



POPULATION ECOLOGY

The Relative Abundance and Spatial Distribution of Wolves in North-Central British Columbia

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ABSTRACT

We conducted a survey to enumerate wolf scats within the range of two “threatened” caribou (*Rangifer tarandus caribou*) herds in north-central British Columbia. The scat survey was conducted along roads within a stratified random sample of watersheds in the Wolverine and Chase caribou recovery plan areas. Watersheds were selected as part of the potential survey population if they were within a subset of the study area known to be used by wolves (based on previous radio-collaring) and if an accumulation of 100-m road buffers represented $\geq 30\%$ of the watershed (enough roads to sample). Stratification of sampling was based on the proportion of high-quality moose habitat within watersheds. One preliminary sample taken October, 2008 was augmented with four monthly samples from late June to late September, 2009. We observed 496 scats along 543 kms of transect, in 12 randomly selected watersheds. We found a significant relationship between the pooled scats / km and the amount of moose habitat within the sampled watersheds. By comparing our data to two other published relationships of wolf density and a standard wolf scat index, we determined that approximate wolf densities in our watersheds could have ranged from 1 to 12 wolves/km². However, as all these relationships are preliminary in nature, based only on low sample sizes, and in some cases, extrapolation of data from other ecological systems, more work is required to confirm or substantiate these results.

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INTRODUCTION

Background

Woodland caribou (*Rangifer tarandus caribou*) in the Southern Mountain National Ecological Area were designated “threatened” by COSEWIC (Committee on the Status of Endangered Wildlife in Canada) in 2002, were added to the Species at Risk Act (SARA) Schedule 1, and are a species at risk under the Forest and Range Practices Act (FRPA) in British Columbia (BC). Caribou are also commonly considered to be a leading indicator of biodiversity and ecosystem health in the boreal and sub-boreal forests (e.g., see ENGO programs such as Caribou Nation¹, Grey Ghosts², and Staring at Extinction³). In the late 1970s, the BC government sensed potential mismanagement of caribou with an apparent decline in populations and annual harvests exceeding 1,500 animals (MacGregor 1985). After curtailing hunting, caribou populations continued to decline and, despite the current legal status, the rate of decline indicates extirpation for many herds in a matter of decades (Wittmer 2004). The common denominator in this decline was considered by Messier et al. (2004) to be increased ungulate (other than caribou) populations. Other ungulates are primary prey for many predators of caribou and their increased numbers have been associated with increased predation on caribou (Wittmer et al. 2005). Under conditions of high ungulate density, caribou apparently suffer more incidental predation from wolves (*Canis lupus*) than would otherwise occur (Bergerud 1983, Seip 1992, Racey et al. 1999). The increased mortality is exacerbated because caribou are possibly more susceptible to wolf predation than other ungulates (Seip 1991, Seip 1992, Thomas 1995). Increases in non-caribou ungulate populations (e.g., moose [*Alces alces*], deer [*Odocoileus* spp.], and elk [*Elaphus* spp.]) have been related to the abundance of young seral forests that occur post-logging (Hatter 1950, Wallmo 1969, Spalding 1990, 1992, Rempel et al. 1997, Rettie and Messier 1998). Roads and other linear corridors may also benefit predator search rates and allow predator’s access to caribou in places that would otherwise be less inaccessible (Jalkotzy et al. 1997; Bradshaw et al. 1997, James and Stuart-Smith 2000, Dyer et al. 2001). The most proximal cause of declining caribou populations is assumed to be predation-related effects that reduce adult caribou survival and juvenile recruitment. Corrective measures to reverse the decline of caribou in the short-term therefore must involve predation mitigation either by managing early seral forest conditions, roads and linear corridors, non-caribou ungulates, predators, or a combination of these. Presumably, such measures would be part of a comprehensive conservation strategy which includes longer-term measures to manage habitat to reduce the likelihood of overlap between caribou and predators hence minimizing the need for continuous management of predators.

