Displacement of Mountain Caribou from Winter Habitat by Snowmobiles

Dale Seip, Chris Johnson and Glen Watts

Abstract Mountain caribou are an ecotype of woodland caribou (*Rangifer tarandus caribou*) that live in subalpine forests in southeastern British Columbia and northern Idaho and Washington. These caribou are listed as Threatened in Canada, Endangered in the United States, and are subject to recovery planning efforts in both countries. Many areas of mountain caribou winter habitat experience intensive use by recreational snowmobilers. During 3 annual surveys, we recorded caribou on all 5 census blocks with little or no snowmobile activity (average density = 0.3 caribou/km^2), but no caribou on a census block with intensive snowmobile activity. We used a Resource Selection Function (RSF) based on radio-telemetry data for the area to compare habitat quality among the different census blocks. The absence of caribou from the intensive snowmobile area could not be explained by differences in habitat quality. The RSF predicted that the intensive snowmobile area should support 53-96 caribou (95% confidence interval) based on habitat quality. We conclude that intensive snowmobiling has displaced caribou from an area of suitable habitat. We recommend that snowmobile activity be restricted from all or

most high quality mountain caribou habitat as part of the recovery planning process.

Key words displacement by snowmobiles, mountain caribou, *Rangifer tarandus caribou*, recovery planning

Mountain caribou are an ecotype of woodland caribou (*Rangifer tarandus caribou*) that live in the mountains of southeastern British Columbia and into northern Idaho and Washington (Heard and Vagt 1998). These caribou are listed as Threatened in Canada, and Endangered in the United States. Both countries are involved in recovery planning efforts to maintain these caribou. One of the recognised threats to mountain caribou populations is disturbance on their winter range by snowmobiles (MCTAC 2002).

Mountain caribou live in a zone of very deep winter snowpack that makes it impossible to feed on ground vegetation in winter. Consequently, these caribou feed primarily on arboreal lichens during the winter months. Throughout the late winter, the caribou are located primarily in subalpine forest and subalpine parkland habitat in areas of gentle terrain (Servheen and Lyon 1989, Seip 1990, Seip 1992a, Seip 2003, Terry et al. 2000, Apps et al. 2001, Johnson et al. 2004.). These habitats contain abundant arboreal lichens, and provide spatial separation from predators that live in the valley bottoms (Seip 1992b).

The deep snow, open forests and gentle terrain also make these areas very attractive to recreational snowmobilers. Snowmobile use in some areas is very intensive with entire mountain-tops criss-crossed with snowmobile tracks. Snowmobile activity is increasing within mountain caribou range as new forest roads increase accessiblity, and improved snowmobile technology increases their ability to reach new areas.

There is a concern among wildlife managers that disturbance by snowmobiles will displace mountain caribou from preferred habitat areas (Simpson 1987, Simpson and Terry 2000, MCTAC 2002, Kinley 2003). The fright and flight response of caribou and reindeer to snowmobile disturbance has been documented (Simpson 1987, Mahoney et al. 2001, Reimers et al. 2003), but complete abandonment of preferred habitats has not been reported. Anecdotal observations indicate that mountain caribou in British Columbia no longer use historic ranges where snowmobile activity is now common, but this relationship has been difficult to quantify. This lack of evidence has led to acrimonious debate during recovery planning regarding the need to restrict snowmobile activity within mountain caribou winter ranges.

On several winter flights to census mountain caribou we observed that one mountain block with very intensive snowmobile use had few or no caribou despite the presence of habitat that appeared to be similar to neighbouring mountain blocks that supported hundreds of caribou. To more rigorously evaluate this relationship, we used a resource selection function (RSF) (Manley et al. 1993) to quantify the value of habitats found across the different mountain blocks that we surveyed for caribou.

We calibrated the RSF with the winter census data from the occupied mountain blocks to predict the number of caribou that should be expected on the snowmobile block based on habitat quality (Boyce and MacDonald 1999). We then compared the number of caribou observed in the intensive snowmobile area to the number of animals predicted based on habitat.

