December 23, 2014

CANADIAN ZINC CORPORATION; PRAIRIE CREEK MINE, NT

Modelling Caribou Occurrence Along the Proposed Prairie Creek Mine All-Season Road

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REPORT

Golder Associates

Executive Summary

The Prairie Creek Mine (the Mine) is a proposed underground lead-zinc-silver mine located in the Northwest Territories of Canada. The Mine and related infrastructure are surrounded by the Nahanni National Park Reserve (NNPR). The Mine is not part of NNPR; however, approximately 83 km of the winter road used to access the Mine crosses through the NNPR. CZN is proposing to upgrade the winter road to an all-season road (the Road). Previous wildlife surveys conducted as part of the Prairie Creek Mine permitting process indicate that woodland caribou (*Rangifer tarandus caribou*) inhabit the lands surrounding the Mine and winter road alignment; however, little information existed on the extent of caribou distribution and area of occupancy along the proposed Road alignment, particularly during the non-winter period. In July 2014, CZN contracted Golder Associates Ltd. (Golder) to conduct a study to determine caribou distribution along the proposed Road during the non-winter period.

The specific objective of this study was to determine the distribution of caribou along the Road since the winter of 2013-14 up to the survey date. Sample sites were selected according to a stratified random design, using the caribou summer habitat suitability index (HSI) of Polfus et al. (2013) to stratify the study area into three categories of suitability. A caribou sign survey was conducted along transects on foot by teams of two surveyors. Incidental wildlife sign encountered along transects was also recorded.

Occupancy models were used to analyze the data. Occupancy models allow variables affecting both presence of animals (i.e., occupancy) and the ability to detect animals when they are present (i.e., detection) to be modelled simultaneously. Covariates of both occupancy and detection were modelled using the logit link function. An *a priori* model set was defined to represent the decreasing hierarchy of site information from sampling design strata, to calculated HSI scores, to covariates used to build the HSI models. Akaike's Information Criterion (AIC) was used to assess the best fit among these models. To estimate the probability of caribou occupancy along the entire length of the road, the final model equation was calculated for all blocks in the study area.

A total of 139 transects were sampled in 35 blocks across the study area. Caribou occupancy was predicted in sampling blocks with higher area of krummholz/alpine shrub landcover, and higher area with an aspect between southeast and northwest in a clockwise direction. Detection was higher for sampling conducted on the road bed.

Based on model predictions, it may be expected that the areas with the highest likelihood of caribou-vehicle conflict during the non-winter period are the Mackenzie Mountains near the Mine site, the lower Sundog Creek drainage, west of the Ram Plateau, and the Silent Hills. There is uncertainty associated with any model and it is important to consider this during interpretation. The proposed Road follows a steeply incised valley through the MacKenzie Mountains, such that caribou would have to move over steep terrain to travel north-south through this area. While this is likely, it is also likely that they would move along the valley bottom, suggesting that some caribou presence may be expected throughout that area. Similarly, sample blocks are only 1.5 km wide, and thus, caribou may also be expected to be present in the region around blocks with higher predicted occupancy, to some extent.

Statement of Limitations

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1.0 INTRODUCTION

The Prairie Creek Mine (the Mine) is a proposed underground lead-zinc-silver mine owned by the Canadian Zinc Corporation (CZN) and located in the Mackenzie Mountains in the southwest corner of the Northwest Territories (NT; Figure 1). The Mine site consists of significant infrastructure and facilities constructed in the early 1980s. A 180 km winter road was also constructed in the early 1980s to haul concentrates from the Mine to market via the Liard Highway (CZN 2010), though the Mine has never been operational. In June 2009, the Nahanni National Park Reserve (NNPR) was officially expanded to completely surround the Mine. The Mine and related infrastructure is not part of NNPR; however, approximately 83 km of the winter road crosses through the NNPR (CZN 2010). The winter road was the subject of an Environmental Assessment approved by the federal Minister in 2012 (EA0809-002). CZN is now proposing to upgrade the winter road to an all-season road (the Road) (CZN 2014). The proposed Road generally follows the winter road alignment assessed during EA0809-002, with some minor realignment to avoid difficult ground conditions and some stream crossings (CZN 2014).