As part of a larger research project we are testing the notion that mitigation of predation rates on caribou can be effectively implemented by having owners of registered trap lines undertake trapping of specific wolf packs in locations of high predation risk (McNay and Giguere 2008). An important component of this project will be to understand the relative abundance and spatial distribution of wolves both in the treatment areas, where wolves are trapped, as well as in control areas where wolves are not trapped. Proper

¹ <http://www.caribounation.org>

² <http://23120.vws.magma.ca/work/caribou/index.php>

³ <http://www.forestethics.org/article.php?id=1122>

implementation of monitoring and mitigation of predation will not occur without accurate information on the distribution and abundance of wolves within the study areas. However, accurate information on wolves can be difficult to collect due to their elusive nature. Wolves are known to travel extensively in search of food and so, their spatial distribution can be expected to vary seasonally and even more generally depending on prey dynamics.

Periodic monitoring of the location and number of wolf scats observed along regular transects is a recommended method for estimating relative abundance and distribution of wolves; especially when vegetation is dense and/or terrain is too rugged to conduct aerial surveys (RISC 1998). Other studies have used this method to determine relative abundance of wolves as well as other canids such as coyote and fox (*Vulpes vulpes*) (Crete and Messier 1987, Gese 2004, Houchin 2005). Crete and Messier (1987) compared scat indices to estimated wolf densities based on radio telemetry in order to test scat surveys as an index of wolf population trend. They found that although their results showed a strong relationship to abundance, the results were subject to large variability. Their results indicated that 70 to 80 sample weeks of data would be necessary to come within a 20% confidence interval. The authors suggested that increasing the total transect length could lessen the variance. Although scat transects are considered to be a reliable inventory method, Kunkel et al. (2005) state that it requires substantial effort. However, Harrison et al. (2002) compared different survey techniques and found that the most efficient survey method to measure relative abundance of swift fox (*V. velox*) was scat collection.

Objectives

Our primary objective was to record wolf scat deposition rates along logging roads as basic information on wolf relative abundance and spatial distribution within the Chase and Wolverine caribou herd areas. We made a preliminary assessment of this technique and chose to continue with it over trapping and collecting hair for the same purpose (McNay et al. 2008). A secondary objective was to use the observations of wolf scats to augment other current efforts to identify wolf pack sizes and spatial distribution in the same study areas where regular monitoring of radio-collared animals is being conducted (McNay and Giguere 2008). Live capture of wolves to affix VHF (very high frequency) or GPS (global positioning system) collars has provided high quality information, but is difficult, expensive, and time-consuming to locate packs. Outcomes of the scat sampling were intended to provide reliable information to make collaring of wolves more efficient. A tertiary objective was to evaluate the need for, and provide an estimated budget for, full implementation of a wolf-scat monitoring program.

STUDY AREAS

Study areas were the Recovery Planning Areas (RPAs) for two herds of woodland caribou described by Heard and Vagt (1998): the Wolverine and Chase herds (Figure 1). The Wolverine herd derived its name from the Wolverine Range, a long range of mountains running north-south located on the east end of the study area. The Chase herd was named after Chase Mountain, which is centrally located within the wintering area of the herd. The hunting of wolves is permitted throughout both study areas.

