WINTER HABITAT USE BY MOOSE IN THE VICINITY OF AN OPEN PIT COPPER MINE IN NORTH–CENTRAL BRITISH COLUMBIA

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ABSTRACT: Patterns of winter habitat use by moose (*Alces alces andersoni*) were documented around an open pit copper mine in north–central British Columbia. Results of browse surveys, pellet–group counts and noise level measurements indicate that moose distribution in the study area is influenced more by differences in browse availability among different habitat types than by disturbance associated with mining. The results demonstrate that moose are being attracted to cutover areas on the periphery of the mine site and have habituated to the presence of the Bell Mine since mining was first initiated 17 years ago.

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Very little information is available in the North American literature on effects of mining activities on moose (Brusnyk and Westworth 1988). In addition to the direct effects associated with habitat loss and displacement of animals due to mine establishment, environmental impact assessments usually consider the possibility that noise and human disturbance will result in reduced use of adjacent habitats throughout the operating phase of the mine. Moose is a species of primary concern at a number of mine sites being operated or planned by Noranda Minerals Inc. across Canada. To obtain a better understanding of the ways in which mining affects habitat use and distribution of moose during the operating phase, a study was initiated in 1989 at the Bell Mine in north–central British Columbia.

The Bell Mine is an open pit copper mine that has been operating since 1972. The mine is situated along Babine Lake, in a region of the province that has historically supported an abundant moose population. Moose have been observed in the vicinity of the mine site year round; however, most sightings by mine personnel occur during the late winter period.

The overall objective of this study was to document patterns of winter habitat use by moose around an operating open pit mine. Specific objectives were to: (1) describe use of habitats in the vicinity of the mine area, (2) to document browse production and use in the area, (3) to document noise levels associated with mining activities and (4) to assess the relative importance of browse supply and noise levels as determinants of winter habitat use by moose.

STUDY AREA

The Bell Mine is located in north-central British Columbia, approximately 160 km east of Smithers. The mine bisects the Newman Peninsula in Babine Lake, the largest lake in the province. While areas around the mine site have been logged in the past and a network of logging roads exists, there is no mine. All access to the mining area is by barge or boat from the town of Granisle on the west side of the lake.

The mine complex, including an open pit, tailingts area and various plant structures, occupies approximately 10 km^2 of the peninsula. The pit which has a diameter of 700 m and is approximately 250 m deep, is serviced by 7 cubic yard electric shovels and 59 tonne haulage trucks. The mine has a site workforce of 280 and operates continuously seven days per week. Blasting of ore reserves in the open pit occurs two or three times per week throughout the year.

The study area lies within the Subalpine fir subzone of the Sub-boreal Spruce Biogeoclimatic Zone (Pojar *et al.* 1982). Most of this forest zone is located upon the Nechako Plateau, ranging in elevation from 500 m to 1350

m above sea level. Habitats in the vicinity of the mine site consist predominantly of differently–aged clearcuts (2–15 years old) interspersed with uncut stands of mature mixedwood or coniferous forest (Fig. 1). The coniferous component is comprised mainly of hybrid white spruce (*Picea glauca engelmanii*) and subalpine fir (*Abies lasiocarpa*), with less frequent occurrences of lodgepole pine (*Pinus contorta*). Aspen (*Populus tremuloides*) is the most widespread deciduous species in the study area, however small stands or individual stems of paper birch (*Betula papyrifera*) and balsam poplar (*Populus balsamifera* ssp. *trichocarpa*) are also present at lower densities. Aspen typically occurs as a co–dominant species in mixedwood stands, with pure stands being limited to south–facing exposures.

The mine site occupies almost the full width of the peninsula. Shoreline timber reserves, averaging approximately 100 m wide, separate the mine from Babine Lake along the east and west sides. The northern portion of the study area is dominated by a 10–year old clearcut. The clearcut is located just north of the open pit and adjacent to a rock dump and heavy equipment area (Fig.1). Small residual stands of aspen and scattered stems of hybrid white spruce occur throughout the clearcut, which is characterized by sapling-sized stands (<4 m high) of regenerating aspen and shrubs. A lightly used access road connects the barge terminal with logging camps located north of the mine area.