Study Area

The study area was the winter range of the Hart Mountains caribou herd in central British Columbia (54^{o} N, 121^{o} W) about 100 km east of Prince George (Figure 1). The winter range is a series of discrete mountain blocks separated by major river valleys from the more contiguous Rocky Mountains to the east. We delineated 6 discrete mountain blocks (Figure 1, Table 1) within the area that were separated from each other by low elevation valleys. Although caribou often used the more rugged, contiguous portions of the Rocky Mountains in summer, in winter, most of them lived on these more gentle mountain blocks on the western fringe (unpublished telemetry data).

These mountain blocks rise from the valley bottoms at about 800 meters to a maximum elevation of 1940 meters. The valley bottoms contain the Sub-boreal Spruce (SBS) and Interior Cedar Hemlock (ICH) biogeoclimatic zones extending up to about 1000 m. (Delong 2003). Caribou primarily use the subalpine forests above those valley bottom forest types. Immediately above the SBS/ICH is the wet, cool subzone of the Engelmann

Spruce –Subalpine Fir Zone (ESSFwk) that extends from about 1000 m to 1300 m. (Delong et al. 1994). The wet, cold subzone of the ESSF (ESSFwc) occurs from 1300 m to treeline at about 1500 m. At treeline, the forests become an open parkland ESSF subzone which extends up to about 1820 m. Treeless alpine habitat occurrs above 1820 m. On most of the mountain blocks, the parkland zone extends to the summits and alpine was uncommon (Table 1). However, the Hedrick block, closest to the core of the Rocky mountains, was higher and more rugged than the others, and contained significant areas of alpine tundra and glacier above the parkland zone .

The ESSF zone contains a mixture of Engelmann spruce (*Picea engelmanni*) and subalpine fir (*Abies lasiocarpa*), with the proportion of subalpine fir increasing with elevation. The upper elevation subalpine fir trees contain abundant amounts of arboreal lichens (*Bryoria* spp.) which provide the primary winter food of the caribou.

The subalpine forests within the ESSFwc zone have an annual snowfall of 782 cm which creates a snowpack that often exceeds 3 m in depth (Delong et al. 1994).

Forest harvesting was widespread in the valley bottoms, but the upper elevation ESSF forests were largely protected as caribou habitat and not available for forest harvesting. However, forest roads in the valley bottoms provided access for snowmobilers. One of the six mountain blocks (Sande) was a recognised snowmobiling area, and had very intensive snowmobile use throughout the winter whereas the other mountain blocks had no or very limited snowmobile use. A cabin providing overnight accommodation for

snowmobilers encouraged use of the Sande area. Snowmobile use was most intensive during weekends but also occurred throughout the week. During our censuses, we observed that almost all of the Sande block was covered in snowmobile tracks throughout the late winter period.

Methods

Caribou census

Caribou in the area were censused in March of 1999, 2002 and 2005. The census technique involved flying the treeline of each mountain block in a helicopter searching for caribou or tracks. Censuses were conducted within a day or two of new snow to ensure that tracks were fresh. When tracks were located, they were followed to locate and count the caribou. In a few cases tracks were located but the caribou could not be found, so the number of caribou was estimated based on the number of tracks. Co-ordinates for each caribou group were determined with a Global Positioning System.

Previous studies using marked animals have found that on average, this census technique locates 87% of the mountain caribou within the census area (Wittmer et al. 2005).

Habitat modeling and population estimation

We used 211 caribou telemetry locations paired with 5 random locations to develop 5 RSFs describing the habitat use and potential distribution of mountain caribou during the

late winter. A detailed description of model development, application and assessment is reported in Johnson and Seip (in review). In summary, we used conditional fixed effects logistic regression to calculate RSF coefficients for 9 variables: 6 biogeoclimatic subzones, slope (polynomial term), and distance to treeline for alpine locations. We used Akaike's Infromation Criterion and multimodel inference to average coefficients across the 5 models and account for model selection uncertainty (Anderson et al. 2000). We then applied the averaged model coefficients to equation 1 and calculated RSF maps for each census block. We used the percentiles calculated from the observed caribou data to define breakpoints and stratify the continuous RSF values (w∗) into 10 habitat classes.