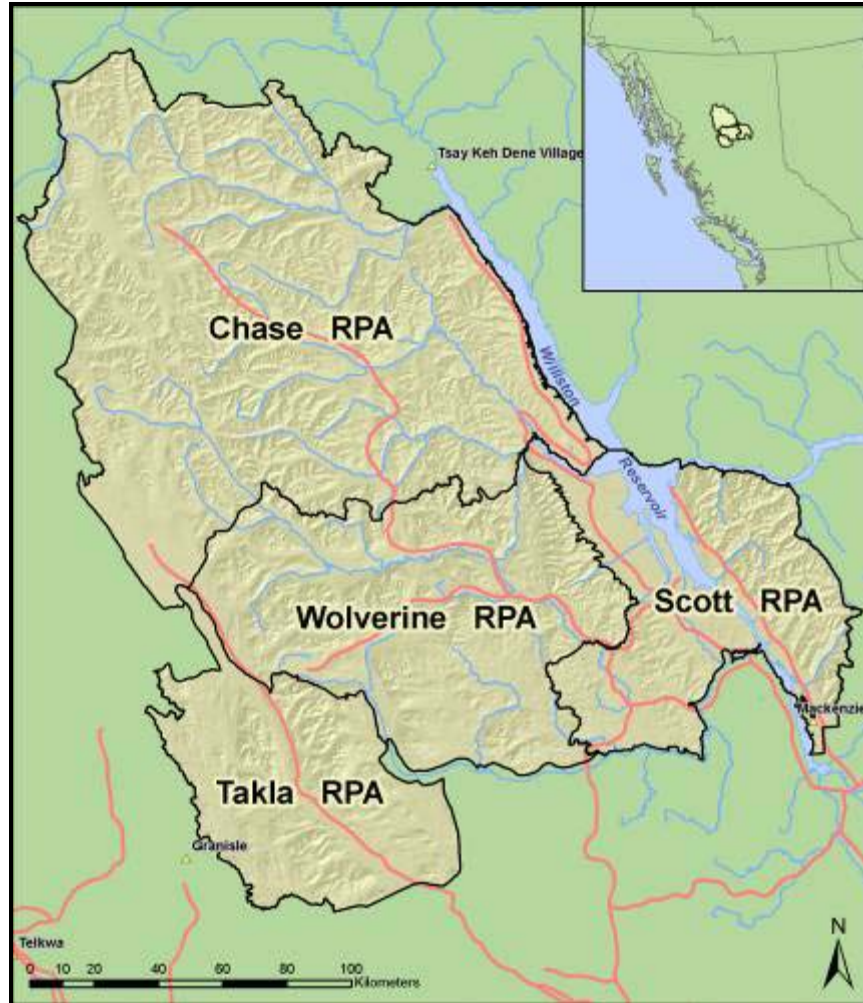


Figure 1. Location of recovery plan areas (RPA) for herds (Chase, Wolverine, Takla, and Scott) of threatened woodland caribou in north central British Columbia.

Wolverine

The Wolverine RPA is 844,313 ha, ranging in elevation from 676 to 2134 m in rolling high-elevation foothills, and includes four major watersheds of the Omineca, Manson, Klawli, and Germansen Rivers. It is roughly bounded in the north by the headwaters of Goat, Nina, and Big Creeks, in the west by Takla, Tsayta, and Indata lakes, in the south by Tchentlo, and Chuchi lakes, and in the east by Sylvester and Gaffney creeks and the eastern slopes of the Wolverine Mountain Range. At low- to mid-elevations, the area is dominated by a Boreal White and Black Spruce subzone (BWBSdk1), two of the Sub-Boreal Spruce subzones (SBSmk1 and SBSmk2 variants), and an Engelmen Spruce-Subalpine Fir subzone (ESSFmv3) dominates the mid- to high-elevations. The Alpine Tundra (AT) prevails above tree line. Extensive areas within the study area have been managed for production of timber.

Chase

The Chase RPA is 1,733,039 ha situated in steep mountainous terrain ranging in elevation from 671 to 2466 m, and has three major watersheds including the Ingenika, Osilinka, and Mesilinka Rivers. It is roughly bounded in the north by the most northerly portion of the Finlay River, in the west by Thutade, Sustut and Driftwood rivers, in the south by Ominicetla Creek, back end of Osilinka River, headwater of Wasi and Flegezand creeks, and in the east by the Williston Reservoir. At low- to mid-elevations, the area is dominated by the BWBSdk1 and SBSmk2 biogeoclimatic variants, and at mid- to high-elevations the ESSF Omineca variant (ESSFmv3) predominates. The Alpine Tundra (At) prevails above the tree line. One trap was located within the Chase RPA.

METHODS

Sample design and spatial data preparation

We chose a stratified random sample as the basic design for sampling observations of wolf scats. The sample unit was 3rd order watersheds ($n = 292$) located within the Chase and Wolverine caribou herd areas (Figure 2) which we then stratified based on the proportion of modeled moose habitat (McNay et al. 2006) found within each as either High (>10%), Moderate (5 to 10%), or Low (<5%). Watershed boundaries were obtained from the BC 1:50,000 Watershed Atlas. The purpose of stratification was so sampling results could be extrapolated throughout the Chase and Wolverine caribou herd areas on the basis of a presumed relationship among the wolf scat index and amount, quality, and spatial distribution of moose habitat. Testing of the extrapolation would require confirmation of associations between wolf scats and: a) estimated wolf numbers observed from other sources (e.g., telemetry of collared packs) and/or b) modeled moose habitat. Provided our study showed positive results, we would propose to pursue these more detailed studies in the future.