Extensive clearcuts also exist on the south side of the mine, adjacent to the tailings disposal area. Logging of these areas occurred only two years ago. Small undisturbed stands of mature hybrid spruce and subalpine fir occur between the clearcut and lakeshore on both sides of the peninsula. An access road leads to the tip of the peninsula, however, it receives only occasional use by mine personnel throughout the year.

The climate of the study area is characterized by long, cold winters and short, wet, and

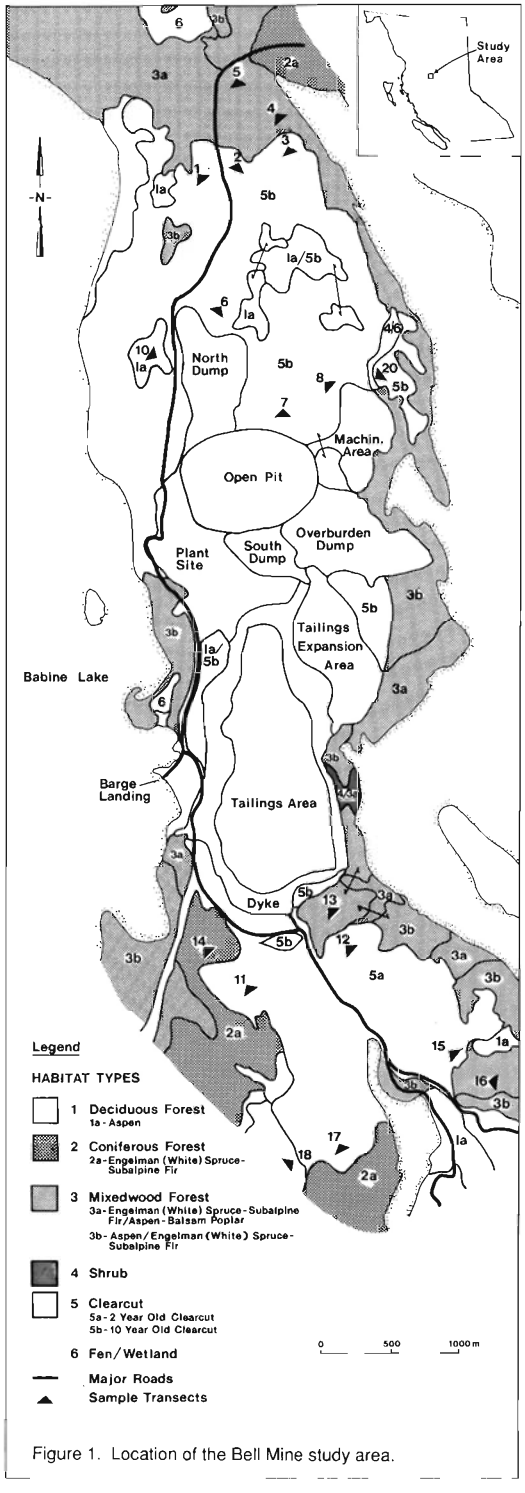

Figure 1. Location of the Bell Mine study area.

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warm summers. Pojar *et al.* (1982) note that the subalpine fir subzone receives the most rain and snow of the three Sub-boreal Spruce Zones in the region. Meterological data for the Babine Lake recording station (elevation 774 m above sea level) indicate a mean annual temperature of 1.1°C but temperatures range from -17.5 °C in winter to 13.7 °C during summer. Mean annual rainfall and snowfall values for the study area are 600.7 mm and 2705.1 mm, respectively.

METHODS

Sampling Design

The sampling design for the study was dictated largely by geographic limitations resulting from the mine's location and past logging activities (Fig. 1). Browse surveys and pellet group counts were conducted along 20 transects placed in clearcut and uncut forest stands located north and south of the mine site. Transects were aligned parallel to the mine site, and each was comprised of 20 sample points, spaced at 25 m intervals.

