

**THE EFFECTS OF  
JUVENILE SPACING ON  
WILDLIFE HABITAT USE  
DURING WINTER IN THE  
INTERIOR DOUGLAS-FIR ZONE  
OF BRITISH COLUMBIA**

by  
M.J. Waterhouse, R.J. Dawson, H.M. Armleder

RR 89003-CA

**R·E·S·E·A·R·C·H  
REPORT**

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Internal Reports of the Ministry of Forests  
Research Program

# **The Effects of Juvenile Spacing on Wildlife Habitat Use During Winter in the Interior Douglas-fir Zone of British Columbia**

by  
M.J. Waterhouse, R.J. Dawson, H.M. Armleder

A Joint Project involving:  
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## EXECUTIVE SUMMARY

Data were collected for a second winter (1 and 2 years post-spacing) to reassess the changes in habitat use by common wildlife in response to juvenile spacing in a mature, uneven-aged interior Douglas-fir forest. The study examined the following species: snowshoe hare, red squirrel, mule deer, moose, and coyote/fox.

Snowshoe hares infrequently used recently spaced blocks probably because of dramatic reduction in cover and food. Since unspaced forest is high use snowshoe hare habitat, the size and spatial distribution of spacing blocks with a larger management unit requires careful consideration if snowshoe hare populations are an important management concern in the area. Red squirrel use was generally lower in spaced areas than in control blocks. Thick patches of immature trees within a mature stand may provide superior thermal and security cover for squirrels. Habitat use by other species did not change measurably in response to spacing.

Unspaced strips left in spaced blocks were used by snowshoe hares and red squirrels. Hare habitat use appears to increase as unspaced strip width and proportion of unspaced area left in the block increase. However, a replicated study is necessary to confirm this result. In any case, even the widest (33m) strips do not maintain the same amount of use by either hares or squirrels as the control blocks do. Mule deer and moose may use the unspaced strips indirectly for thermal and security cover. The size and shape of unspaced areas in spaced blocks and the placement of spaced blocks near unspaced areas need to be examined further.

Over a 1-year period, the mean slash depth in all blocks decreased by 43% while the area covered by measurable slash decreased by 22%. The trees were parallel felled, then bucked into 4-m lengths. Also, the felled trees were slashed to a depth of less than 0.5 m in five of six blocks. Deep, extensive slash in a block, especially in conjunction with snow, can impede animal movement. Rapid slash reduction makes habitat within the block available in a shorter time span.

Man-made trails may be necessary to provide access through deep, continuous slash. The first winter that data were collected, mule deer, moose, coyote, and fox made extensive use of trails in 1-year-old and recently spaced blocks. In the second winter (1989), however, shallower slash and a thick layer of snow made it impossible to assess trail use in all but one block.

Further research is necessary to determine the short- and long-term effects of spacing on wildlife in different seasons and under a variety of conditions.

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## INTRODUCTION

Juvenile spacing is a widely used stand-tending practice in the interior of British Columbia. While spacing is silviculturally beneficial, little research has directly assessed the positive and negative impacts on wildlife in various forest subzones. To address this problem in one specific subzone, a preliminary study was conducted in the 100 Mile House Forest District in the winter of 1987/88 (Waterhouse *et al.* 1988). Six blocks of multi-layered, mature interior Douglas-fir forest (IDFb2) were juvenile spaced in the fall of 1986 and 1987. They demonstrate a variety of spacing densities and prescriptions such as minimizing slash depth, making trails and leaving unspaced strips of regeneration within the block. These blocks provided us with an opportunity to study the effects of spacing on habitat use by several wildlife species: mule deer (*Odocoileus hemionus*), snowshoe hare (*Lepus americanus*), red squirrel (*Tamiasciurus hudsonicus*), fox (*Vulpes vulpes*), coyote (*Canis latrans*), and moose (*Alces alces*).

The prime objective of this study (1988/89) was to collect more data to consolidate and extend the results and conclusions found by the preliminary investigation. Those conclusions were as follows: First, mule deer, moose, and coyote/fox strongly preferred moving along man-made trails to moving through slash. Second, snowshoe hares significantly preferred unspaced versus spaced areas, red squirrels tended to favour unspaced areas, and the other species showed no preference. Third, there was a trend for snowshoe hare track density to increase with width of unspaced strips left in spaced areas. Fourth, no relationships between animal use and distance from an unspaced/spaced edge were detectable.

## STUDY AREA AND METHODS

The six spaced blocks and three control blocks were established on the Big Lake mule deer winter range, located 10 km west-northwest of 100 Mile House, B.C. All of the blocks lie on gentle (5-15%) northeast slopes between 1067 and 1180 m elevation.

The area is classified as IDFb2, a subzone in the interior Douglas-fir zone.<sup>1</sup> Douglas-fir is the climax tree species. The spaced and control blocks are located in moderate crown closure stands (35-45%) of uneven-aged, mature Douglas-fir where, before spacing, 60% or more of each block was occupied by dense patches of regeneration (10000 - 30000 stems per hectare). Other than the regeneration, understory shrubs are sparse. The herb layer is usually dominated by pinegrass (*Calamagrostis rubescens*).

The climate in this subzone is typified by warm, dry summers and cold, dry winters. Weather data were collected at Williams Lake airport by Environment Canada. The mean January minimum temperature ranges from -14.5 to -18.5°C. The average January month-end snowpack is 40 cm (n = 27 years). Total annual precipitation is about 41cm. Specific weather information was recorded for each track survey (Table 1). Temperature data were collected from Williams Lake airport and snow depth was measured on an open cutblock landing adjacent to the study blocks.

TABLE 1. Temperatures and open snow depths recorded on the track survey dates

Date	Snow depth <sup>a</sup> (cm)	Maximum Temperature <sup>b</sup> (°C)	Minimum Temperature <sup>b</sup> (°C)
January 02	28.0	-5.9	-19.3
February 02	31.0	-21.6	-34.0
February 17	35.0	-10.5	-24.2
March 01	34.0	-8.9	-27.5

<sup>a</sup> Recorded on the Big Lake study area.

<sup>b</sup> Recorded at Williams Lake airport.

<sup>1</sup> Cariboo Forest Region Biogeoclimatic Map. 1986. B.C. Ministry of Forests, Cariboo Forest Region Forest Sciences Section. Unpubl. map.

The blocks were laid out and spaced according to specific requirements (Figure 1; Table 2). They had different prescriptions for slash depth, stem density, man-made trails, and widths of unspaced strips.

Animal use of control and spaced blocks was assessed from track counts after fresh snowfalls, along marked transect lines (Waterhouse *et al.* 1988). Records were made if the tracks occurred in spaced or unspaced strips. Four assessments were made between January 02 and March 01, 1989. All track counts were standardized to tracks/50 m per week from total number of tracks per total number of metres of transect line per number of hours since the last snowfall in each block. Because coyote and fox tracks could not be distinguished from each other in most cases, they were grouped.