Woodland caribou (*Rangifer tarandus caribou*) inhabiting the Greater Nahanni Ecosystem include both the Northern Mountain and Boreal ecotypes. The Northern Mountain ecotype is listed as Secure in the Northwest Territories (GNWT 2014), has been designated as Special Concern by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2014), and is listed as Special Concern on Schedule 1 of the *Species at Risk Act* (SARA) (SRPR 2014). Northern Mountain caribou inhabit the Mackenzie Mountains and have distinct seasonal migrations between summer and winter ranges. The Boreal ecotype is listed as Sensitive in the Northwest Territories (GNWT 2014), has been designated as Threatened by COSEWIC, and is listed as Threatened on Schedule 1 of the SARA (SRPR 2014). Boreal caribou do not occur in discrete herds but live in small, dispersed, and relatively sedentary bands east of the Mackenzie Mountains (Gullickson and Manseau 2000, Larter and Allaire 2010). Threats to both ecotypes include habitat loss, degradation, and fragmentation due to anthropogenic disturbance, and associated shifts in predator-prey dynamics (COSEWIC 2014).

In July 2014, CZN contracted Golder Associates Ltd. (Golder) to conduct a study to determine caribou occupancy along the proposed Road during the non-winter period. In terms of providing data representative of the non-winter period and the restricted time frame available for the current environmental assessment, it was decided that a ground-based sign (i.e., scat and/or tracks) survey offered the best scientific basis for determination of caribou occupancy along the Road. The majority of caribou in proximity to the Mine and Road are of the Northern Mountain ecotype, and this report includes information only on Northern Mountain caribou (hereafter caribou) occupancy along the proposed route during the non-winter period. Boreal caribou occupancy was not assessed as part of this study because: 1) boreal caribou prefer peatlands that are difficult to survey on foot due to a high water table, 2) scat may decompose quickly in peatlands due to the high water table, 3) recent leaf litter in the boreal plains during the fall season can obscure sign and compromise detectability, and 4) boreal caribou are not expected to be present west of the Nahanni Range.

2.0 OBJECTIVE

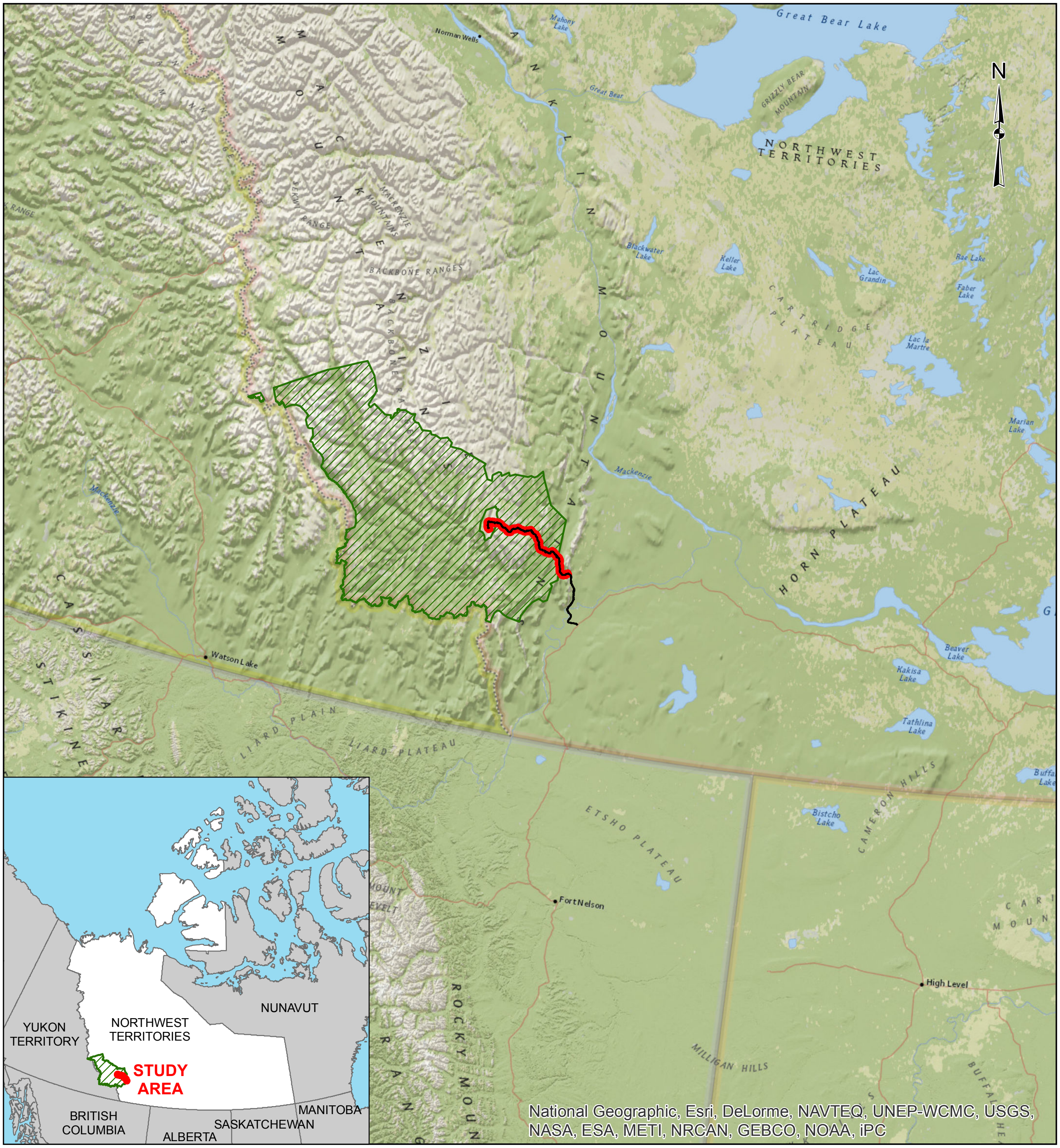
The specific objective of this study was to determine the presence of caribou along the proposed Road in the snow free months, and use these data to estimate the probability of future caribou occurrence.