One half of the transects were located within 300 m of the mine edge, while the remaining transects were established at distances greater than 1000 m from the mine site. It was felt that these two distance categories would provide a clear indication of any reduction in habitat use that might occur immediately adjacent to the mine area, where noise levels and human activity are greatest. Noise level measurements taken at the start of the study indicated that mine noise was largely attenuated at a distance of 1000 m.

An attempt was made to sample each of the major habitat types present around the mine site, including both 2–year old and 10–year old clearcuts, mature spruce–fir forest, mature spruce–dominated mixedwood forest and mature aspen–dominated mixedwood forest. While aspen stands do occur to a limited extent near the north end of the mine, comparable stands were not present at distances exceeding 1000 m. A single transect was placed in aspen forest to provide an indication of the relative importance of this habitat type in comparison to other habitat types in the area.

Browse Surveys

Stem densities of browse species were derived using Batchelor's (1973, 1975) corrected–point–distance method. Additional information collected from each selected browse stem included: species, clump size (number of stems), height (cm), number of browsed (ungulate or hare) and unbrowsed twigs (greater than 2.5 cm in length) within a 0.3 to 2.5 m height range. Statistical procedures for determining browse preferences by ungulates followed Neu *et al.* (1974). The chi-square statistic was used to test the null hypothesis that ungulates utilized browse species in proportion to their availabilities. If the null hypothesis was rejected, a Bonferroni Z statistic was calculated to determine preference or avoidance of browse species.

Pellet Group Surveys

Pellet group counts were conducted in conjunction with the spring browse survey to obtain estimates of cumulative winter habitat use by moose and deer. Numbers of pellet groups were counted within 50 m^2 circular plots centered at each sample point. All pellet groups were tallied if at least one-half of the pellets fell within the sample plot. Only those pellet groups that appeared to be deposited during the previous winter were counted.

Intensity of habitat use by moose (mean pellet groups/plot) in relation to habitat type and distance from the mine site was tested using analysis of variance (ANOVA) procedures. Prior to ANOVA, every two sample plots along each transect were averaged and a square-root transformation was applied to equalize the variances and normalize the data set (Kleinbaum and Kupper 1978, Sokal and Rohlf 1981). Significant differences identified during ANOVA were partitioned using multiple classification analysis (MCA) (Norusis 1988). The null hypothesis of no

difference in ungulate use among habitat types or distance strata was tested at a probability level of $P<0.05$.

Noise Level Measurements

To provide an indication of the noise environment that moose are exposed to around the mine, sound level measurements were taken in forested and clearcut habitats at various distances from the mine in late May and early June. Sound level measurements were recorded during 15 minute daylight monitoring periods using a Brule and Kjaer Model 2230 sound level meter. In addition to the maximum and minimum noise levels, Leq and peak impulse noise levels were also recorded. The Leq is a statistic used for measuring the sound levels associated with fluctuating machinery noise. It is defined as the steady sound pressure level which, over a given period of time, has the same total energy as the actual fluctuating noise. Peak impulse levels refer to the peak noise levels associated with impulse sounds such as those generated by blasting, hammering and certain machinery noises. Impulse sounds, which are characterized by a rapid rise time and a duration of less than one second, are usually considered to have greater potential for eliciting a startle reaction by wildlife than continuous sound.

RESULTS

Distribution and Habitat Use

During the study, moose were observed only infrequently around the mine site. Reports by mine personnel indicate that, while moose are present in the area throughout the year,the greatest number are observed during late winter (January–April). During that period, congregations of 20 or more moose have been observed around the mine and occasionally within the mine area itself (Fig. 2).

Fig. 2. A group of eight moose observed on the edge of the mine pit in March, 1986 (photo by R. McArthur, Noranda Minerals Inc.)