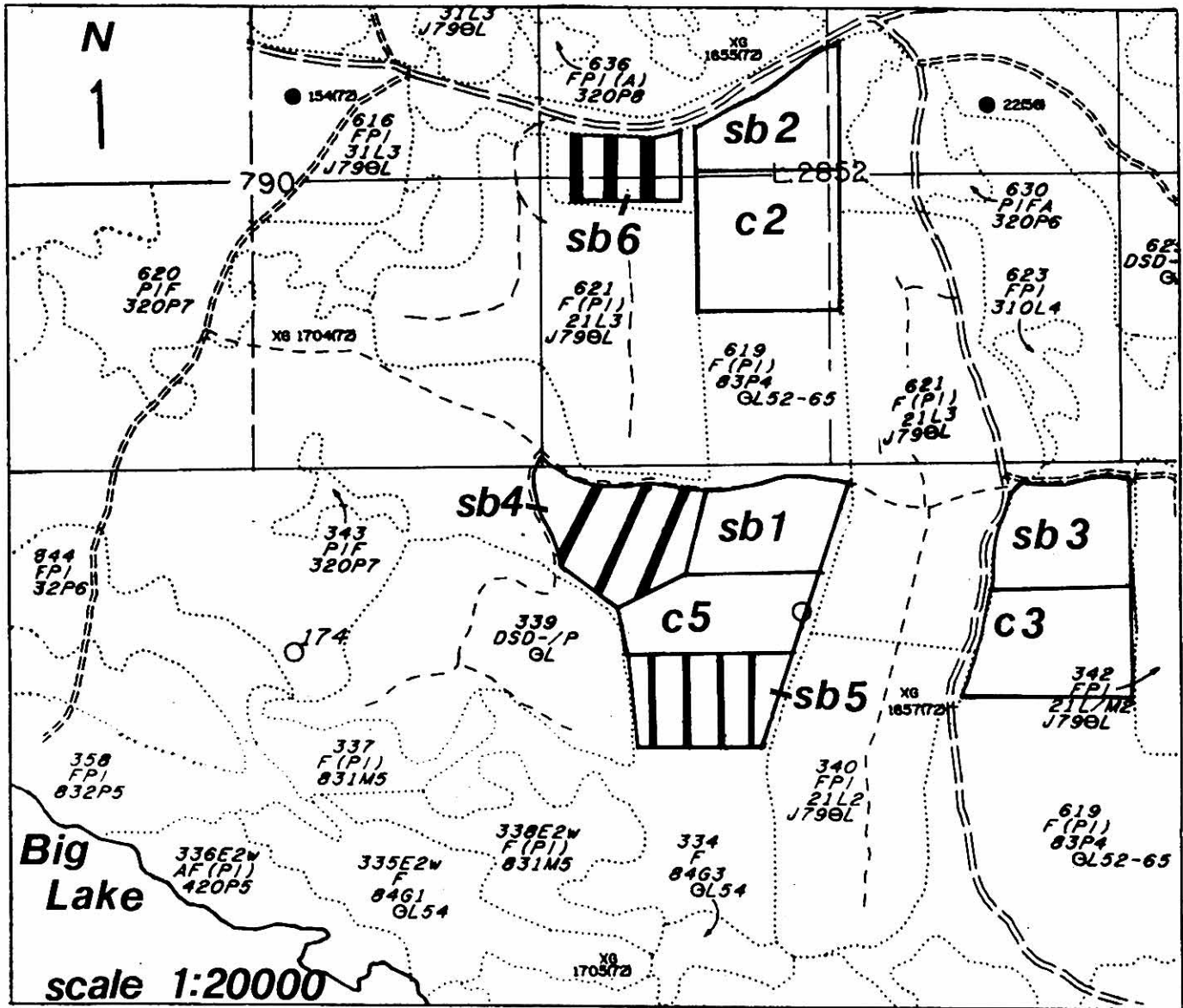


FIGURE 1. Layout of spaced blocks and control blocks on the Big Lake study area near 100 Mile House, B.C.

TABLE 2. Design and specifications of the spaced blocks at Big Lake, B.C. Typical spacing specifications are provided for comparison

Block	Total area of block (ha)	Percent of block unspaced	Width of unspaced strips (m)	Width of spaced strips (m)	Trails made	Specified maximum slash depth (m)	Specified interspacing (m)
Typical block		0	-	-	No	1.0	3.0
SB #1	9.5	0	-	-	Yes	.5	2.5
SB #2	8.7	0	-	-	Yes	.5	2.5
SB #3	12.0	0	-	-	Yes	.5	2.5
SB #4	12.4	19.4	25	85	Yes	1.0	3.5
SB #5	10.3	14.6	15	67	Yes	.5	3.0
SB #6	6.3	33.3	33	70	No	1.0	2.5

To examine the impact of juvenile spacing on wildlife, track density in the spaced areas of the six spaced blocks was compared with track density in paired unspaced controls. Only three control blocks were available in the vicinity of the spaced blocks. Control 5 was paired with spacing blocks 2, 4, and 5; control 2 was paired with spacing blocks 2 and 6. Control 3 was paired only with spacing block 3. Even though spacing prescriptions were not identical for all blocks, they were considered to be replicates of spaced Douglas-fir forest. Treatment effects were evaluated using a paired comparison t-test for each species and date.

Animal use of unspaced strips was compared between blocks and with the unspaced controls.

Snowshoe hare pellets, collected in mid-March 1988, were sent to Washington State University (Wildlife Habitat Laboratory) for standard faecal fragment analysis.

Slash depth and coverage and stem densities for each block were measured according to the methods outlined in Waterhouse *et al.* (1988).

## RESULTS

The mean reduction in slash depth, based on the average reduction in each block, was 43% over a 1-year period, while the amount of ground covered by slash decreased by 22% (Figure 2). Appendix 1 contains means and standard deviations for slash depth and coverage for each block for both years.

Animal use of trails was not assessed in 1989 because the shallow slash depth and moderate snowpack (about 35 cm in the open) made it difficult to discern trails.

Paired t-tests for each assessment in 1988/89 show that snowshoe hares significantly preferred control blocks to spaced areas ( $p = .05$ ;  $n = 6$ ), while red squirrel track density was significantly higher in the control blocks than in spaced areas in three of the four assessments ( $p = .05$ ;  $n = 6$ ) (Table 3). Mule deer, moose, and coyote/fox did not use spaced and control areas differently. Figure 3 illustrates the mean and confidence limits (95%) of the differences between the spaced area of spacing blocks and their control blocks for each species and assessment. For simple comparisons, mean use of spaced areas of spacing blocks and their controls, rather than the differences, are presented in Figures 4-8 for each species. Standardized raw data for each species, block, and assessment date are located in Appendix 2.

Comparisons of animal use of spaced and unspaced strips within spacing blocks (SB4, SB5, SB6) were made. Snowshoe hares and squirrels used unspaced strips far more than spaced areas of the blocks, while mule deer, moose, and coyote/fox appeared to prefer spaced areas (Appendix 3).

