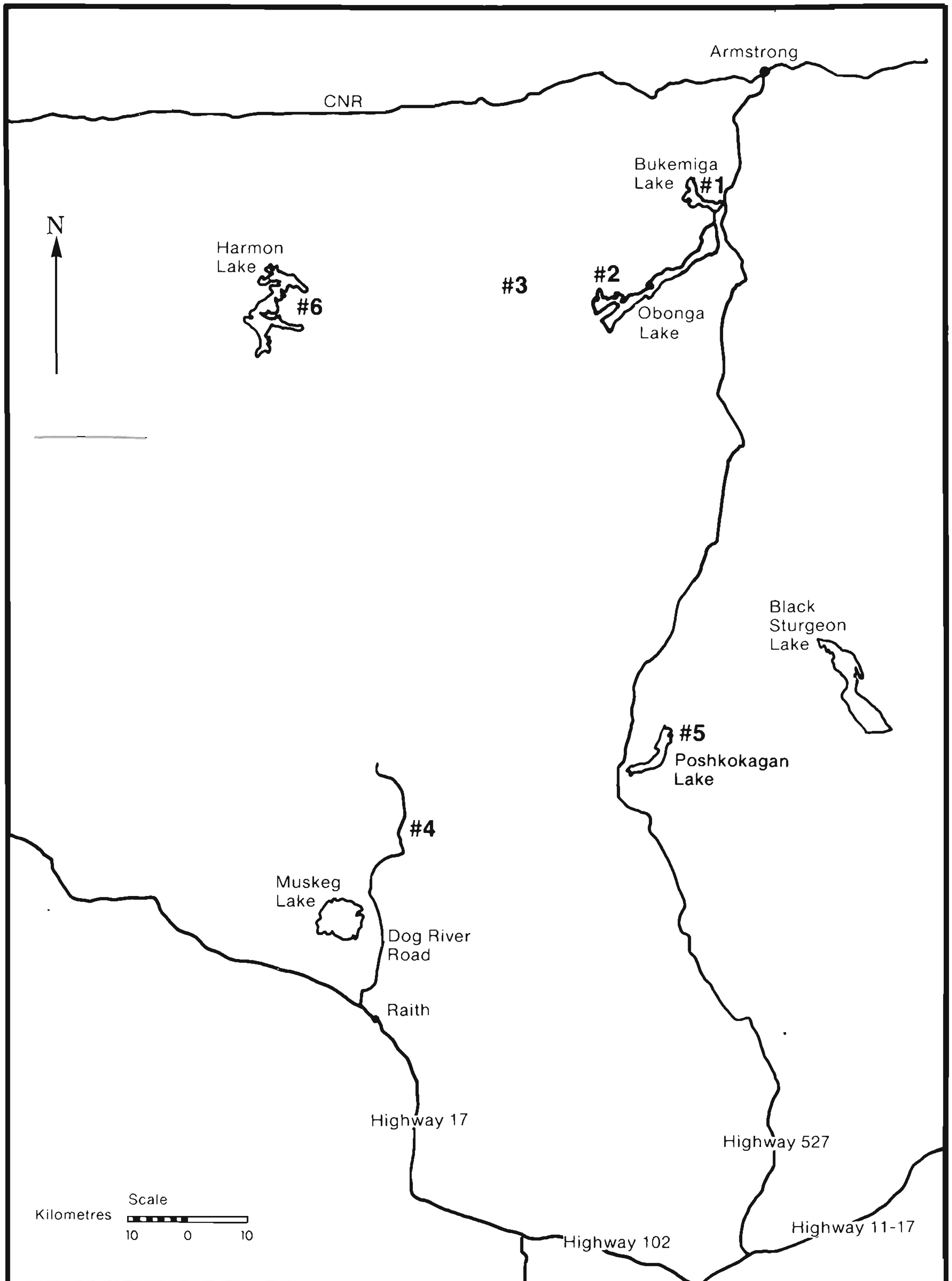

Fig. 1. Study site locations

by 25 to 75% hardwood composition with the balance being conifer. Nearly 50% of Ontario's productive forest land is mixedwood forest (McClain 1981). Timber species present before harvest were: white spruce (*Picea glauca*), black spruce (*P. mariana*), balsam fir (*Abies balsamifera*), trembling aspen (*Populus tremuloides*) and white birch (*Betula papyrifera*). Study site 1 was predominantly jack pine (*Pinus banksiana*) with less than 10% white spruce and aspen. Study site 6 was composed of more than 75% mature to overmature white spruce.