Analysis of the pellet–group data indicated that habitat type was a more important factor influencing moose distribution than distance from the mine site (Table 1). Differences between the two distance categories were not significant ($P>0.05$) whereas highly significant ($P<0.01$) differences were detected among the six habitat types. Pellet group densities were significantly higher than the overall mean in 10–year old clearcut and aspen habitats (Table 2). Densities for these habitat types exceeded 300 pellet groups/ha, more than twice the densities recorded in most of the other habitat types (Fig. 3). Two–year old clearcuts supported the lowest use by moose during the 1988–89 winter period. In the case of all habitat types sampled, pellet group densities were as high or higher within 300 m of the mine site as they were in the 1000–2000 m distance category (Fig. 3).

Table 1. Effects of habitat type and distance from the minesite on the distribution of moose (as indicated by pellet groups) over-wintering near an open pit copper mine in north–central British Columbia, 1989.

Source of Variation	df	MS	F	P
Main Effects	6	9.194	26.921	0.000
Distance Strata	1	0.966	2.830	0.094
Habitat Type	5	10.188	29.830	0.000
2–way Interaction	4	0.063	0.185	0.946
Habitat X Distance	4	0.063	0.185	0.946
Explained	10	5.542	16.227	0.000
Residual	189	0.342		
Total	199	0.603		

Table 2. Multiple classification analysis of the distribution of moose pellet groups in relation to distance from the mine site and habitat type near an open pit mine in north–central British Columbia, 1989.

Factor	N	Deviation	Eta
Distance Strata			
<300 m from mine site	100	0.07	
>1000 m from mine site	100	–0.07	
			0.09
Habitat Type			
Spruce–Fir Forest	10	–0.20	
Spruce–Aspen Mixedwood	20	–0.20	
Aspen–Spruce Mixedwood	40	–0.33	
Aspen Forest	20	0.53	
2–year old Clearcut	40	–0.73	
10–year old Clearcut	70	0.58	
			0.66
R^2			0.46
Grand Mean			1.11

Browse Availability and Use

Results of the browse survey showed a preference by moose for six shrub species including low-bush cranberry (*Viburnum edule*), red-osier dogwood (*Cornus stolonifera*), saskatoon (*Amelanchier alnifolia*), white birch, willow (*Salix* spp.) and mountain ash (*Sorbus scopulina*) (Table 3). Willow was especially highly preferred by ungulates. Many of the willow stems in both the two-year old and 10-year old clearcuts were heavily browsed during the previous winter as well as in past years. Rose (*Rosa acicularis*) was used in proportion to it's availability while the remaining four species were browsed significantly less than their relative availabilities.

The highest densities of preferred browse species occurred in the 10-year old clearcut, with willow accounting for almost 33% of the total (Table 4). Intermediate densities of preferred browse species were found in aspen and mixedwood habitats, while the lowest densities were recorded in the two-year old clearcut and mature coniferous forest habitats. Low-bush cranberry was typically the most abundant of the preferred browse species in forested habitats, while willow was the most abundant species in the clearcuts.

Levels of browse use by moose appeared to be strongly related to browse availability (Fig. 4). Highest use occurred in the 10-year