$$w^*(\mathbf{x}) = \exp(\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots \beta_k x_k) \quad (1)$$

Independent census data and RSF maps of habitats can be combined to estimate the expected density of animals for an area based on habitat values (Boyce and McDonald 1999). The RSF based estimation procedure divides the observed population among RSF habitat classes according to strength of selection for an area of each class. Density of animals within each class across the reference area can then be calculated and applied to other areas to estimate the number of animals that should occur based on those habitat values.

We used the census data for each of the three survey years from 4 of the 5 blocks with observed caribou to generate separate RSF based density estimators (n=12). The Hedrick block was more rugged than the other blocks (Table 1) and therefore we did not believe

that it provided a representative measure of caribou density. We applied each estimator to the Sande block where we observed intensive snowmobile use and few caribou. These estimates represented the number of caribou that might have been expected based on habitat value in the absence of snowmobile activity. For reference, we also present simple density estimates exclusive of the habitat weighting factor.

Results

During all three censuses, significant numbers of caribou were recorded on the 5 mountain blocks where snowmobile use was low or absent, whereas no caribou were found on the Sande block that had extensive snowmobile use (Figure 2). During the 2005 census, tracks of 1 or 2 caribou were located on the Sande block but the caribou could not found. Those tracks were in a rugged portion of the block that was inaccessible to snowmobiles. Similarly, in March 2004 we counted 8 caribou on the Sande block during an overview flight, but those caribou were on a side ridge that was not accessible to snowmobiles.

Density of caribou on the occupied blocks averaged 0.3 caribou/km^2, and ranged from 0.07 to 0.59 caribou/km^2 (Figure 3). The rugged, higher elevation Hedrick block always had a lower density than the other occupied blocks. The density on those lower elevation, less rugged census blocks averaged 0.42 caribou/km^2, and ranged from 0.1 to 0.59 caribou/km^2. Based on the density of caribou in those less rugged occupied blocks, the Sande block should have supported 13 to 77 caribou in March.

The most parsimonious RSF model consisted of terms for biogeoclimatic zone, distance to treeline for alpine locations, and a polynomial term for slope (AIC_c w_i = 0.64) and was a good predictor of withheld caribou locations ($\bar{r}_s$ = 0.878, $P < 0.001$). Results of the RSF agreed with our general understanding of mountain caribou ecology: avoidance of low elevation SBS habitats (β = -4.6762, 95% Confidence Inteval (CI) = -6.354 – -2.998) and selection for upper elevation ESSF forests (β = 1.440, 95% CI = 0.967 – 1.912), parkland (β = 2.177, 95% CI = 1.698 – 2.656), and alpine tundra (β = 1.537, 95% CI = 0.674 – 2.400) in proximity to treeline.

The RSF analysis indicated some variability in the habitat quality among the different census blocks (Figure 4). The Captain-Otter block had the greatest proportion of good habitat (Classes 1 & 2) and the lowest proportion of poor habitat (Classes 7-10). The Hedrick block had the lowest proportion of good habitat and the greatest proportion of poor habitat. The Sande block had large amounts of Class 1 & 2 habitat, so the absence of caribou could not be explained by the absence of good quality habitat.

Application of the RSF-based density estimation technique to 3 years of census data and 4 reference blocks resulted in an average estimate of 75 caribou (95% CI = 53 – 96) for the Sande block. Estimates, however, were quite variable across years and blocks ranging from 13-136 animals.