All cutover areas except study site 1 had been scarified. There was no scarification within clumps of residual timber or in most low areas. Other species present in the cutover areas included: beaked hazel (*Corylus cornuta*), serviceberry (*Amelanchier alnifolia*), pin cherry (*Prunus pensylvanica*), red osier dogwood (*Cornus stolonifera*), mountain ash (*Sorbus americana*), green alder (*Alnus crispa*), willow (*Salix* spp.),viburnum (spp.), mountain maple (*Acer spicatum*) and speckled alder (*Alnus rugosa*).

Climate

The major climatic factors in this study were snowfall and mean monthly temperature for December through March. The winter of 1986/87 had above average temperatures for all 4 months and below average snowfall for every month except February (Table 1). The winter of 1987/88 had below average temperatures for January and February, and the snowfall was below normal for all 4 months. Snow was generally deeper and temperatures lower in the more northerly study areas.

METHODS

Aerial Surveys

The objective of the aerial surveys of corridors and adjacent cutovers was to record the amount of moose use, as measured by moose sightings and tracks.

Study areas were surveyed during the winter using a Cessna 185 on sunny days with winds less than 30 km/hr and an air temperature greater than minus 25 degrees celsius. Flights were between 10:30 and 15:00 hours, at least 4 days apart and when there had been no significant snowfall or high winds for at least one day.

Tracks were observed by circling 100 to 150 meters over the study area and tracks were recorded on a sheet of acetate covering an aerial photograph of the area. The area was circled until each track was recorded.

Tracks were digitized onto a base map of the area and a geographic information system, ARC/INFO (ESRI 1989), was used to estimate: (1) the length of track in the cutover area, (2) the length of track and the area of the cutover within 45 meters of each cover type, (3) the length of track and the area of cutover outside of 45 m from each cover type, (4) the length of track and the area of the cutover within 90 m of each cover type and (5) the length of track and area of cutover outside of

Table 1. Mean monthly temperatures and snowfall for December through March in Thunder Bay, Ontario. Thirty year average, winter of 1987 and winter of 1988.

	Temperature (degrees Celsius)			Snowfall (cm)		
Month	30 year average	1986/87	1987/88	30 year average	1986/87	1987/88
December	-11.1	-7.2	-6.2	46.2	16.8	17.2
January	-15.4	-10.5	-15.9	48.4	30.0	34.2
February	-13.0	-6.0	-16.0	30.7	41.6	11.6
March	-6.3	-3.0	-4.8	34.2	9.8	30.2

90 m from each cover type. The area within 45 m of an edge was referred to as the 45 m buffer, the area within 90 m, the 90 m buffer.

The length of track within each buffer was determined as the sum of: (1) the length of track within the buffer and (2) the length of track within the cover type that was buffered. Including the length of track within the cover type made it impossible to distinguish between a preference for cover types and a preference for the buffer for some cover types. Records of tracks in cover types with open canopies may indicate a preference for the cover type itself, while tracks near cover types with coniferous canopies will show use only in relation to the buffer area.

Data were analyzed in this fashion because it was impossible to record all tracks under a coniferous canopy using fixed wing aircraft. Tracks were recorded where they went into the dense cover and where they left it. Also, in areas 2, 4, 5, and 6 extensive patches of hardwood residual within the cutovers were heavily used and recording only the amount of track around the edge of these areas might not have adequately represented the use the area received.