This study was conducted under the terms and conditions outlined in Parks Canada Agency Research and Collection permit NAH-2014-16716 (to Golder Associates Ltd.) and NT Department of Environmental and Natural Resources Wildlife Research permit WL500260 (to Canadian Zinc Corporation).

3.0 METHODS

3.1 Study Area

The study area is defined as the 2 km buffer zone surrounding the length of the Road, west of the Nahanni Range (Figure 1). The study area encompasses 222 km^2 of western NT, including 139 km^2 of NNPR. It is located in the Boreal Cordillera-High Boreal ecological region, which is characterized by broad valleys and lowlands, deeply dissected plateaus, long ridges, and rugged limestone peaks (ECG 2010). Lowland coniferous and mixed forests dominate, with sedge wetlands at lower elevations and in the valleys and a variety of wetlands and alpine communities at higher elevations (ECG 2010).



LEGEND

- PRAIRIE CREEK MINE ALL-SEASON ROAD ALIGNMENT
- STUDY AREA
- NAHANNI NATIONAL PARK

100 0 100

SCALE 1:5,000,000 KILOMETRES

PROJECT

CANADIAN ZINC CORPORATION
PRAIRIE CREEK MINE
NORTHWEST TERRITORIES

TITLE

PRAIRIE CREEK MINE ALL-SEASON ROAD STUDY AREA

Golder Associates

PROJECT		09-1422-5007	FILE No.	
DESIGN	KD	03 Dec. 2014	SCALE AS SHOWN	REV. 0
GIS	CDB	03 Dec. 2014		
CHECK	KD	04 Dec. 2014	FIGURE: 1	
REVIEW	MJ	23 Dec. 2014		