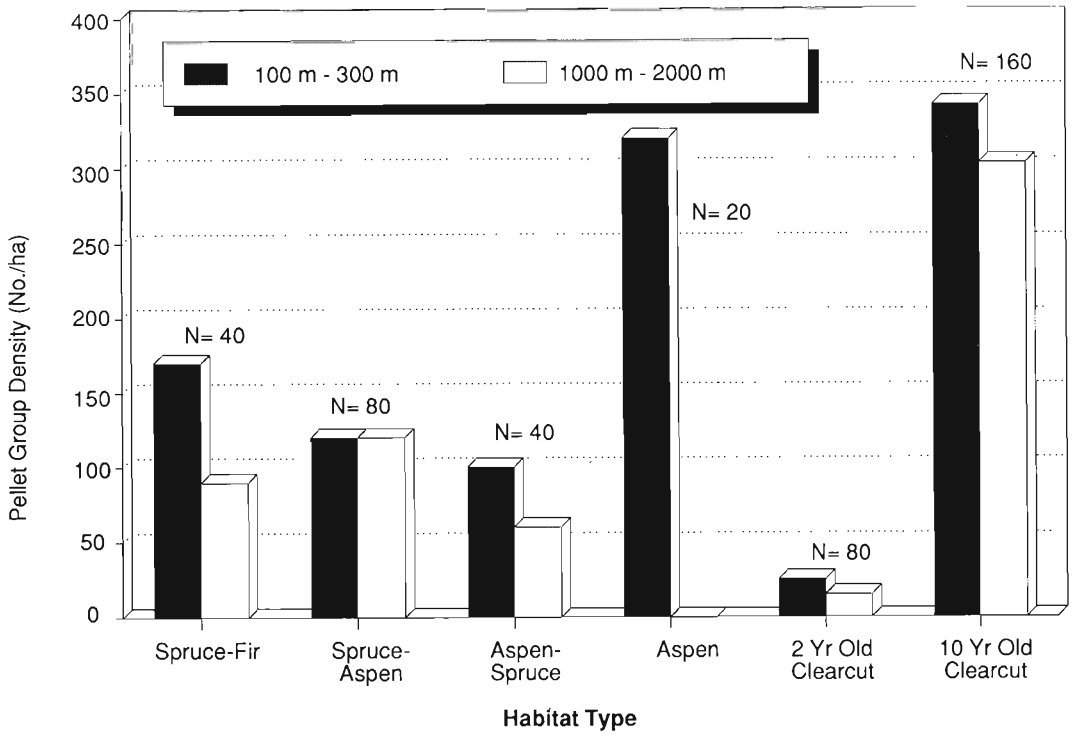

Fig. 3. Moose pellet group densities in principal habitat types in relation to distance from the Bell Mine Site, Granisle, B.C., winter 1988-89.

Table 3. Ungulate browse preferences in the vicinity of an open pit copper mine in north–central British Columbia, 1989.

Browse Species	Number of Available Twigs	Proportion Browsed		95% Confidence Interval[1]	Preference Rating[2]
		Exp.	Obs.		
Aspen	1491	0.113	0.035	0.023<Pi>0.047	–
Bálsam Poplar	169	0.013	0.001	0.000<Pi>0.003	–
Low–bush Cranberry	1553	0.118	0.163	0.139<Pi>0.189	+
Red–osier Dogwood	777	0.059	0.123	0.102<Pi>0.144	+
Saskatoon	895	0.068	0.105	0.085<Pi>0.125	+
White Birch	428	0.032	0.134	0.112<Pi>0.156	+
Willow	1255	0.095	0.345	0.314<Pi>0.376	+
Rose	888	0.067	0.053	0.039<Pi>0.067	0
Alder	789	0.060	0.004	0.000<Pi>0.008	–
Mountain Ash	114	0.009	0.026	0.016<Pi>0.036	+
Subalpine Fir	4829	0.366	0.012	0.005<Pi>0.019	–
Total	13188	1.000	1.001		

[1] Bonferroni statistic indicates preference or avoidance. If the expected proportion falls outside of the confidence interval, a significant deviation from the expected is indicated (Pi < 0.05)

[2] Indicated whether a species was preferred (+), avoided (–) or used in proportion to it's availability (0).

Table 4. Densities (stems/ha) of major browse species by habitat type in the vicinity of an open pit copper mine in north–central British Columbia, 1989.

Browse Species	Densities of Browse Species (stems/ha)					
	Spruce–Fir	Spruce–Aspen	Aspen–Spruce	Aspen	Clearcuts	
					2-Yr	10-Yr
PREFERRED SPECIES						
Low–bush Cranberry	1759	6254	5801	5633	365	2425
Red–osier Dogwood	24	2386	1380	0	1119	2425
Saskatoon	0	0	609	505	355	1822
White Birch	0	0	55	168	83	1375
Willow	0	171	0	252	1413	5139
Mountain Ash	0	24	55	0	50	16
Rose	84	2672	480	3393	99	2565
Sub–total	1867	11507	8380	9951	3484	15388
OTHER SPECIES						
Aspen	24	122	277	68	149	1235
Balsam Poplar	0	0	0	84	20	253
Alder	36	0	249	0	1216	115
Subalpine Fir	570	64	314	0	30	46
Sub–total	630	186	840	252	1415	1649
Total	2497	11693	9220	10203	4899	17037