A chi square goodness of fit test was used to test whether track length was distributed in proportion to area within and outside of the 45 and 90 m buffers for each study site. In a second test, the proportion of track length within and outside of 45 and 90 m of each cover type within each study site was compared with the proportion of area available. Ninety percent confidence limits were calculated for the observed proportion of track length in each buffer area (Neu *et al.* 1974, Byers and Steinhorst 1984) and these buffer areas were classified as preferred, used as available, or avoided.

Preferred areas were defined as those in which the proportion of area in the buffer was outside of the calculated confidence interval and less than the proportion of track length in the buffer. Areas used as available were defined as those in which the proportion of area available was within the confidence interval. Avoided areas were defined as those where the proportion of area in the buffer was outside of the confidence interval and greater than the proportion of track length in the buffer.

Browse Surveys

The objective of the browse survey was to establish whether there was a change in moose feeding intensity or diet composition with increasing distance from corridors.

At least 3 starting points for survey lines were randomly chosen along each corridor. One survey line was added for each 200 meters of corridor over 1 km. Survey lines consisted of 24 plots and ran perpendicular to the corridor. Plots were 2 X 10 m in size with 5 m between plots. Each side of the corridor had 9 plots going out into the cut area and 3 plots within the corridor. Three distance strata were defined: 0-45, 45-90, and 90-135 meters from the corridor.

Data collected on each plot included: plant species, plant height class (.5-1.0 m, 1.01-2.0 m, >2.0 m), number of stems by species, and whether the stems were browsed or unbrowsed. Only the previous winter's browsing was recorded. The number of twigs for all species and height classes was tallied for one randomly selected plot within each distance stratum. This allowed a comparison of the number of twigs available and browsed among strata. On plots with stems >3.0 m in height, only twigs that were available for browsing (<3.0 m) were tallied. Stem counts per stratum, browse preference, diet composition and twig counts per stratum were compared using contingency tables.

Snow Surveys

The objective of the snow survey was to see if the corridors were acting as snow fences, causing snow depths to be greater near the corridor. This deeper snow could reduce the amount of use the area received and reduce the effectiveness of the corridor as a component of moose habitat.

Snow depth was measured at monthly intervals at 4 different study areas selected for their easy access during the winter months. Three corridors (areas 2, 4 and 5) were oriented along a north-south axis and one corridor (area 3) was oriented on an east-west axis. At each area, 2 survey lines perpendicular to the corridor were randomly located and plots 10, 20, 60, 40, 80, and 120 meters from the corridor edge were sampled. In addition, a plot was placed 20 meters within each side of the corridor. Ten snow depths were measured perpendicular to the survey line and with 1 m between measurments at each plot. The same lines and plots were used throughout the winter. Mean snow depths within and outside the corridor were compared using the least significant difference test.

RESULTS

Aerial Survey

Fourteen aerial surveys were flown over two winters; five surveys were flown in 1987 and nine in 1988. A total of 31 moose were sighted including 5 single moose and 13 groups. Out of 31 moose sighted, 22 were within 45 m of some kind of cover, 4 were within 45 m of a corridor and all other moose sighted were beyond 90 m from cover. A total of 353.6 km of track was recorded. The average total length of track within each study area was 58.9 km, ranging from 16.9 to 101.1 km.

Table 2. Track length per hectare within and outside of the 45 and 90 meter buffers for each area.

	Meters per hectare of track length			
	Within	Outside	Within	Outside
Study site	45 m	45 m	90 m	90 m
1	1167	460*	852	412*
2	3024	1985*	2324	1702*
3	1559	1032*	1358	927*
4	767	787	666	185*
5	478	234*	378	260*
6	363	216*	319	190*

* significant difference at $P < 0.01$

Track length was not distributed in proportion to area within each study area (Table 2). Moose preferred both buffers of all cover types grouped together except for the 45 m buffer of area 4.