Discussion

Caribou were rarely located on the Sande mountain block that had intensive snowmoble use, even though the habitat model indicated that it contained high quality habitat and should have supported about 75 caribou. On the few occasions when caribou were present, they were using portions of the block that were inaccessible to snowmobiles. It appears that caribou were being displaced from the area by snowmobiles. Other studies have reported some local displacement of caribou and reindeer by snowmobiles (Simpson 1987, Simpson and Terry 2000, Mahoney et al. 2001, Reimers et al. 2003), but this study suggests complete displacement from an entire mountain block. Local displacement may result in increased energetic costs to caribou or reindeer (Reimers et al. 2003). However, complete displacement from high quality habitats could force caribou into inferior habitats where they have a greater risk of mortality from avalanches, predation or nutritional and energetic stress. Given that mountain caribou populations are Threatened or Endangered, and most populations are declining (Wittmer et al. 2005), any additional negative population pressure will be detrimental to recovery efforts.

Caribou numbers and density were also lower on the Hedrick census block which was higher and more rugged than the other census blocks. Although the RSF indicated that this block had substantial amounts of good habitat, that habitat was interspersed with areas of unsuitable alpine and glaciers which appeared to reduce the suitability of the entire area for caribou. Nonetheless, this block still supported higher caribou densities than the intensive snowmobile area on the Sande block.

It is important to note that our estimates of caribou density for the Sande block represent a range of possible values, not the exact number of caribou we should expect in the absence of snowmobiles. As we demonstrated in a companion study (Johnson and Seip, in review), population density will influence the distribution and abundance of animals among reference areas and consequently the range of predictions. Only where a reference population is at ecological carrying capacity can we be assured that estimates will not be biased by interannual variation in distribution. Unfortunately, this assumption is difficult to test under most field conditions, (but, see Boyce and Waller 2003). Although variation in density can limit the accuracy and precision of the technique, the bias should result in conservative estimates. If future surveys report greater densities of animals in the reference blocks across our study area, for example, then estimates of caribou for the Sande block should increase accordingly. Predictions, however, also are sensitive to occupancy patterns that result from caribou overfitting or underfitting patches (relative to habitat quality) and inherent error and uncertainty in RSF scores and maps (Johnson and Seip, in review). The impact of these latter factors could lead to estimates that inflate the true impact of snowmobiles on caribou distribution.

Management implications

It is not known if the displacement from the Sande block has had any negative population impacts for this herd because they had alternative areas of good quality habitat to use.

However, if snowmobile activity continues to expand to more areas of high quality habitat, the caribou would eventually be displaced to poorer quality habitat. Caribou forced into poorer quality winter habitat may experience an increased risk of accidental deaths from avalanches in steeper terrain, increased energy expenditure required to move through deeper snow or steeper terrain, reduced forage availability, or increased risk of predation. Those factors would have negative impacts on population growth and compromise recovery efforts.

To limit the threat of snowmobiling to caribou recovery, we recommend that snowmobiling should be restricted from high quality mountain caribou winter habitat, or at least limited to a small proportion of the total high quality habitat for each herd.

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Table 1. Characteristics of the mountain caribou census blocks.

Census Block	Snowmobile Activity	Area above 1500m (km^2)	% of area above 1800 m
Captain/Otter	none/low	214	0
Bearpaw	none/low	217	2
Severeid	none/low	110	1
Torpy	none/low	143	1
Hedrick	none/low	493	15
Sande	intensive	134	3