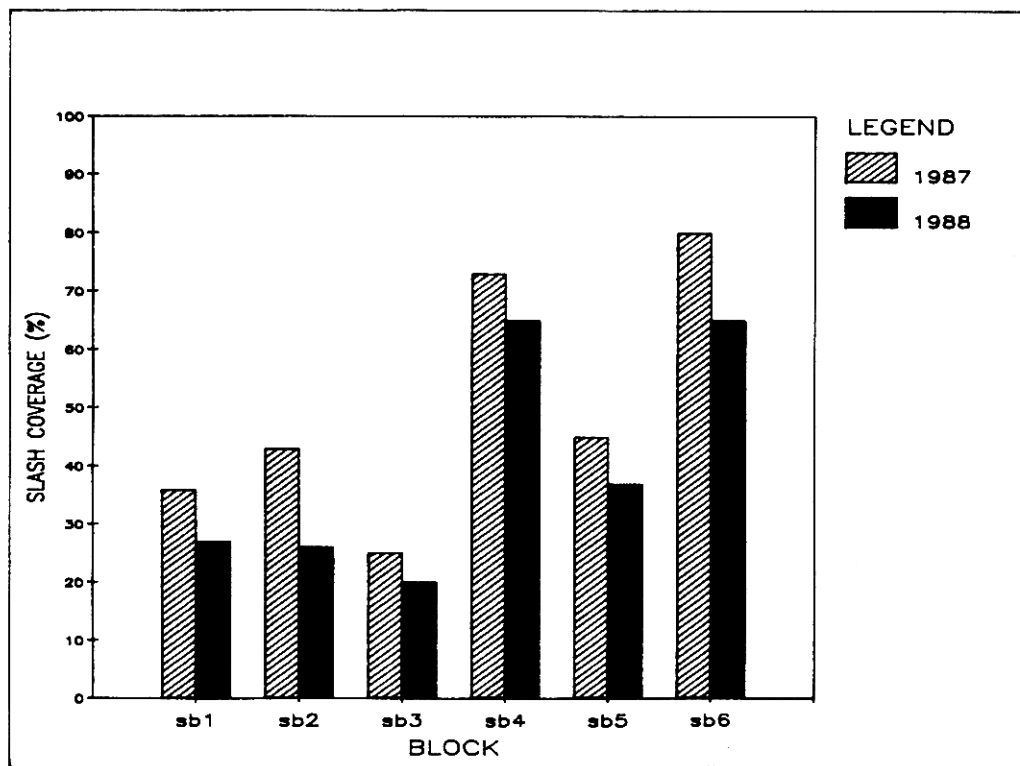
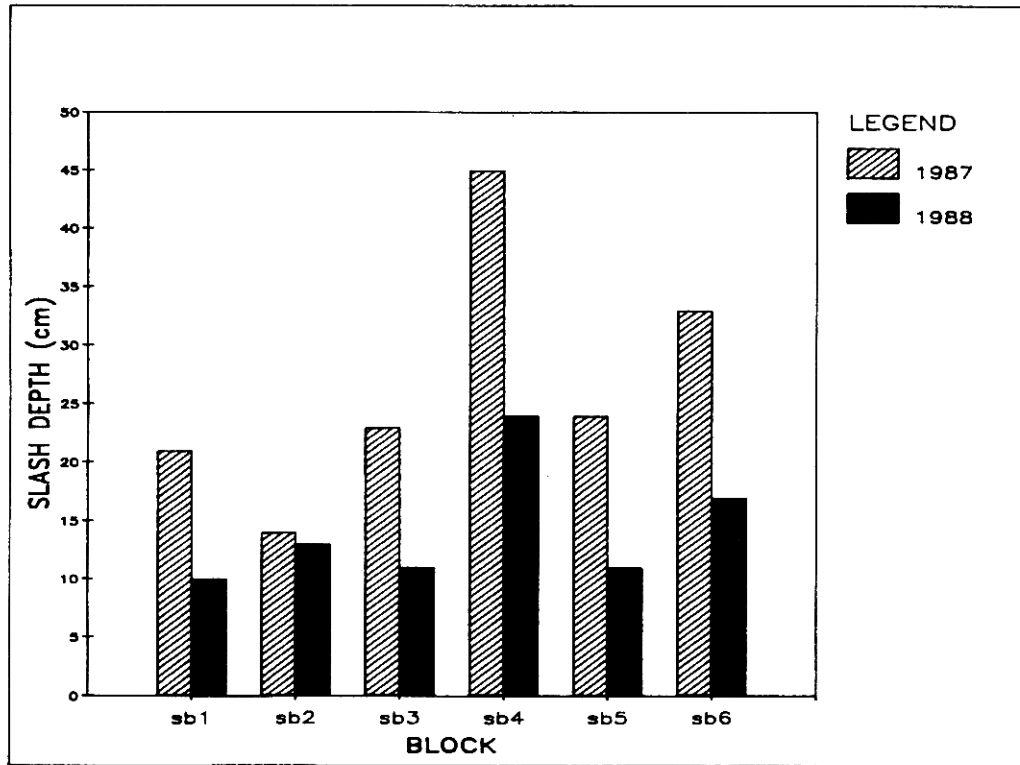


FIGURE 2. Mean slash depth and mean slash coverage of each spaced block on the Big Lake study area in 1987 and 1988.

TABLE 3. Paired comparison t-tests of animal use between spaced and control blocks at Big Lake. Each mean difference (d) is calculated from six paired differences of control and spaced blocks<sup>a</sup>

Species	Date											
	January 2			February 2			February 17			March 1		
	$\bar{d}^b$	SE $\bar{d}$	P	$\bar{d}$	SE $\bar{d}$	P	$\bar{d}$	SE $\bar{d}$	P	$\bar{d}$	SE $\bar{d}$	P
Snowshoe hare	-20.95	5.29	.02	-18.75	5.43	.02	-19.86	2.98	.01	-11.57	2.07	.01
Mule deer	2.80	2.04	.30	-4.82	3.90	.40	1.73	0.80	.10	-2.32	2.73	.50
Red squirrel	-2.17	0.38	.01	-3.72	1.10	.02	-1.37	3.22	.50	-2.87	1.08	.05
Coyote/fox	-0.73	0.16	.01	0.27	0.51	.50	-0.08	0.46	.50	0.45	0.47	.40
Moose	0.47	0.51	.50	-0.33	0.31	.40	0.23	0.32	.50	-0.28	0.22	.40

<sup>a</sup>  $\bar{d}$  = mean difference =  $\frac{(S_i - C_i)}{n}$  where  $C_i$  = mean animal use in the  $i$ th control block.  
 $S_i$  = mean animal use in the  $i$ th spaced block.  
 $n$  = the number of paired spaced/control blocks.

SE $\bar{d}$  = standard error of difference.  
 P = level of significance.

<sup>b</sup> Negative values indicate greater use of controls.

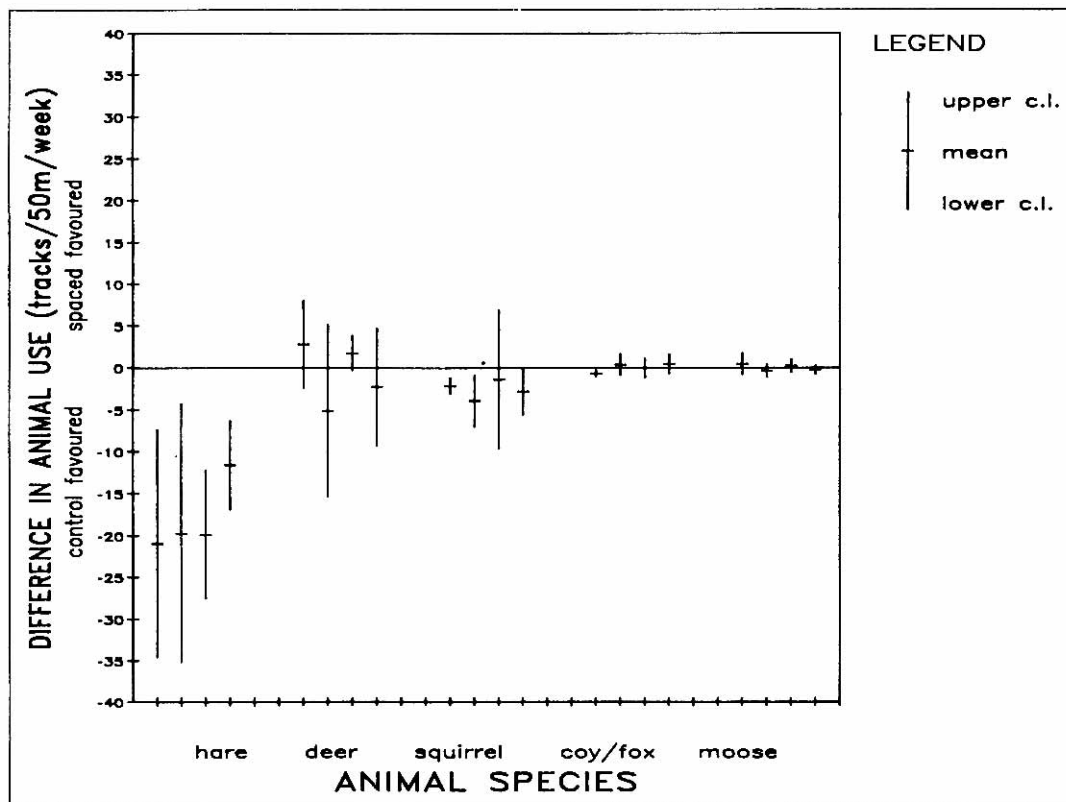


FIGURE 3. Mean and 95% confidence limits (c.l.) of differences in use between the spaced areas of spacing blocks and their controls for each species on four assessment dates. Confidence limits overlapping the zero line indicate that there is no significant difference between animal use of spaced areas and control blocks. Confidence limits totally above or below the zero line indicate statistically significant favouring of spaced or control habitats, respectively.