For the initial application, we chose to work only within those watersheds in which we had some prior information about wolves. We then obtained digital road information and, using a 1-km buffer on road segments, determined the proportion of each watershed having sufficient opportunity for selecting transects. We arbitrarily assumed watersheds having >30% coverage of the road buffer would provide that opportunity. We then chose a random sample of the “road by watershed” polygons proportionally allocated among the three moose habitat strata, for potential study in subsequent years. Although more than one road buffer could exist within watersheds; we restricted the potential for watersheds to appear only once in the random sample. From the random sample, we authoritatively drew another sample of 2 to 3 units from each moose habitat strata for preliminary application of the sampling design. Based on literature and previous studies (Crete and Messier 1987) we established the goal for sampling intensity within random sample units to be about 0.08 km/km² and chose to capture the potential spatial variation in wolf scats by allocating effort on up to three transects where no transect was less than 3-4 kms in length.

Sample collection

Once we were located in a watershed selected for study we sought road transects that were travelled enough to eliminate all shrubby vegetation but not travelled so intensive as to compromise the detection of wolf scats. We avoided roads that exceeded 1200 m asl. Two observers experienced in detecting and stratifying scats by species drove (either by truck or All Terrain Vehicles) the transect watching for scats on both sides of the road. When only one observer was present, transects were repeated to observe scats on the side of the road that was disregarded on first pass.

We collected study-level information according to standards (RISC 1998) including but not limited to study area, weather, date, project, transect labels, length, start and end positions, width of road, map standard, etc. At each observation, we determined the species that deposited the scat, relative age of any general animal sign, descriptor of scat condition, number of scats, habitat types along the roadside, and a spatial reference for the observation. Scats were removed from the road following data collection in anticipation of repeat sampling.

Data analysis

Proportion of road buffer was the area covered by a 1-km buffer on roads in a watershed divided by the watershed area. Proportion moose habitat was the amount of moose habitat in a watershed divided by the watershed area. Intensity of sampling was the length of transect driven in a watershed during a sampling session divided by the watershed area. Average scats / km was the number of scats observed in a watershed during a sampling session divided by the length of transect driven in that session. Standard deviation of scats/km was based on the average scats/km. Pooled scats/km was the total number of scats observed in a watershed divided by the total length of transects driven. We tested for potential associations between scat deposition rates and the proportion moose habitat, watershed size, and sampling session using standard analysis of variance techniques. Pooled data from all but the one sample session in 2007 and from the first sample session in 2008 were standardized to scats per 100 km week of transect for comparison to results from other studies.

RESULTS

Third-order watersheds were on average, about 80 km² (n = 432, SD = 189) which suited our purpose as a sample unit since units much smaller than a wolf pack range was desirable. By our estimation, wolves in our study area could range between 200 - 2000 km² (Figure 2). We were able to evaluate moose habitat for about 89% (n = 292, 30,946 km²) of the watersheds in the study area. On average, moose habitat made up about 5% of each watershed but the composition was variable (max = 59%, SD = 8%) and skewed toward low abundance (Figure 3a). Restriction of the sampling to areas where we had some knowledge of wolves (Figure 2) led to 199 potential watersheds (16,489 km²). Of these 199 watersheds, 160 (14,713 km²) had at least some roads for sampling, and 115 (12,712 km²) of those met our criteria for having at least 30% covered by a 1-km buffer on roads (Figure 3b).