For all study areas, tracks within the 45 or 90 m buffer of the corridor cover type indicated that those buffers were either preferred or used as available (Table 3). Other cover types with preferred buffers were the residual hardwood and residual mixedwood. Avoided types included: alder swamp, timbered swamp, uncut forest edge and grass/cattail marsh.

Table 3. Total number of buffer areas that were preferred, avoided or used as available (P<0.01) for all six study sites.

Cover Type	Number preferred	Number used as available	Number avoided
Corridor (all types)	7	15	0
Residual hardwood	6	2	0
Residual mixedwood	4	10	0
Alder swamp	0	5	1
Timbered swamp	0	8	2
Stream and lake reserve	0	8	0
Uncut forest edge	0	12	6
Residual blocks	0	8	0
Residual conifer	0	4	0
Grass/cattail marsh	0	6	2
Peat bog	0	2	0

Snow Survey

Snow in all areas was significantly (P<0.05) shallower in the corridor than in the clearcut. Maximum snow depths ranged from 65.8 cm to 92.8 cm (Fig. 2). With no major thaw during January or February of 1988, the first time that crusted snow could support a man with snowshoes was March 12. By April 2, the snow softened after midday

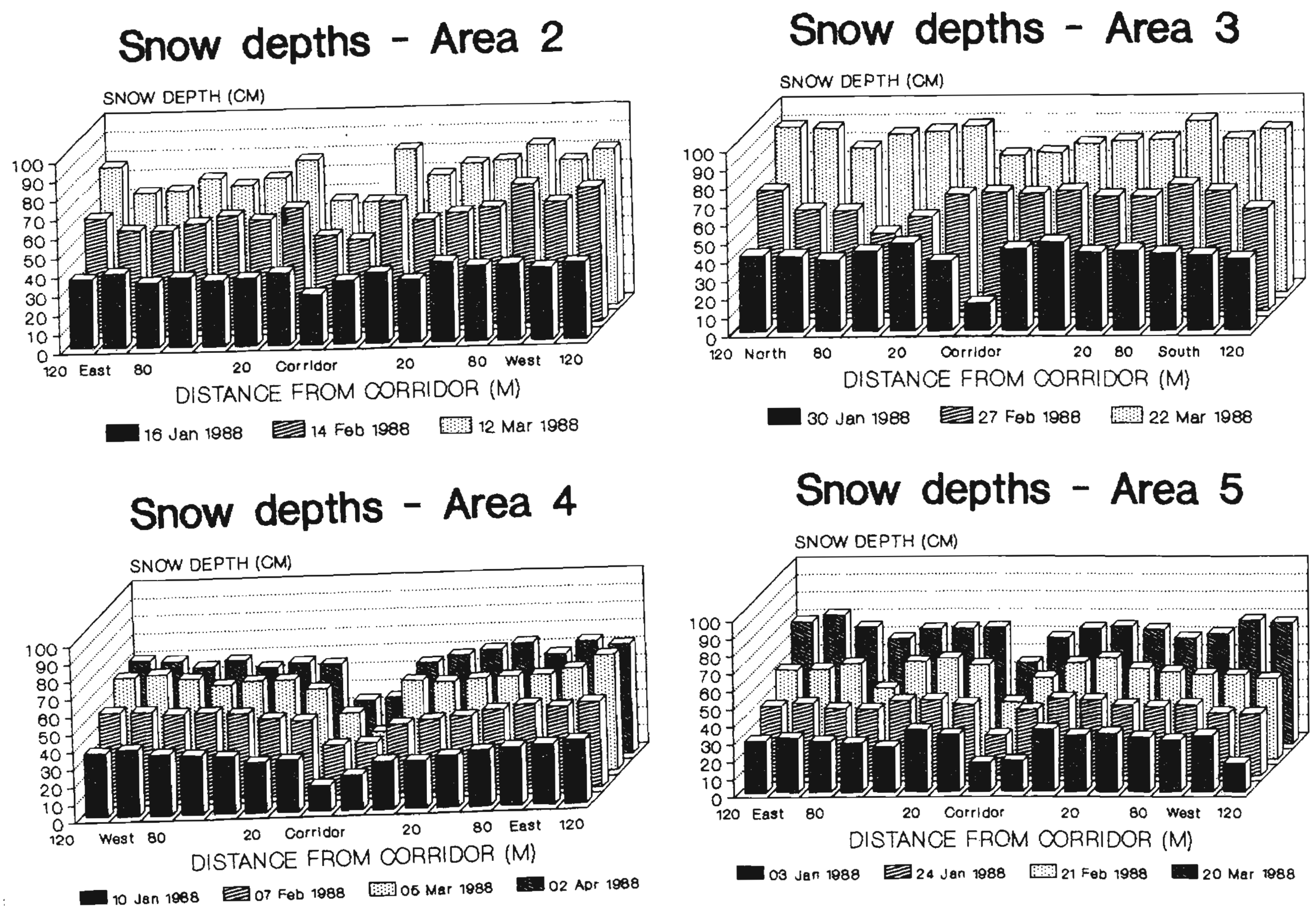

Fig. 2. Snow depths for all areas.

and snow depths were beginning to decline.

Browse Survey

One hundred and eighty-nine plots were sampled in 1987 and 918 plots were sampled in 1988. Only 5 of the 6 study sites were sampled.

The mean numbers of unbrowsed stems per plot showed no significant differences ($x^2 = 6.6$, 8 df, $P>0.05$) among strata or areas. The mean number of browsed stems per plot also showed no significant difference ($x^2 = 8.5$, 8 df, $P>0.05$) among strata or areas. Although the mean number of unbrowsed twigs per plot and the mean number of browsed twigs per plot were not distributed randomly among strata or areas (unbrowsed $x^2 = 234.1$, 8 df, $P<0.01$, browsed $x^2 = 69.9$, 8 df, $P<0.01$), there was not any clear relationship between number of twigs browsed and distance from the corridor.

The 4 species with the highest percentages of stems browsed (white birch 28%, aspen 16%, pin cherry 15%, and willow 11%) were not distributed ($x^2 = 194.2$, 6 df, $P<0.01$) or browsed ($x^2 = 36.9$, 6 df, $P<0.01$) randomly across strata. However, when the ratio of unbrowsed to browsed stems was compared there was no pattern that was significantly different ($x^2 = 1.22$, 6 df, $P>0.05$) from random in browsing between strata or species. This suggests that moose browsed where availability of preferred browse species was greatest, regardless of distance from the corridors.