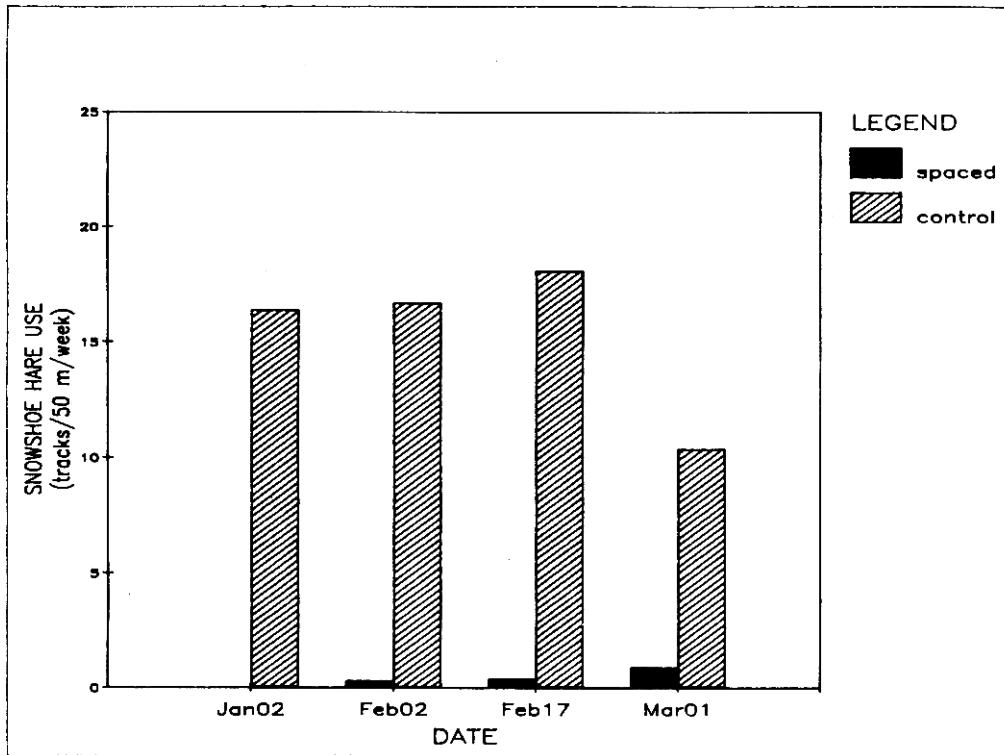


FIGURE 4. Mean snowshoe hare track density (tracks/50 m per week) in spaced areas of spacing blocks and control blocks in 1989.

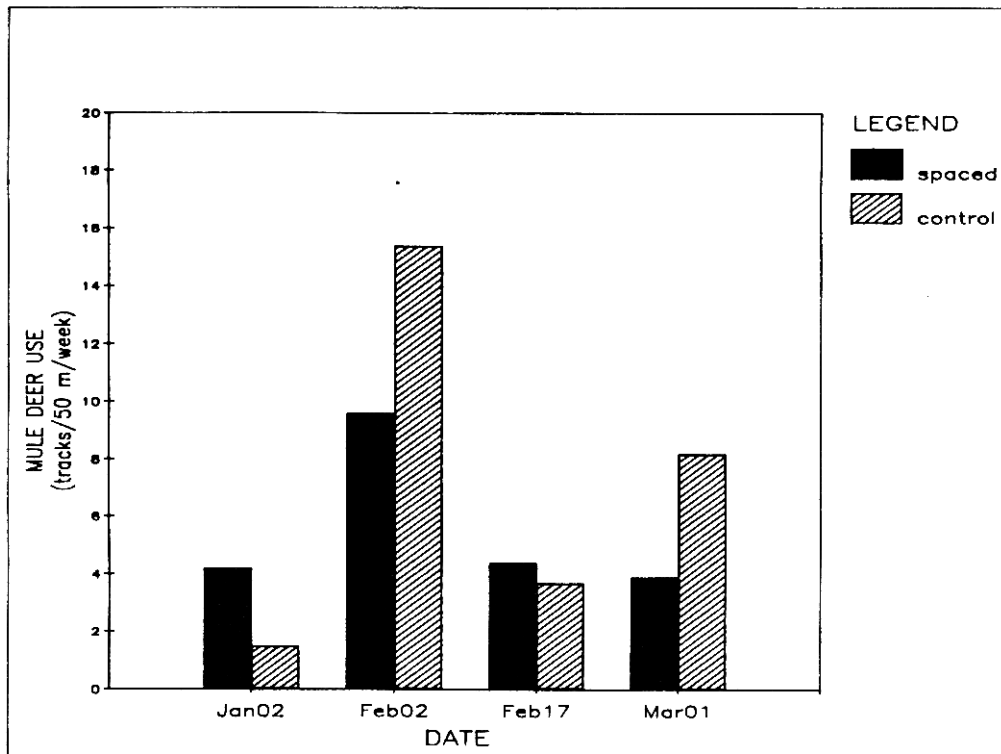


FIGURE 5. Mean mule deer track density (tracks/50 m per week) in spaced areas of spacing blocks and control blocks in 1989.

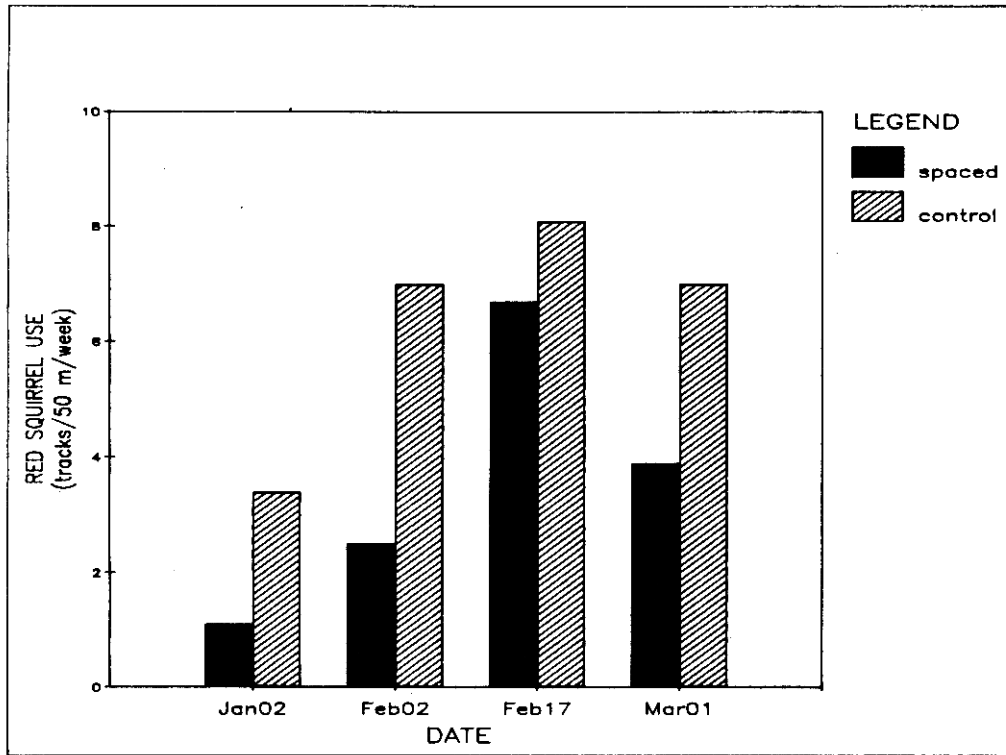


FIGURE 6. Mean red squirrel track density (tracks/50 m per week) in spaced areas of spacing blocks and control blocks in 1989.