We enumerated wolf scats along multiple transects in twelve of the random sample watersheds (Table 1); 5 watersheds characterized by a relatively high amount of

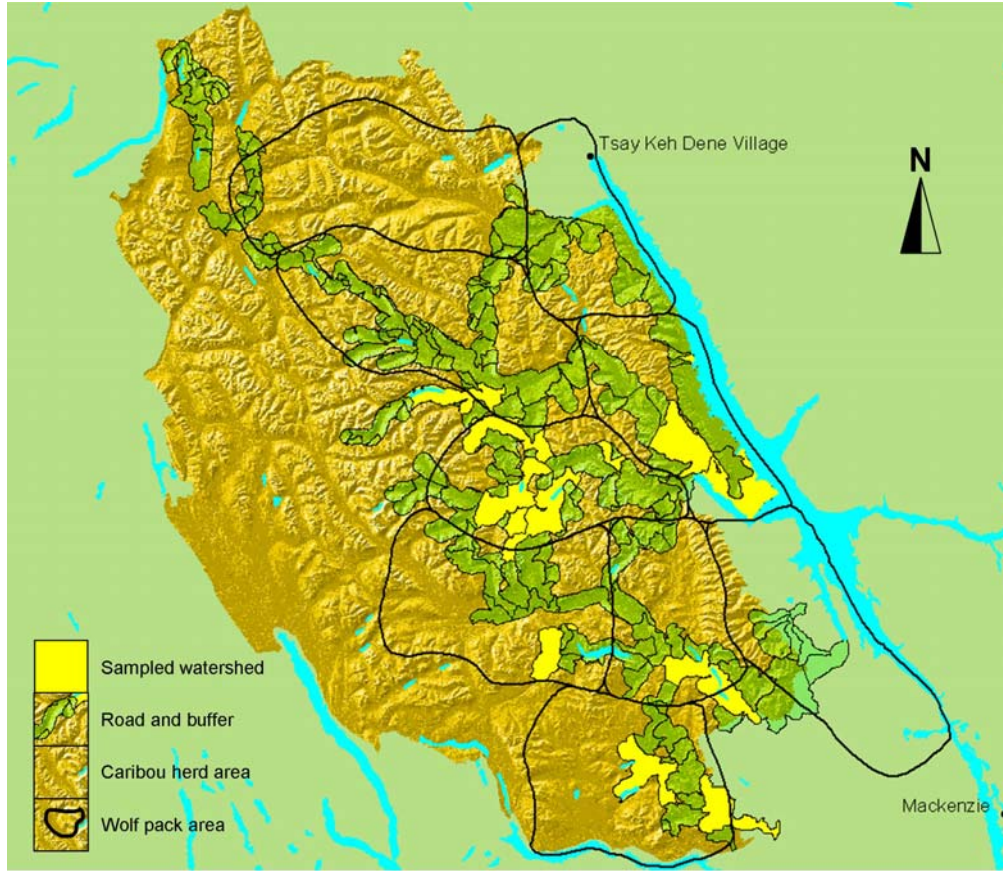


Figure 2. Watersheds selected for sampling wolf scat deposition rates within wolf pack areas and caribou herd areas (Chase and Wolverine) situated north-east of Mackenzie in north-central British Columbia.