DISCUSSION

Aerial surveys showed that corridor edges were either preferred or used as available within a clearcut. Thus, corridors are an effective management option for increasing the amount of cutover available for use because they increase the amount of edge available to moose. However, browsing near the corridors was not related to distance from the edge of cover. Instead, browsing seemed to be related to availability.

Habitat Selection Factors

Factors that can influence moose habitat selection in winter are: food availability, predation, escape cover and meteorological conditions such as snow depth and hardness, air temperature and wind speed. Food availability and use in this study were comparable to other studies of winter habitat (Prescott 1968, Crête and Jordan 1982, Hamilton *et al.* 1980). Peek *et al.* (1976) had up to 33% browsing as measured by spring line transect counts but concluded that overbrowsing was not a problem because of the number of alternate forage sources. Browsing of willow, aspen, cherry and birch stems ranged from 11% to 28% over all areas. This relatively low amount of browsing indicates that food availability was not limiting on any of the study areas.Predation can also affect habitat selection. Edwards (1983) suggested that cows with young calves occupy areas with relatively poor food quality in order to avoid wolves on Isle Royale. Moose may have been selecting patches that offered a combination of preferred browse species and escape cover. Escape cover affects both food availability for moose and their success in avoiding predators. The role of terrain as escape cover may be especially important in cutovers. Welsh *et al.* (1980) found that use of cutovers increased with increasing ruggedness. Sight can be blocked effectively by a moose being on the side of a ridge or in a narrow ravine. Ruggedness of terrain will probably also effect the distribution of browse plants. Plant distribution is more likely to be patchy in a more rugged area due to abrupt microsite differences within the cutover.