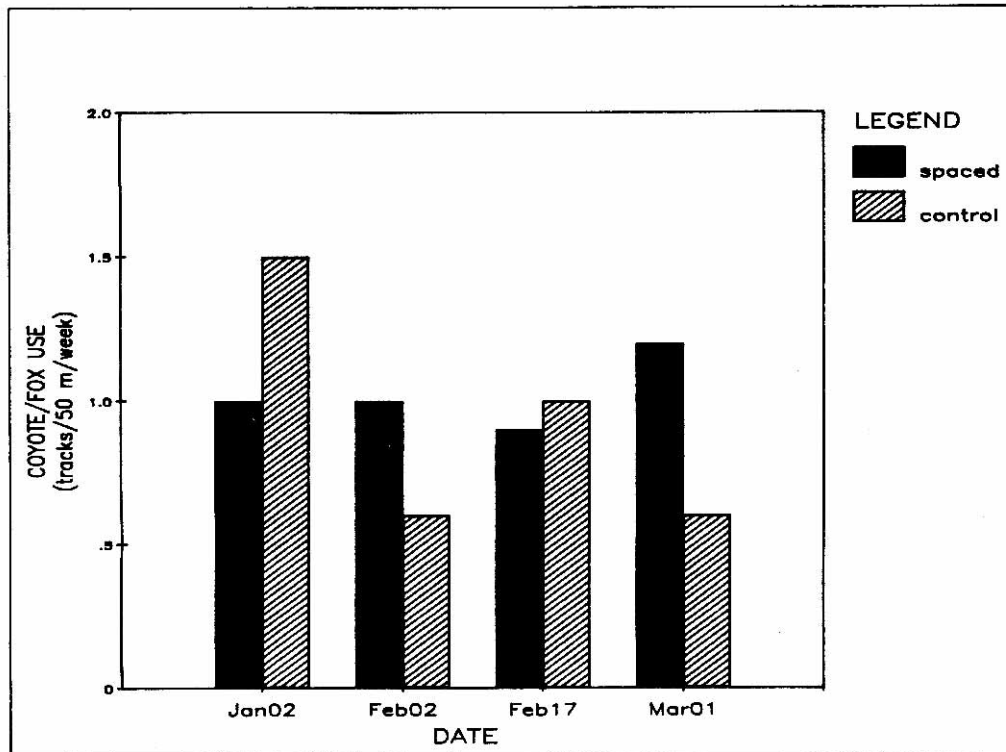


FIGURE 7. Mean coyote/fox track density (tracks/50 m per week) in spaced areas of spacing blocks and control blocks in 1989.

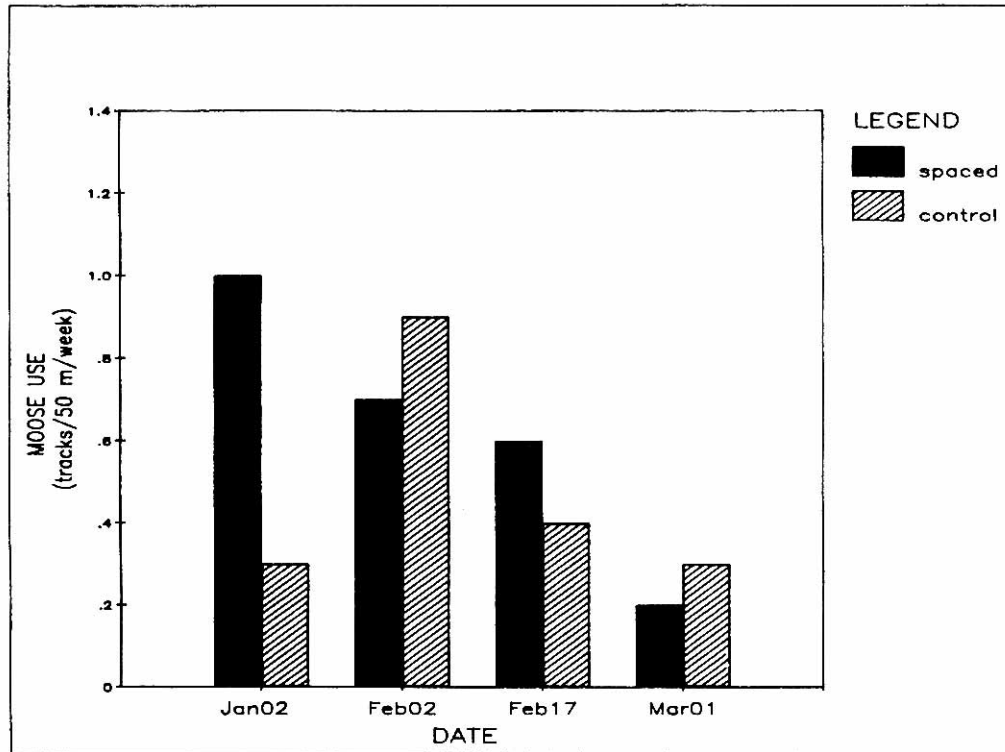


FIGURE 8. Mean moose track density (tracks/50 m per week) in spaced areas of spacing control blocks in 1989.

The number of tracks/50 m per week was compared between the unspaced strips of spacing and 6 and their control blocks, for each animal species per assessment (Appendix 4). As in results, there is a trend for hare track density to increase with unspaced strip width. This experiment was not replicated and the observed differences could have been caused by site as strip width differences. Some of these potentially confounding site effects can be eliminated control hare track density is subtracted from the mean unspaced strip density for each date (Figure four assessment dates, SB5 containing 15-m strips had lower hare track density than its control, containing 33-m strips had equal to or greater hare track density than its control. Use of the 25-m highly variable.

For other species, use does not increase or decrease with strip width. However, red densities generally tend to be higher in unspaced strips than in control blocks, while mule deer coyote/fox use tends to be greater in controls than in unspaced strips (Appendix 4).

Spaced blocks containing unspaced strips do not maintain either hare or squirrel density controls (Table 4). As the proportion of unspaced to spaced area within a block increases, density, compared to the controls. Squirrel density remains constantly lower in the entire changes in the amount of area left unspaced. Mule deer, moose, and coyote/fox use entire blocks as they use controls.

Casual observation within treatment and control blocks did not detect increases or decreases track density with distance from space/unspaced edges. Occasional tracks were seen up to 15 spaced/unspaced boundaries between blocks into the spacing. Unspaced strips may be too narrow edge effects.

Faecal fragment analysis of hare pellets collected in March 1988 in controls and unspaced indicated a large component of Douglas-fir (39%) and lodgepole pine (13%) needles. The rest consisted of bark, common shrubs, forbs, grasses, mosses, and lichens (Table 5).