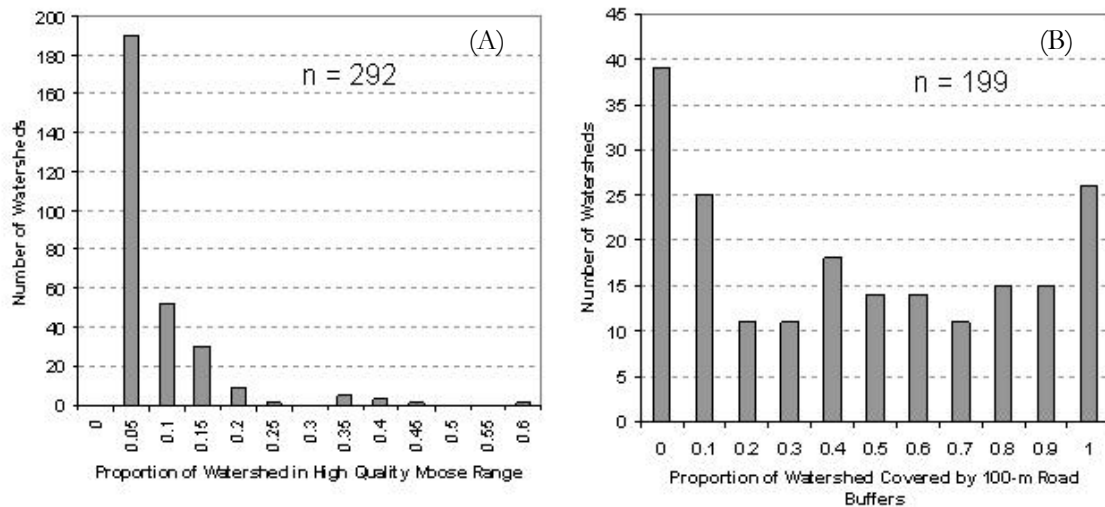


Figure 3. Proportions of selected watersheds chosen for a study of wolf scat abundance that had (A) high quality moose habitat and (B) that were covered by 100-m road buffers.

Table 1. Characteristics of samples taken in 12 watersheds chosen for a preliminary application of techniques to enumerate wolf scats for the purpose of estimating relative abundance and distribution of wolves in north-central British Columbia.

	Relative Amount of Moose Habitat											
	High				Moderate				Low			
Watershed reference	7397	6926	6799	6704	5374	6270	6651	6511	7869	7663	6625	7327
Watershed area (km ²)	220.49	34.96	168.00	152.76	153.16	176.39	65.63	154.85	144.72	451.75	199.15	165.57
1-Km road buffer (ha)	48445	3398	15819	48206	58746	76507	2503	11818	13805	14981	12682	8712
Proportion road buffer	0.77	0.97	0.94	0.71	0.88	0.70	0.38	0.76	0.95	0.33	0.64	0.53
Moose habitat (ha)	7624	1335	1693	6821	82929	10242	656	1538	1380	3195	936	236
Proportion moose habitat	0.12	0.38	0.10	0.10	0.32	0.09	0.10	0.10	0.10	0.07	0.05	0.01
Strata average (SD)	0.21 (0.14)				0.09 (0.01)				0.03 (0.02)			
Sampling sessions	4	4	1	5	1	5	3	5	1	4	5	5
Transect length (kms)	11.00	7.50	14.80	11.90	14.70	12.10	10.70	17.30	15.00	16.00	13.80	14.00
Transect sampled (kms)	39.00	28.70	14.80	66.40	14.70	60.50	32.40	65.90	15.00	70.00	69.60	66.00
Intensity of sample (km/km ²)	0.05	0.21	0.09	0.08	0.10	0.07	0.16	0.11	0.10	0.04	0.07	0.08
Strata average (SD)	0.11 (0.06)				0.10 (0.05)				0.08 (0.01)			
Total scats	43	19	3	36	9	130	23	122	34	16	41	20
Average scats/km	1.30	0.66	0.20	0.54	0.61	2.15	0.65	2.04	2.27	0.22	0.59	0.30
SD scats/km	0.58	0.09	0.00	0.32	0.00	0.58	0.26	0.74	0.00	0.10	0.23	0.10
Strata average (SD)	0.76 (0.19)				1.35 (0.30)				0.44 (0.13)			
Pooled scats/km	1.10	0.66	0.20	0.54	0.61	2.15	0.71	1.85	2.27	0.23	0.59	0.30
Pooled scats/100 km week	16.88	15.24		7.20		45.45	11.35	18.99		1.34	5.69	5.61

moose habitat, 5 by moderate amounts of moose habitat, and 2 in watersheds having relatively low amounts of moose habitat. The proportion road buffer in these watersheds ranged from 0.33 to 0.97. The total length of transects driven in all 5 sampling sessions was 543 km for an average per session sampling intensity ranging between 0.04-0.21 km/km² (Table 1). We observed a total of 496 scats with more than 100 observed in each of two watersheds; both with moderate amounts of moose habitat. The average scats/km varied from 0.20 to 2.27 with an overall average of 0.94 (n = 45, SD = 0.16).

There was no apparent association ($P > 0.100$) between pooled scats/km and watershed area, 1-km road buffer area, proportion road buffer, proportion moose habitat, sampling session, or intensity of sampling. The observed, pooled square-root of wolf scats/km was significantly ($R^2 = 0.35$, $P = 0.0549$, $F_{1,9} = 4.86$) associated with the total amount of moose habitat within individual sample units (Figure 4).