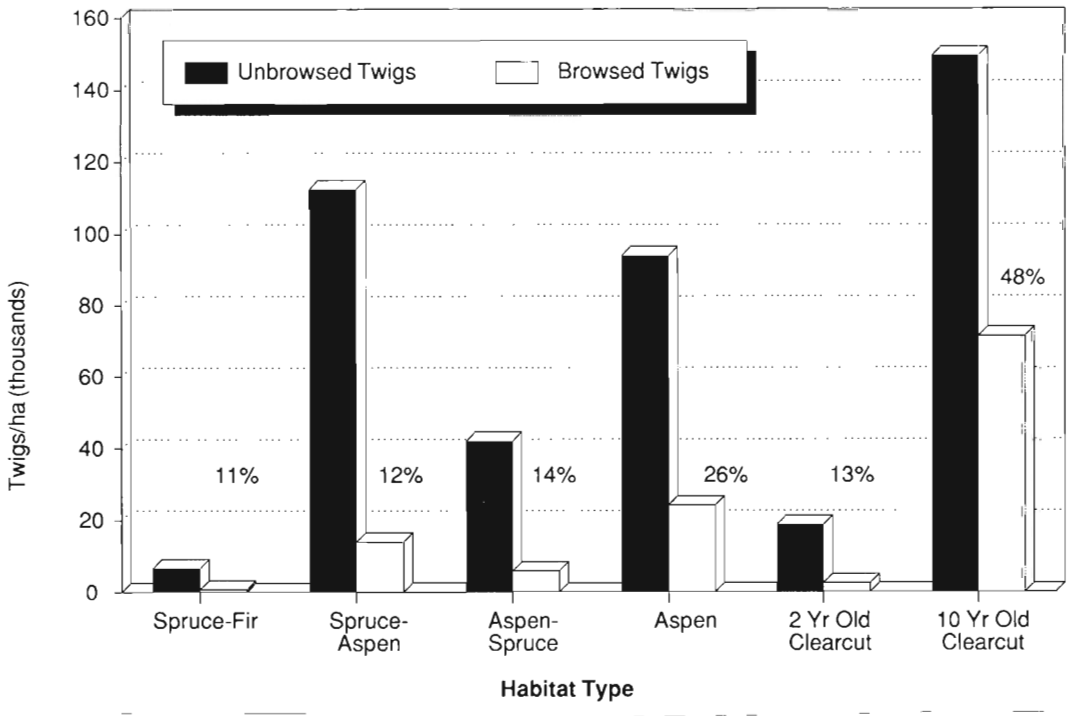

Fig. 4. Comparison of twig availability and browse use in principal habitat types in the Bell Mine study area, Granisle, B.C., winter 1988-89. (Numbers above bars indicate the percentage of available twigs removed by ungulates).

old clearcut and aspen habitats where over 47% and 26% respectively, of the available twigs were browsed. Browse use did not exceed 14% in any of the other habitats sampled. The mine apparently had little influence on winter browsing patterns, since the intensity of browsing within 300 m of the mine was usually greater than or equal to levels recorded at distances greater than 1000 m (Fig. 5).

Noise Levels

Generally, noise levels associated with various mine activities did not exceed 90 dBA at distances of >100 m (Table 5). The highest noise levels result from blasting, although those levels tend to be highly variable depending on the size of the charge and position of the blast within the pit. Small blasts involving less than 45 kg of explosive resulted in noise levels that were similar to the warning whistles that are used to warn mine personnel prior to detonation. Production blasts, however, may use as much as 20000 kg of explosive. Peak impulse noise levels recorded during four production blasts ranged from 88 to 135 dBA at a distance of approximately 200 m. These blasts resulted from the detonation of charges ranging from 6464 kg to 19323 kg. Noise levels did not appear to be appreciably different between forested habitats and clearcuts at similar distances.