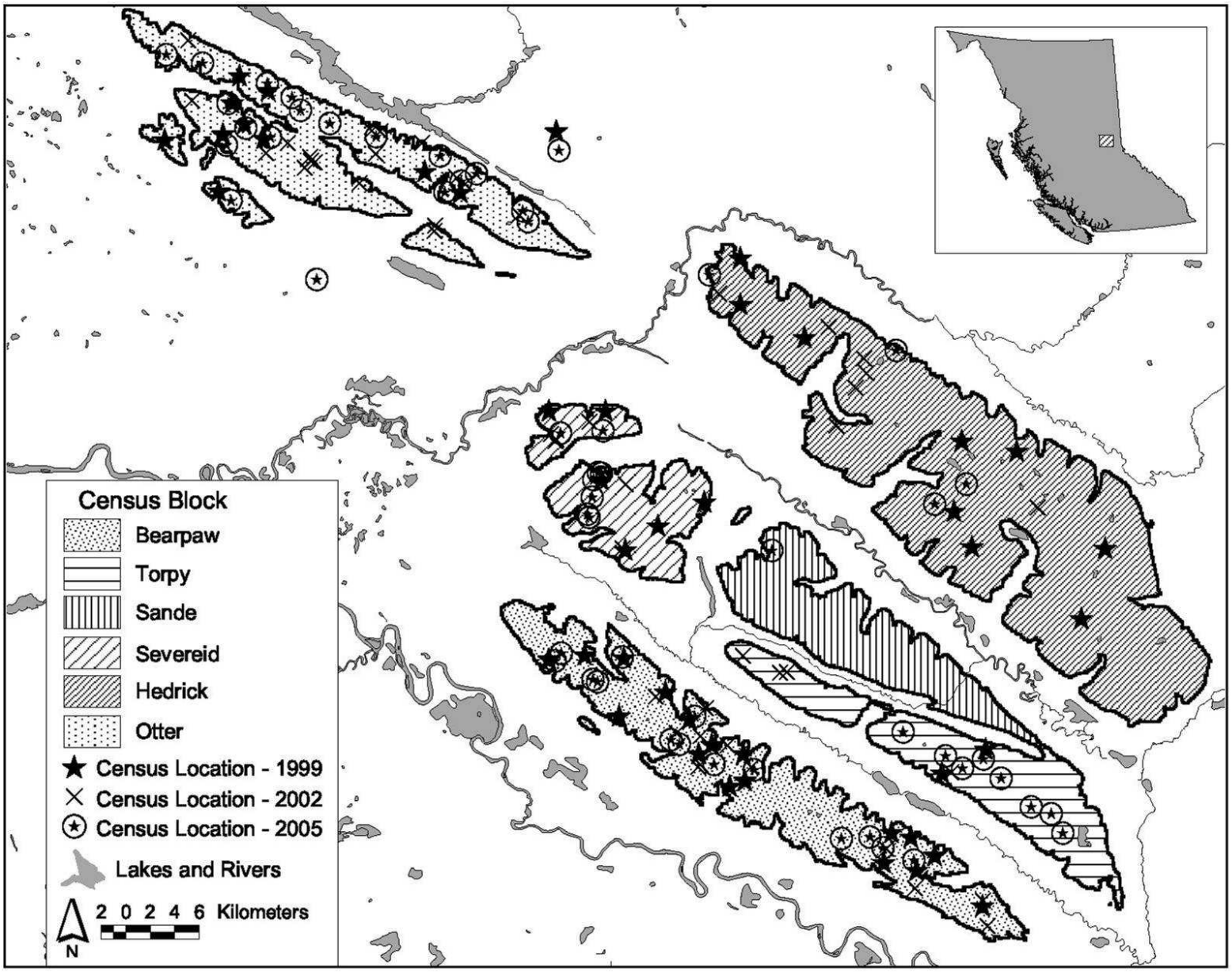
Figure Captions:

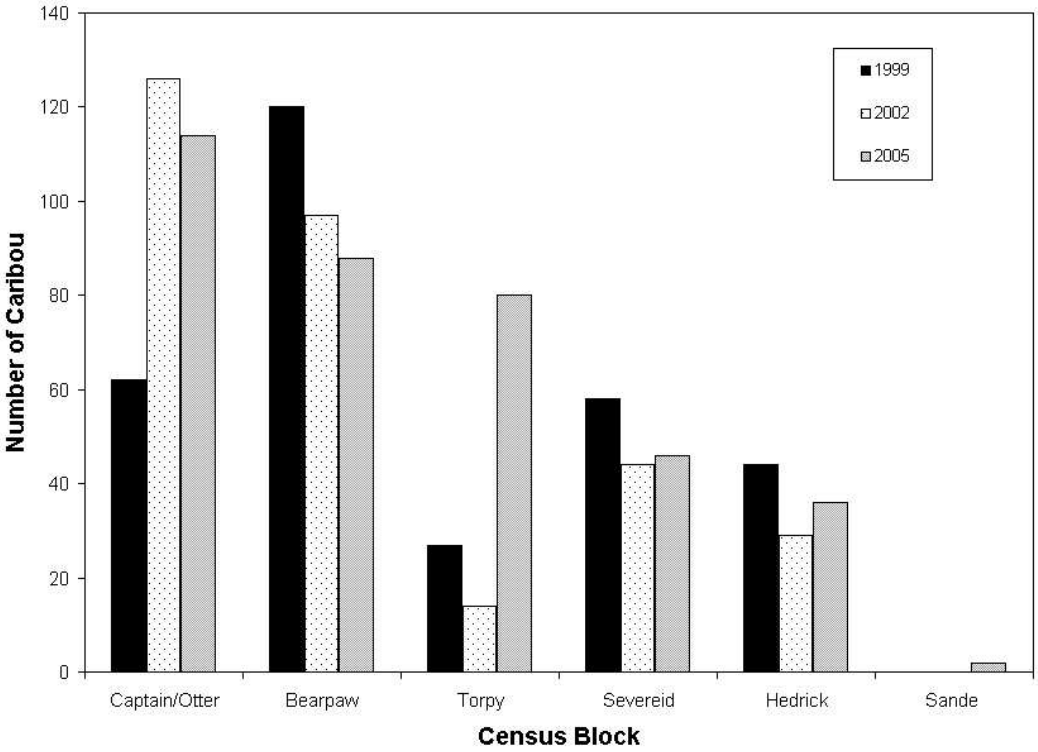
Figure 1. Map of the study area showing the census blocks and locations of caribou during March surveys.

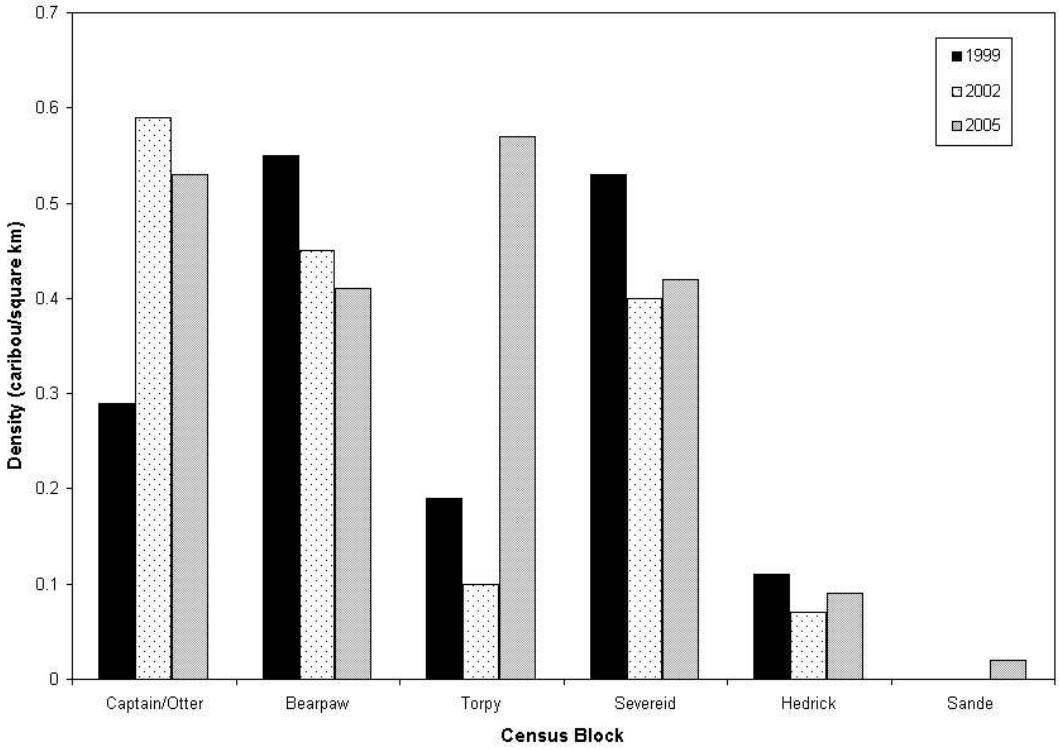
Figure 2. Number of caribou in each census block during March surveys. The Sande block had extensive snowmobile activity.