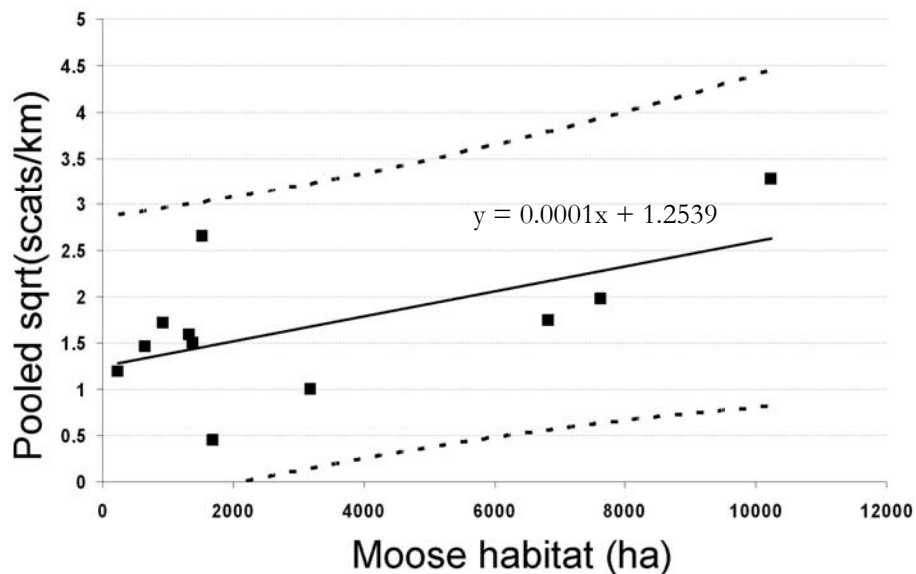


Figure 4. Relationship between observed wolf scat deposition rate (pooled sqrt(scats/km)) observed along logging roads and the total amount of modeled moose habitat (ha) within selected watersheds in the recovery planning areas for the Chase and Wolverine caribou herds located in north-central British Columbia, 2007-2008.

We could only find data from two studies that reported wolf scat deposition rates related to wolf density (Atkinson and Janz 1994, Crete and Messier 1987). For comparison purposes our standardized scat index (scat / 100 km week) are presented with those of the other studies in Figure 5. Based on an average of these published relationships, wolf densities in our sample watershed could have ranged from 1 to 12 wolves/km².

DISCUSSION AND RECOMMENDATIONS

Although we did observe a significant relationship among scat deposition rates and the amount of moose habitat, the intercept was higher than expected and the relationship