Snow depths of 60-70 cm will impede moose movement and snow depths greater than 90 cm severely restrict movement (Coady 1974). Since snow depths were <70 cm for all but 4 weeks during 1988, moose movement was relatively unrestricted during this study. The coldest mean monthly temperatures during this study period were in

January and February of 1988 (-15.9 and -16 degrees celsius respectively). These mean monthly temperatures were still above that which would stress a healthy calf moose (Renecker *et al.* 1978).

Characteristics of Preferred Areas

Corridors offered a mixture of food, thermal cover, escape cover and snow conditions that were favourable to moose. Forage was as abundant near corridors as it was in the clearcut and showed no sign of being over-browsed. There was usually a conifer dominant canopy within corridors that could intercept snow and provide cover from radiative heat loss. Corridors provided escape cover by being wide enough for a moose within the corridor to not be seen from the cutover. Shallower snow depths within corridors allowed moose to travel through corridors with less energy expenditure than if they were moving through a clearcut.

In this study corridors were preferred less often than hardwood residual. This may have been a function of the particular winters experienced during the study. If snow depth or hardness had been a more important factor in habitat selection, corridors may have shown more concentrated use. In a winter with deeper or harder snow, residual areas would no longer be accessible (Hamilton *et al.* 1980, McNicol and Gilbert 1980) while corridors would still provide the same benefits.

Hardwood residual was preferred in all areas where it was available but these data may be biased towards showing more use than corridors because tracks within the residual were recorded and those within corridors were not. However, hardwood residual areas did have properties that made them preferable to moose. Although a hardwood canopy does not significantly reduce the depth of snow (Weitzman and Bay 1959), the stems could break the wind so there was less wind packing of snow in hardwood residual areas. Brusnyk and Gilbert (1983) found that areas with a semi-open canopy tend to have taller stems of browse species in greater abundance than the clearcut. This effect was exaggerated on these study sites because most of the cutover area outside of the residual had been scarified. Therefore, hardwood residual probably offered high food availability, softer than average snow and escape cover among mature trees, young trees and shrubs.

The conifer component of mixedwood residual cover types offered lower snow depths as well as escape and thermal cover. Mixedwood residual could offer browse near the edges, or in the interior of the stand if the hardwood component was significant.

Validity of Results

The aerial survey results, which showed that moose prefer areas near corridors differed from browse survey results, that did not show these preferences. However, the two findings are not necessarily contradictory. The aerial surveys measured a general pattern of use. They showed where moose had been browsing, travelling or avoiding predators from January through March. Aerial surveys gave a better representation of how moose used the clearcut area and the cover within the clearcut during the winter months. The browse survey results, on the other hand, show browsing from late fall to early spring. This extended time period includes the shift from early to late winter browsing areas (Crête and Jordan 1982, Phillips *et al.* 1973) and may include changes in diet preferences (Peek *et al.* 1976). Also, the browse survey may have shown differences in use in relation to distance from cover if it had been related to other features that provided cover (i.e. terrain and residual timber) rather than just distance from the corridor.

Management Recommendations

This study has shown that moose use corridors of uncut timber left during commercial timber harvesting. To maximize use, corridors should provide thermal and escape cover, available browse near the corridor and enough conifer component to reduce the snow depth within corridors. Corridors 100-200 m wide in this study provided adequate escape cover and maintained snow conditions similar to those in an uncut stand. A narrower corridor could be effective if the timber were dense enough to provide complete canopy cover but not so dense as to prevent a moose from moving through it. If blowdown were expected to be significant, a wider corridor might provide cover longer. In broken terrain where timber quality varies, a wider corridor would be necessary to provide shallower snow depths and uniform cover along the length of the corridor. The wider corridor would make it more likely that there was some dense conifer canopy to intercept falling snow and provide thermal cover.

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