DISCUSSION

The Bell Mine is located in one of the most important moose ranges in British Columbia, with densities ranging from 0.5 – 1.0 moose/km^2 (Eastman and Ritcey 1987). Because the mine has been in operation since 1972, it has afforded an excellent opportunity to examine spatial patterns of winter habitat use by moose around an established mine.

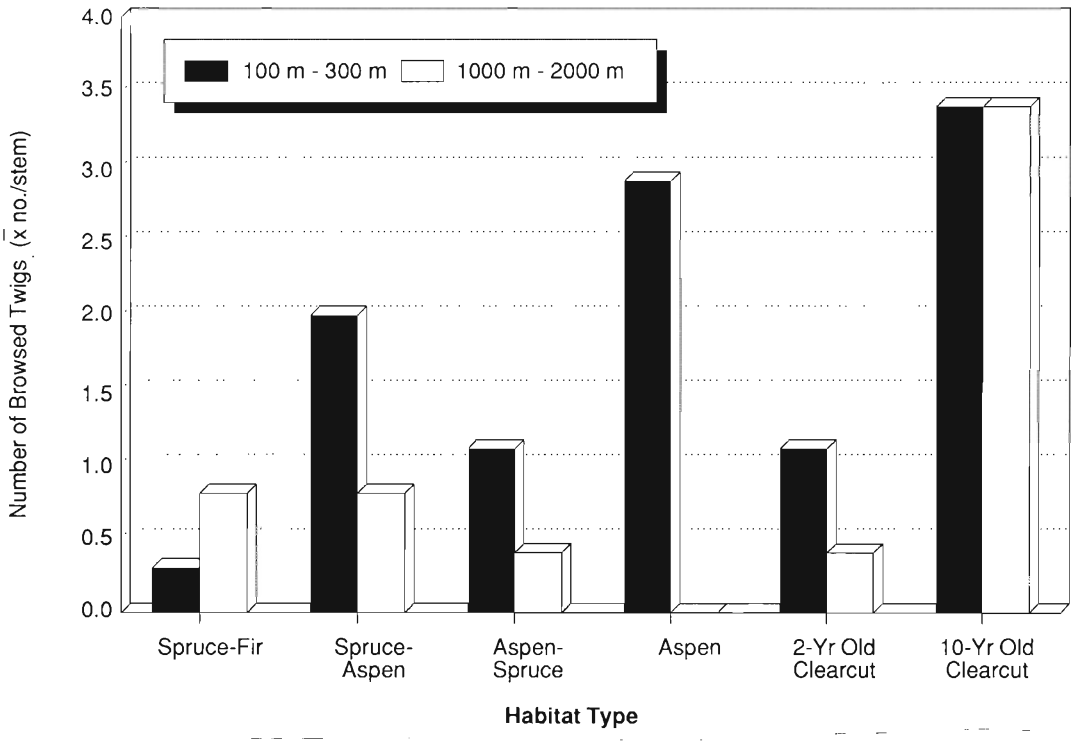

Fig. 5. Use of preferred browse species by ungulates in principal habitat types in relation to distance from the Bell Mine Site, Granisle, B.C., winter 1988-89.

Table 5. Noise levels (dBa) associated with various mining activities in the vicinity of an open pit copper mine in north–central British Columbia, 1989.

Source	Distance (m) from Pit	Noise Level Readings (dBa) Max.	Min.	Leq	Peak Impulse
GENERAL MINE NOISE					
Open/Clearcut	100	63	42	55	84
Areas	100	102	–	65	86
	300	57	35	39	86
	400	60	35	39	86
	500	64	29	46	63
	700	69	37	43	71
	1250	57	22	29	70
	1300	59	27	36	74
Forested	250	57	37	44	80
	400	53	35	39	77
	1650	62	25	43	67
	2000	60	–	32	66
BULLDOZER	50	132	132	132	132
	250	71	52	58	75
WARNING WHISTLE	200	–	–	–	80
BLASTING: small[1]	200	–	–	–	69–84
large[2]	200	–	–	–	88–135

[1] < 45 kg of explosives
[2] 6464 – 19323 kg of explosives

The results of this investigation demonstrate that moose are able to habituate to various disturbances associated with surface mining. Pellet group counts and browse surveys did not show any reduction in habitat use adjacent to the mine during the winter period. In fact, the highest pellet group densities were recorded along a transect located approximately 100 m from the open pit. This particular area is a wet site that contains high densities of willow, one of the most preferred browse species in northern British Columbia (Mr. D. Steventon, B.C. Wildlife Branch, pers. comm., May 17 1989; Goulet 1985). Moose and deer pellet groups were observed within 15 m of the pit and in residual patches of shrub or forest cover within the mine area itself.