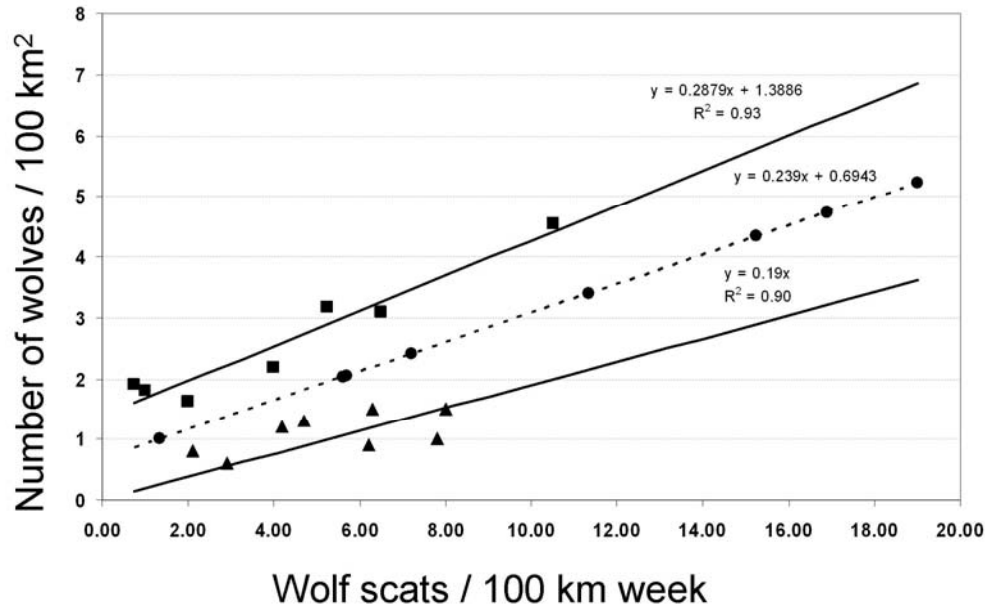


Figure 5. Density of wolves (number / 100 km²) predicted by regressions based on a wolf scat index (scats / km week) where data were collected from Vancouver Island, British Columbia (1983-1986 ■, Atkinson and Janz 1994) and southwestern Quebec (1980-1983 ▲, Crete and Messier 1987) and an approximate wolf density was estimated for scat data collected in north-central British Columbia (2007-2008 ●).

was leveraged by only a few samples observed at high amounts of moose habitat; the sampling could benefit from having more samples at that end of the axis. Selection of sample transects may have obscured the relationship in watersheds that had relatively low amounts of moose habitat. For example, the spatial location of roads seemed favorable for detecting wolves in some watersheds but not in others perhaps because of varying proximity to moose habitat. Also, wolves apparently will use some roads and not others even within the same watershed; perhaps as a function of territorial behavior (Mech and Boitani 2003) rather than hunting. Attempting more control on these potential sources of variance may be accomplished by authoritatively choosing transects (within randomly selected watersheds) that have a high likelihood of being used by wolves. This could be initiated prior to field work using a GIS to assess the geographic location of transects (e.g., spatial proximity to moose habitat or wolf pack territory boundaries).

Sampling design issues may also have obscured the relationship we expected. For example, the design could be improved by removing the classification of moose habitat and relying on the actual amounts of habitat as an inverse weight on the random selection procedure (i.e., higher probability of drawing a sample at high amounts of moose habitat). Another design improvement might be to change the sample selection to be based on the amount of moose habitat within the road buffer rather than just the amount of moose habitat in the watershed. The consequences of this would be that, within the stratification of moose habitat, those watersheds with closer proximity of roads and moose habitat would be favored in the stratified random sample.

Despite these potential improvements to the sampling layout and survey design, we were able to demonstrate a relationship between wolf scat deposition rates and moose habitat with reasonable little effort. Based on this result, there is potential viability for then estimating wolf abundance across the entire study area using amount of modeled moose habitat as the explanatory variable. This assumes a secondary, known relationship among wolf scat deposition rates and number of wolves (Atkinson and Janz 1994, Crete and Messier 1987), something we have yet to accomplish. The two published relationships are relatively strong but each are based on relatively low sample sizes. The relationship from Vancouver Island, where the prey was primarily black-tailed deer (*Odocoileus hemionus columbianus*) is almost double that of the relationship in southwestern Quebec where the primary prey was moose. Its unclear how this difference in prey would lead to the difference in the relationships but it does point out that the relationship is likely to be sensitive to regional differences in the ecological setting; a precaution in the use of these regressions addressed by Crete and Messier (1987). Modifying our sampling design to use a random sample of watersheds within wolf census units rather than watershed units alone would help us to substantiate (or refute) the existence of such a relationship in our study area. In other work (McNay et al. 2009), we have been able to provide a preliminary stratification of wolf census units within the Chase and Wolverine herd areas and have placed radio-collars on wolves in half of these units. Future data collection to enumerate wolfs based on the radio-collared packs will progress our efforts to determine if we can relate the standard scat index to density of wolves.

The scat deposition survey provided benefits to the larger study of predation risk (McNay et al. 2009) beyond the prospect of a relationship with which to model wolf population estimates. We also gained an immediate sense for the spatial distribution of wolves in the study area which led to a successful live-trapping event and the collaring of a wolf pack that was previously unstudied (MacDonald 2009). We were also able to identify sites commonly used by wolves which will improve efficiency of future live-trapping and/or wolf removal.

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