REFERENCE

BASE DATA OBTAINED FROM ESRI.
DATUM: NAD83 PROJECTION: NORTHWEST TERRITORIES LAMBERT

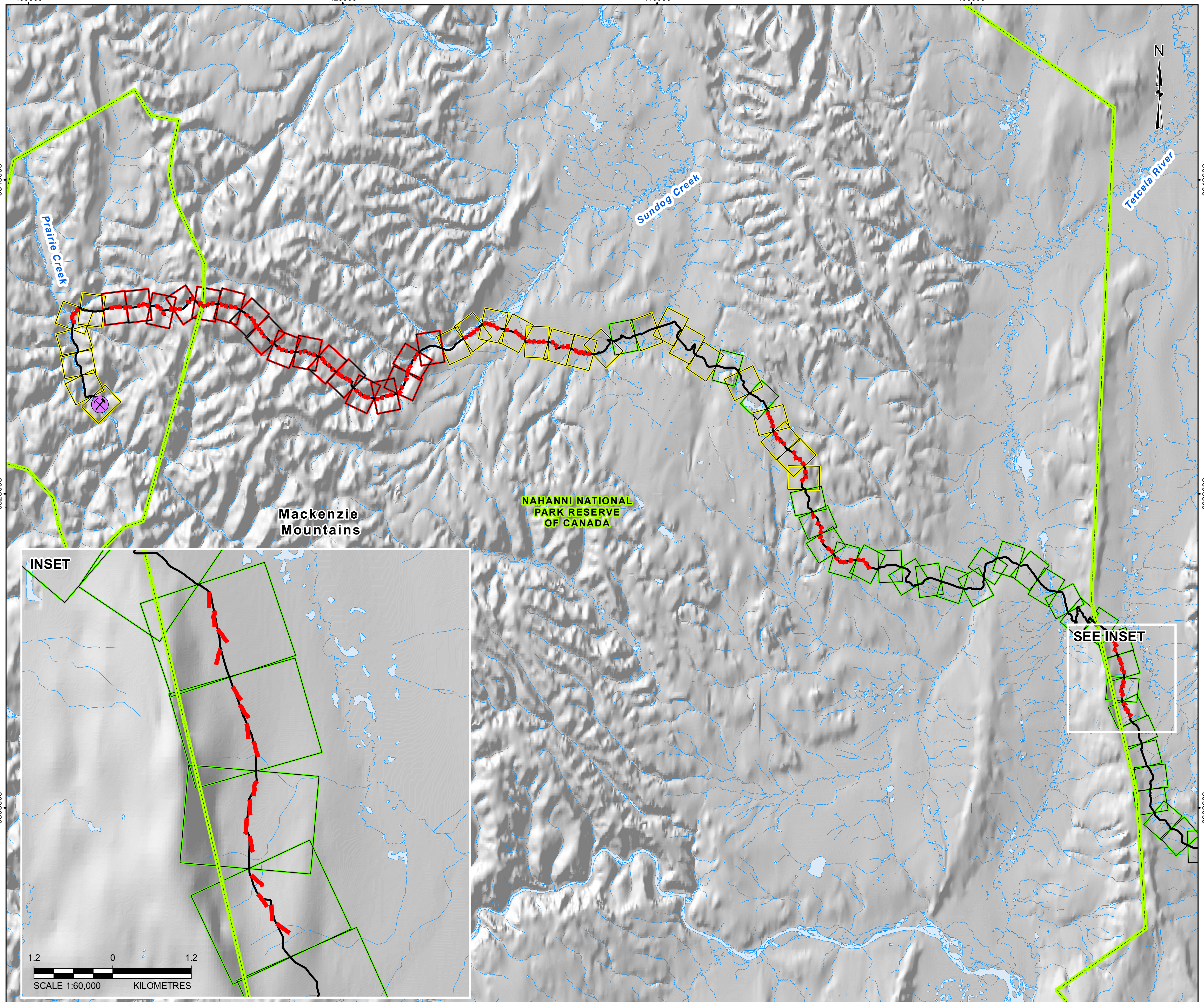
N:\Bur-Graphics\Projects\2009\1422\09-1422-5007\GIS\projects\2014\Figure_1_Prairie_Creek_Mine_Site_Area.mxd

3.2 Sampling Design

Sample sites were selected according to a stratified random design based on the caribou summer habitat suitability index (HSI) of Polfus et al. (2013). Habitat suitability indices are models used to explicitly quantify assumptions about wildlife habitat quality, and have been used extensively to predict the potential effects of habitat alteration on wildlife populations and to evaluate land management alternatives (Marzluff et al. 2002). In this case, HSI scores reflect relative probability of use for mountain caribou. The summer HSI of Polfus et al. (2013) included variables for land cover, elevation, and aspect. The Canada 250 m Land Cover Time Series 2000-2011, at a resolution of 250 m × 250 m (NRC 2012) was reclassified by a Golder vegetation ecologist, to match the land cover categories included in Polfus et al. (2013). Elevation was scored as above or below 1150 m. Aspect was scored as either between 315° to 135° (which is Northwest to Southeast in a clockwise direction, moving past north) or not between 315° to 135° (which is Southeast to Northwest in a clockwise direction, moving past south). Habitat suitability index scores ranging between 0 and 9 were calculated for each 10 m^2 cell in a raster file in ArcGIS, based on the resolution of the elevation and aspect variables. Three HSI categories were defined based on equal area of HSI scores: low (bottom 40% of HSI scores by area), moderate (middle 30%), and high (top 30% of HSI scores by area). The area of each HSI category was summarized within a 1.5 km x 2 km block centered on the road alignment, and each block was assigned to the high, moderate or low stratum based on the HSI category covering the majority of area within the block (Figure 2).