The results of the study actually indicate somewhat higher use of areas close to the mine, where browse availability is high. Moose are apparently responding more to the abundant browse supplies available in the 10-year old clearcut than to the presence of the mine itself. At least in the winter of 1988–89, availability of browse had a more pronounced influence on winter habitat selection by moose in the study area than did availability of dense cover. However, the presence of moderately–high pellet group densities in mature spruce–fir stands, which contained negligible amounts of browse, may indicate that moose are attracted to conifer stands for shelter during winter storms or periods of unusually cold weather.

The younger (2-year old) clearcuts appear to have limited value for moose. While the 2-year old clearcuts supported a dense herbaceous ground cover, browse densities and mean heights of preferred browse species were low. During late winter, snow depths may approach or exceed the mean heights of preferred browse species (59 cm +/- 2.0 S.E., N=123), greatly reducing browse availability to moose.

The concentrations of moose near the

mine site in late winter may also be influenced by other factors. The general region around the mine site is exposed to local hunting pressure and to predation by wolves. Restrictions on hunting in the vicinity of the mine site and perhaps the aversion of wolves to areas of concentrated human and industrial activity, may provide a degree of security for moose that is not available in areas further from the mine site.

Habitats in the study area may also be more productive than habitats in neighbouring areas. Although lands along the east side of Babine Lake have been exposed to extensive logging, many of the clearcuts have received herbicide applications (i.e. glyphosphate) to control deciduous regrowth and increase productivity of commercially important forest species. Kennedy and Jordan (1985) reported that while glyphosphate is extremely effective as a shrub control agent in forest management, it can also negatively affect browse production over a long period of time. Connor and McMillan (1988) found that moose use of glyphosphate treated cutovers was considerably lower than levels of moose use in untreated cutovers. The 10-year old clearcut adjacent to the Bell Mine was not treated with herbicide, and consequently may represent one of the more productive winter browsing areas in the region.

The importance of browse quantity and quality to moose has been well documented in the past (Bonar 1985, Eastman 1983, Telfer 1978, 1988, Oldemeyer *et al.* 1977, Poliquin *et al.* 1977, Oldemeyer 1974, Peek 1974). However, the extent of influence this may have on moose behaviour, particularly with respect to various types of resource developments and other human-related disturbances, is unclear.

The predictability of visual and acoustical stimuli are important factors that will influence the rate of habituation (Geist 1978) and subsequent use of habitats adjacent to mining developments. Busnel (1978) reported that panic reactions in wildlife may be elicited by any type of abrupt acoustical or visual intrusion, but if other senses of the animal are not stimulated or if the noise is not associated with an alarming event (Geist 1978), most species will learn to ignore the disturbance source.

In the case of the present study, overwintering moose in the vicinity of the mine site have become conditioned to noise and general mine activity levels associated with vehicular traffic, plant machinery and blasting of ore reserves. Although pre-mining data on the levels or patterns of moose habitat use were not available for the mine site, suitable browse supplies associated with the 10-year clearcut and adjacent blocks of mature coniferous cover are likely important factors in moderating the effects of various mine-related activities and noise levels on the local moose population. However, seasonal patterns of moose habitat use (i.e. during the snow-free periods of the year), age and sex composition data, and detailed information on the behavioural responses of moose overwintering near the mine site are not known. Such information would provide a more detailed and complete understanding of moose behaviour in relation to human-related disturbances and perhaps aid both wildlife and mine managers in the decision-making and planning processes regarding resource developments and the potential effects of these developments on local moose populations.

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