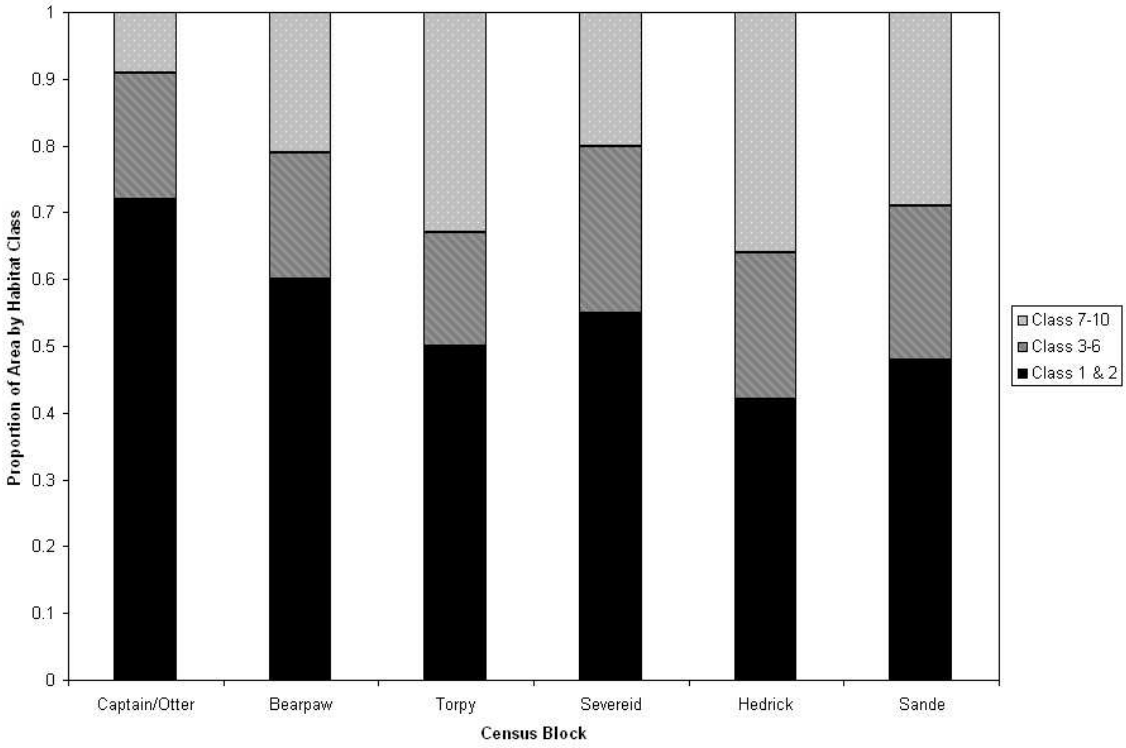
Figure 3. Density of caribou in each census block during March surveys. The Sande block had extensive snowmobile activity.

Figure 4. Quality of winter habitat on the census blocks based on a Resouce Selection Function (Good: Class 1 & 2, Medium: Class 3-6, Poor: Class 7-10).


Census Block
Bearpaw
Torpy
Sande
Severeid
Hedrick
Otter
Census Location - 1999
Census Location - 2002
Census Location - 2005
Lakes and Rivers
2 0 2 4 6 Kilometers
N


140
120
100
80
60
40
20
0
Number of Caribou
1999
2002
2005
Captain/Otter
Bearpaw
Torpy
Severeid
Hedrick
Sande
Census Block


0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Density (caribou/square km)
1999
2002
2005
Captain/Otter
Bearpaw
Torpy
Severeid
Hedrick
Sande
Census Block


Proportion of Area by Habitat Class
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Captain/Otter
Bearpaw
Torpy
Severeid
Hedrick
Sande
Census Block
Class 7-10
Class 3-6
Class 1 & 2