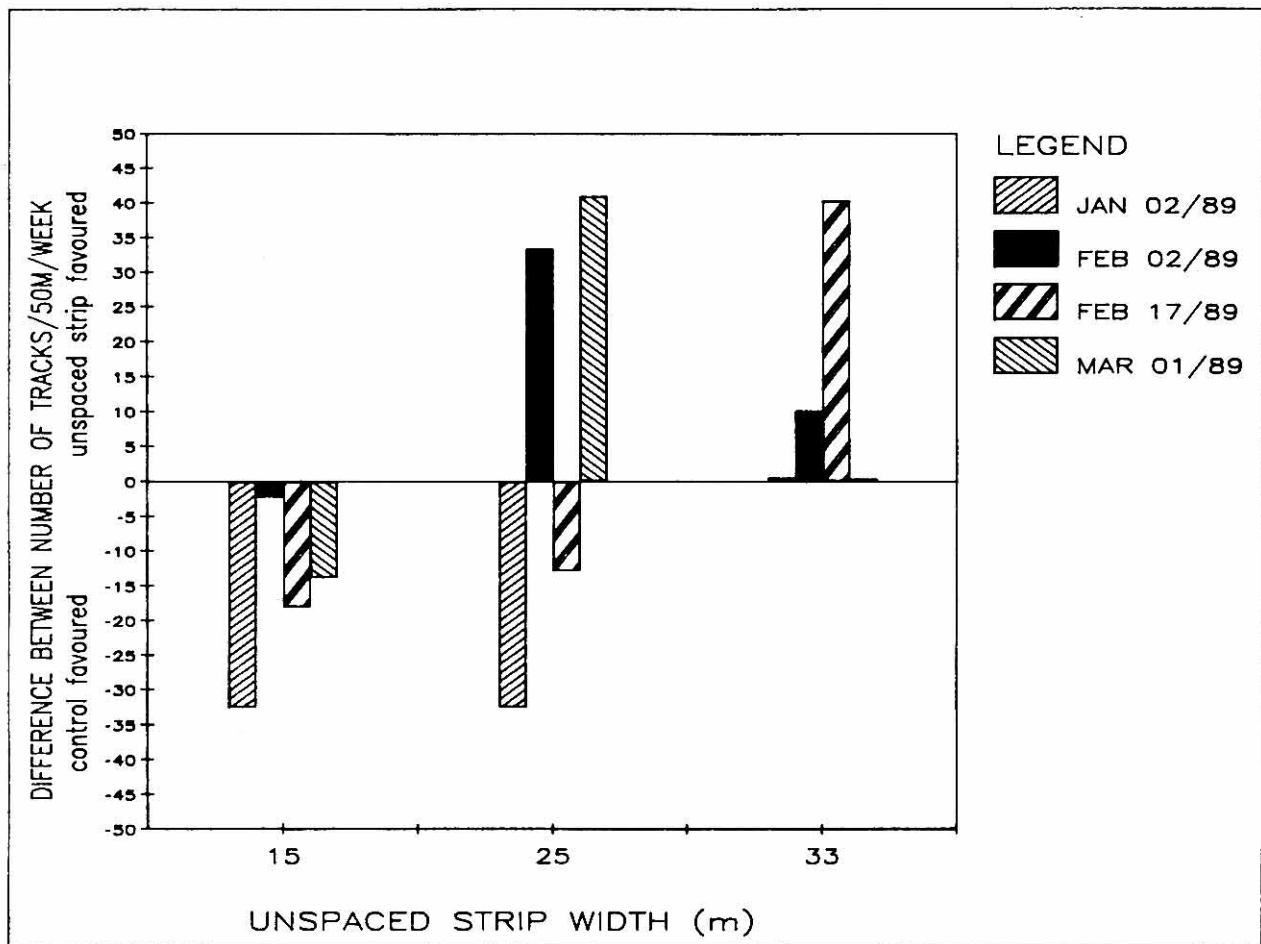


FIGURE 9. The difference in showshoe hare use between the unspaced area of each spacing block and its control.

TABLE 4. Snowshoe hare and red squirrel use (tracks/50 m per week) of each entire spacing block (spaced plus unspaced strips) and its corresponding control block on the Big Lake study area near 100 Mile House, B.C.

Species	Date	Block					
		SB #4 <sup>a</sup>		SB #5 <sup>b</sup>		SB #6 <sup>c</sup>	
		entire	control	entire	control	entire	control
Snowshoe Hare	Jan. 13/88	4.7	18.7	0.9	18.7	8.5	6.0
	Feb. 05/88	7.7	28.9	0.7	28.9	19.9	28.5
	Jan. 02/89	0.0	32.6	0.0	32.6	3.8	11.3
	Feb. 02/89	8.6	14.5	2.0	14.5	14.9	35.0
	Feb. 17/89	1.3	20.2	2.3	20.2	21.2	26.9
	Mar. 01/89	9.7	13.9	2.2	13.9	6.6	15.9
Red squirrel	Jan. 13/88	0.4	3.3	0.5	3.3	0.9	2.0
	Feb. 05/88	0.9	1.2	0.4	1.2	0.7	7.9
	Jan. 02/89	1.8	3.0	1.4	3.0	2.5	3.5
	Feb. 02/89	2.4	4.2	0.4	4.2	3.8	7.9
	Feb. 17/89	30.2	6.5	4.0	6.5	6.4	10.8
	Mar. 01/89	8.0	8.8	6.6	8.8	2.9	1.9

<sup>a</sup> Contains 25-m unspaced strips.

<sup>b</sup> Contains 15-m unspaced strips.

<sup>c</sup> Contains 33-m unspaced strips.

TABLE 5. Composition of snowshoe hare diet during winter on the Big Lake study area near 100 Mile House, B.C.

Food items		Percent of diet
Douglas-fir	<i>Pseudotsuga menziesii</i>	38.92
Lodgepole pine	<i>Pinus contorta</i>	13.33
Bark		10.72
Other conifers		0.48
Rose family	<i>Rosaceae</i>	3.17
Soopolallie	<i>Shepherdia canadensis</i>	3.06
Willow	<i>Salix spp.</i>	3.13
Other shrubs		
Blueberry	<i>Vaccinium sp.</i>	
Oregon-grape	<i>Mahonia aquilifolium</i>	4.82
Forbs		3.42
Grasses		5.18
Sedges		0.25
Mosses		8.14
Lichens		5.18

The snowshoe hare population is expected to peak around 1990 (Sullivan 1984). The mean track density within each control shows the snowshoe hare population did not differ significantly between the winter of 1987/88 and 1988/89 (Appendix 5).

## DISCUSSION

### SLASH REDUCTION AND MAN-MADE TRAIL USE

Spacing creates large amounts of slash which may impede animal movement. Slash depth and the amount of area covered by slash depends on pre-spacing stem density and the spacing prescription. Usual spacing guidelines limit slash depth to a maximum of 1 m. Trees cut were parallel felled, bucked into lengths less than 4 m, and limbed so slash did not exceed 0.5 m in depth in five of the six blocks. The slash reduced very quickly through drying and snowpress. The rate of reduction, initial slash depth, and distribution of slash are important in determining the need for man-made trails.

In the 1st year of this study, deer, moose, and coyote/fox selectively used trails where mean slash depth exceeded 20 cm in five of six blocks.

Other data collected showed that deer avoided walking through slash greater than 20 cm deep (R.J. Dawson, H.M. Armleder, and M.J. Waterhouse, unpubl. data, 1987, B.C. Ministry of Forests, Williams Lake, B.C.). As the combined depth of slash and snow increases, so does the energy required to move through it. In 1989 it was difficult to discern the man-made trails because of the average 43% reduction in slash depth and the blanket of snow (approximately 20 cm deep in the stands). However, in SB4 where the mean slash depth still exceeded 20 cm, deer and moose were often following old trails or travelling in areas with shallow slash and snow. Careful treatment of slash during spacing results in rapid settling of slash. In many cases this will make the creation of man-made trails to ease animal access unnecessary.

## HARES

As found in the winter of 1987/88, spacing on the Big Lake study area virtually eliminated winter habitat used by hares. Despite the between block variability in the type of spacing, hare use of control blocks was significantly higher than in spaced areas. Recent work by the B.C. Ministry of Environment (J. Young, pers. comm., March 1989, Williams Lake) in the interior Cedar-Hemlock biogeoclimatic zone also found much lower winter use in spaced 20-year-old mixed conifer blocks compared to that in paired control blocks. Similarly, Sullivan (1984) found 20% lower yearly use in spaced areas compared to that in controls in juvenile pine stands near Prince George, B.C., after fresh slash had died and compacted, reducing food and cover. Results from other studies have documented high correlations ( $r = .71$ ;  $p = .01$ ) between stem density and hare use (Conroy *et al.* 1979; Wolfe *et al.* 1982). Conroy *et al.* (1979) comment that the highest hare use occurs in areas of habitat interspersions, which provide a diversity of cover and food, rather than in areas of continuous dense regeneration or openings.

In the interior Douglas-fir zone where the shrub and herb layers are sparse, thickets of dense regeneration provide critical cover and food. Litvaitis *et al.* (1985) found hare survival positively correlated with stem density ( $r = .74$ ;  $p = .04$ ). Dense coniferous stands provide superior thermal cover during periods of low temperatures and high winds, and they protect hares from predators such as foxes, coyotes, lynx, and hawks by creating visual obstructions (Wolfe *et al.* 1982; Sievert and Keith 1985).

Conifer needles and bark, especially that of Douglas-fir, made up 63% of the winter hare diet on the Big Lake study area. Availability of regeneration is at least 10 times greater in control blocks than in spaced blocks. Also, low conifers (not spaced when less than 0.5 m tall), low shrubs, herbs, and mosses would be less available in spaced blocks, where they could be covered by a combination of snow and slash. Unspaced areas may also provide more forage by causing greater variability in snow depth. Thickets may change the distribution and depth of snow within a stand by blocking the wind and directly intercepting snow. In future, food in spaced areas will become more abundant as vegetation responds to increased light and moisture. Already, shrubs cut during spacing are vigorously sprouting.

Unspaced strips left within spaced blocks conserve some hare habitat. However, even when 33-m wide unspaced strips are preserved within spaced blocks, overall hare use of the block was still much lower than that of the control. There may be a critical area and distribution of unspaced habitat that hares need to survive. Islands (strips), especially when disconnected from large unspaced areas, may not provide enough food or protection from predators.

The density of hare tracks appeared to increase with strip width, though because of the unreplicated experimental design this result may be confounded with site effects. For example, hare use of 15-m strips (SB5) was lower than use of the controls in all four assessments. These lower densities may be due to the narrowness of the strips. As well, however, the eastern half of SB5 was not as thickly covered by dense thickets as the control before spacing. Also, the hare use of 33-m strips (SB6) equals or exceeds use of the control. Whether the hares intensified use of these strips because of reduced habitat space or were more abundant there before spacing is a question that a replicated experiment could answer.

## RED SQUIRRELS

Red squirrel track density was significantly lower in the spaced areas of blocks than in the control blocks, in three of the four assessments. The paired t-test using data from February 17 showed no significant difference between use of spaced and control areas, though the mean use of control blocks was higher than for spaced areas. Squirrel use of spacing block 4 (SB4) in this assessment was extraordinarily high. Close examination of the raw data from SB4 found intense activity in only 2 of the 16 transect segments. The number of tracks in the 2 adjacent high use segments was between 16 and 19 tracks per 50 m, while in the other segments it varied from 0 to 6 tracks per 50 m. The burst of activity caused enough variability to eliminate a possible significant difference between the spaced and control areas.

Sullivan (1987) also reported lower squirrel density in spaced juvenile lodgepole pine stands than in unspaced control stands in the Cariboo Forest Region. Unspaced thickets act as visual blocks to aerial and ground predators and also provide thermal cover. On our study area, squirrels may continue using spaced

blocks to some degree because mature Douglas-fir trees provide a fairly reliable food source and escape routes. Within uneven-aged Douglas-fir stands there is typically an abundance of woody debris, such as fallen logs, which are used as lookouts and feeding sites (Thomas 1979).

Squirrels tended to use unspaced strips within spaced blocks more intensively than either spaced areas or control blocks. This trend may be a result of individuals shifting habitat use within their territories. Unspaced strips, in this case, would be highly valuable. However, spaced blocks containing strips overall maintain lower squirrel densities than the control blocks in our study.

#### **OTHER SPECIES**

Mule deer, moose and coyote/fox showed no significant response to spacing. Spaced areas and control blocks were used equally. However, unspaced strips appear to be used less than either the spaced areas or control blocks. Within a spaced block, it is easier for a large animal to move through areas of shallow slash and snow, rather than through strips containing thick patches of regeneration. In control blocks, these animals, especially moose and deer, are frequently observed to move through natural, connected areas of low stem density rather than through thickets of conifers.

Even though the area within unspaced strips is not intensively used by large animals, the strips may be a valuable habitat component within a spaced block, particularly for mule deer. Bands of dense regeneration reduce air flow through the block, improving thermal cover. Also, strips provide security cover from predators by reducing sight distance. Nyberg *et al.* (1986) felt that maintaining some security and escape cover in spaced stands was necessary for coastal deer while the young stands develop into functional winter range.

### **MANAGEMENT IMPLICATIONS**

Data from two winters have shown that spacing can have dramatic short-term effects on some wildlife species. These data, plus information from the literature, highlight some potential management concerns.

Before modifying any spacing prescription for wildlife, the forest manager must know which wildlife species are of concern and what the characteristics are of the area to be spaced. For many areas, no modification of the optimal silvicultural prescription will be necessary.

Our work clearly shows that spacing in the dense Douglas-fir forest at Big Lake excludes winter use by snowshoe hares. Extensive, contiguous spaced blocks may result in snowshoe hare "deserts", at least in the winter. If the objective of wildlife managers is to maintain hare habitat, then unspaced areas would have to be left. The optimal size and pattern of these unspaced areas is not yet known.

Our results indicate that hares use unspaced strips within spaced blocks. However, questions still remain about the viability of this strip habitat for hares. Would strip-using hares become easy prey for predators? Sievert and Keith (1985) report that the rate of predation increases when hares must travel a long distance between patches of good cover. Would narrow strips of unspaced forest be able to support the same density of hares as larger blocks would? What is the optimal strip width? Do unspaced strips within blocks need to be contiguous with unspaced areas around blocks? The results of this study show that there may be some differences in hare density in different strip widths. If there is some threshold of strip width below which hare density sharply decreases, it should be recognized in spacing prescriptions.

Spacing can have both positive and negative effects on other wildlife species. Negative effects include lower red squirrel use of spaced areas. Is lower habitat use by squirrels acceptable and will it remain constant in the long term? Also, most large species experience decreased mobility in deep, continuous slash. This could be ameliorated by prescribing man-made trails and/or a method of slash treatment which reduces slash depth and accelerates decomposition. Finally, spacing decreases security and thermal cover within a block. Unspaced strips left in blocks provide cover for hares and squirrels. They also increase thermal and security cover for animals such as deer and moose, which may make little direct use of the strip habitat.

Spacing can also benefit wildlife. Forage production may increase quite rapidly after spacing, although little information is available for interior Douglas-fir. Spaced trees will develop large, wide crowns more quickly than will unspaced trees. These crowns are valuable as snow interception cover on mule deer winter ranges.

By using existing knowledge on spacing/wildlife interactions and by focusing future research on the key outstanding questions, forestry and wildlife managers should be able to arrive at optimal integrated management solutions.

## **RESEARCH RECOMMENDATIONS**

1. The results of this study should be evaluated by replicated experiments. These experiments should be designed specifically to test the effect of differences in spacing prescription variables including leave strip width, slash depth and coverage, presence of man-made trails, and stem density on wildlife habitat use. Experiments should be conducted over a wide range of snow depths. Strip width replication could be accomplished by including several strip widths within each of several blocks. Additionally, evaluation of track density in untreated blocks with no nearby spacing may be necessary to estimate current animal habitat use. Spacing could cause animals to concentrate in nearby controls, thereby resulting in exaggerated differences in animal density.
2. The effect of spacing on wildlife use should be examined in all seasons.
3. The evaluation of the impact of spacing on wildlife should be extended to other forest types where large-scale spacing programs are planned.
4. The long-term effects of spacing on wildlife habitat should be examined. These effects would include post-spacing changes in:
  - i. the quantity and species composition of available forage;
  - ii. slash depth; and
  - iii. security, thermal, and snow interception cover.
5. The use of spaced edge habitats under various conditions and seasons should be examined further.
6. The effects of size, shape, and location of spaced blocks on wildlife within broad habitat types should be examined over time.
7. The effects of spacing on other wildlife species including birds should be assessed.
8. A study of the movements of marked red squirrels, snowshoe hares, and small mammals would be valuable to monitor response of individuals to spacing.

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**APPENDIX 1. Slash depth and slash coverage in the Big Lake spacing blocks measured in the fall of 1987 and 1988<sup>a</sup>**

Block	Year spaced	1987						1988					
		Slash depth <sup>b</sup> (cm)			Slash coverage <sup>c</sup> (m <sup>2</sup> )			Slash depth (cm)			Slash coverage (m <sup>2</sup> )		
		n	$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s
SB #1	1986	16	21	5	30	36	25	20	10	7	30	27	20
SB #2	1986	24	14	9	30	43	23	22	13	7	39	26	20
SB #3	1986	18	23	10	29	25	16	20	11	6	30	20	16
SB #4	1987	25	45	23	33	73	20	45	24	17	53	65	20
SB #5	1987	27	24	9	43	45	46	24	11	8	37	37	21
SB #6	1987	24	33	15	24	80	12	28	17	10	36	65	18

<sup>a</sup> n = sample size.

$\bar{x}$  = mean.

s = standard deviation from the mean.

<sup>b</sup> Measurements of zero slash depth were not included.

<sup>c</sup> All plots were 100 m<sup>2</sup>.

**APPENDIX 2. Raw data collected for all species in spaced areas of spaced blocks and control blocks on the Big Lake study area near 100 Mile House, B.C. Animal use was standardized to tracks/50 m per week**

Species	Dates	Block								
		SB1	SB2	SB3	SB4	SB5	SB6	CB 5 <sup>a</sup>	CB 2 <sup>b</sup>	CB 3 <sup>c</sup>
snowshoe hare	Jan. 02	0	0	0	0	0	0	32.6	11.3	5.3
	Feb. 02	0	0	0	0.2	0.4	1.0	14.5	35.0	0.6
	Feb. 17	0	0	0	0	2.3	0	20.2	26.9	7.1
	Mar. 01	0	0.9	0	0	2.6	2.1	13.9	15.9	1.5
mule deer	Jan. 02	0.6	16.7	0.9	0.4	0	6.6	0	3.9	0.6
	Feb. 02	16.5	18.8	4.5	0.8	15.5	1.4	14.5	11.3	20.3
	Feb. 17	6.1	0	11.8	6.2	2.3	0	2.4	0	8.8
	Mar. 01	11.5	0	3.1	2.2	2.0	4.5	4.1	4.3	16.3
red squirrel	Jan. 02	1.5	0	2.4	1.4	1.2	0.3	3.0	3.5	3.8
	Feb. 02	0.2	1.1	9.7	1.6	0.4	2.0	4.2	7.9	8.9
	Feb. 17	4.8	2.2	8.3	19.3	2.7	2.7	6.5	10.8	7.1
	Mar. 01	5.0	1.3	4.0	5.5	4.6	2.9	8.8	1.9	10.3
coyote/fox	Jan. 02	0.8	1.2	0	1.8	1.6	0.6	2.1	1.6	0.9
	Feb. 02	0.5	0.4	2.9	1.4	0.2	0.7	0.9	0.8	0.2
	Feb. 17	0.7	1.1	0.4	2.5	0	0.5	0.5	1.8	0.6
	Mar. 01	2.0	0.4	0.3	1.0	3.3	0	0.9	0.8	0
moose	Jan. 02	0.6	0	0.2	1.0	1.0	3.0	1.0	0	0
	Feb. 02	1.1	1.1	0.9	0.6	0	0.7	1.2	1.4	0
	Feb. 17	0	0.6	0.7	0.6	0	1.6	0.5	0	0.6
	Mar. 01	0.6	0.4	0	0	0	0	0.9	0	0

<sup>a</sup> Control 5 was paired with SB1, SB4, and SB5.

<sup>b</sup> Control 2 was paired with SB2 and SB6.

<sup>c</sup> Control 3 was paired with SB3.

**APPENDIX 3. Animal use (tracks/50 m per week) of spaced and unspaced strips within spacing blocks SB4, SB5, and SB6 on the Big Lake study area**

Date	Block	Species									
		Snowshoe hare		Mule deer		Red squirrel		Coyote/Fox		Moose	
		S <sup>a</sup>	UNS <sup>b</sup>	S	UNS	S	UNS	S	UNS	S	UNS
Jan. 02	SB4	0	0	0.4	0	1.4	3.7	1.8	1.8	1.0	0
	SB5	0	0	0	0	1.2	2.5	1.6	1.2	1.0	0
	SB6	0	11.9	6.6	2.6	0.3	7.3	0.6	0	3.0	0
Feb. 02	SB4	0.2	48.0	0.8	0	1.6	5.8	1.4	0	0.6	0
	SB5	0.4	12.2	15.5	9.5	0.4	0	0.2	0.4	0	0
	SB6	1.0	45.2	1.4	0	2.0	7.5	0.7	0	0.7	1.5
Feb. 17	SB4	0	7.3	6.2	0	19.3	81.3	2.5	1.5	0.6	0
	SB5	2.3	2.1	2.3	4.3	2.7	12.5	0	0	0	0
	SB6	0	67.3	0	0	2.7	14.4	0.5	0	1.6	0
Mar. 01	SB4	0	54.9	2.2	2.3	5.5	19.9	1.0	0	0	0
	SB5	2.6	0	2.0	1.6	4.6	19.3	3.3	1.6	0	0
	SB6	2.1	16.3	4.5	0	2.6	2.7	0	0	0	0

<sup>a</sup> Spaced areas.

<sup>b</sup> Unspaced strips.

**APPENDIX 4. Animal use (tracks/50 m per week) of unspaced areas in spacing blocks SB4, SB5, and SB6 compared to that in control blocks**

Date	Block	Species									
		Snowshoe hare		Mule deer		Red squirrel		Coyote/Fox		Moose	
		U <sup>a</sup>	C <sup>b</sup>	U	C	U	C	U	C	U	C
Jan. 02	SB4	0	32.6	0	0	3.7	3.0	1.8	2.1	0	1.0
	SB5	0	32.6	0	0	2.5	3.0	1.2	2.1	0	1.0
	SB6	11.9	11.3	2.6	3.9	7.3	3.5	0	1.6	0	0
Feb. 02	SB4	48.0	14.5	0	14.5	5.8	4.2	0	0.9	0	1.2
	SB5	12.2	14.5	9.5	14.5	0	4.2	0.4	0.9	0	1.2
	SB6	45.2	35.0	0	11.3	7.5	7.9	0	0.8	1.5	1.4
Feb. 17	SB4	7.3	20.2	0	2.4	81.3	6.5	1.5	0.5	0	0.5
	SB5	2.1	20.2	4.2	2.4	12.5	6.5	0	0.5	0	0.5
	SB6	67.3	26.9	0	0	14.4	10.8	0	1.8	0	0
Mar. 01	SB4	54.9	13.9	2.3	4.1	19.9	8.8	0	0.9	0	0.9
	SB5	0	13.9	1.6	4.1	19.3	8.8	1.6	0.9	0	0.9
	SB6	16.3	15.9	0	4.3	2.7	1.9	0	0.8	0	0.9

<sup>a</sup> Unspaced strips.

<sup>b</sup> Control.

**APPENDIX 5. Snowshoe hare use (tracks/50 m per week) of control blocks on the Big Lake study area in the winter of 1987/88 and 1988/89**

Block	Year	
	1987/88 <sup>a</sup>	1988/89 <sup>b</sup>
C5	23.8	20.3
C2	17.3	22.3
C3	11.2	3.6

<sup>a</sup> n = 2 assessments.

<sup>b</sup> n = 4 assessments.