Survey blocks with major river crossings or excessively wet terrain were not considered for sampling due to crew health and safety concerns and the low likelihood of observing caribou sign in those habitats. Otherwise, all high and moderate strata survey blocks were sampled, and a proportion of low strata survey blocks were sampled. The low strata blocks were selected to cover representative areas along the remainder of the road alignment.

Transect start points were placed at 300 m intervals along the road alignment and a 250 m transect was placed at a random bearing within a 68° range on either side of the road alignment. This ensured that the entire length of each transect was within 150 m of the Road alignment. Within each survey block, transects crossing major bodies of water, occurring in excessively steep terrain (i.e., ≥ 40° slope), or crossing into two sample blocks were removed, and four of the remaining candidate transects were randomly selected for sampling.



N:\Bur-Graphics\Projects\2009\1422\09-1422-5007\GIS\projects\2014\Figure_2_Caribou_Sign_Sample_Sites.mxd

LEGEND

- PRAIRIE CREEK MINE
- PRAIRIE CREEK MINE ALL-SEASON ROAD ALIGNMENT
- SURVEYED TRANSECT
- PARK BOUNDARY
- WATERCOURSE
- WATERBODY
- SAMPLE BLOCK

CARIBOU SUMMER HABITAT SUITABILITY

- HIGH
- MODERATE
- LOW

REFERENCE

WATER FEATURES OBTAINED FROM CANVEC © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
DIGITAL ELEVATION MODEL OBTAINED FROM GEOBASE®.
DATUM: NAD83 PROJECTION: UTM ZONE 10
DATUM: NAD83 PROJECTION: UTM ZONE 10

5 0 5
SCALE 1:250,000 KILOMETRES

PROJECT

CANADIAN ZINC CORPORATION
PRAIRIE CREEK MINE
NORTHWEST TERRITORIES

TITLE

CARIBOU SIGN SAMPLE SITES ALONG THE PROPOSED PRAIRIE CREEK MINE ALL-SEASON ROAD ALIGNMENT

Golder Associates

PROJECT		09-1422-5007	FILE No.	
DESIGN	KD	03 Dec. 2014	SCALE AS SHOWN	REV. 0
GIS	CDB	03 Dec. 2014	FIGURE: 2	
CHECK	KD	04 Dec. 2014		
REVIEW	MJ	23 Dec. 2014		

3.3 Sampling Method

A sign survey was conducted on foot by teams of two surveyors. The first person navigated and dragged a 50 m rope behind them to establish the sampling transect. The second person walked slowly but continuously along the rope, searching for wildlife sign within 1 m on each side of the rope (approximately one arm's length), using their feet, or hands to clear ground cover where needed. Detected caribou pellets were categorized according to pellet density: single, > 1 and ≤ 10, or > 10; group description: scattered, clumped, or individual pellets; and age: fresh, old, very old to verify that only detections from the snow-free months were included in the analysis. In general, fresh scat is wet, green or black, and does not contain any mold. Old scat is dryer, may be cracked, and is more grey than black. Very old scat is dry, may be cracked into pieces or partially disintegrated, grey to white, and may contain mold or fungus. If snow/avalanche conditions have affected the location of the pellets or if the animal was moving, there may be single pellets detected or they may be scattered across a larger area. Depending on the diet, ungulate pellets are sometimes clumped instead of remaining in individual pellets. Summer diets often result in clumped pellets (Naughton 2012). Thus scattered, individual pellets that are very old may be from the winter months, while clumped fresh or old pellets are likely from the snow free months. It is assumed that all tracks are from the snow-free months.

Incidental wildlife sightings can supplement information collected during formal wildlife surveys to help assess changes in relative abundance over time (Hochachka et al. 2007). When detected, presence of scat for the following species was recorded once per transect: black bear, grizzly bear, wolverine, grey wolf, Canada lynx, moose, Dall's sheep, mountain goat, deer. Caribou sign and/or sightings detected while moving to transects or detected outside the 1 m transect area were also recorded as incidentals.

Additional information collected during surveys included date and time of survey, weather conditions, presence of snow patches, and major land cover type in each 50 m increment along the transect.

3.4 Statistical Analysis

3.4.1 Modelling Approach

Species detection is often imperfect because factors other than species presence influence the ability to detect species use of a sample site (MacKenzie et al. 2006). For example, wildlife tracks can only be detected in mud or snow, and scat may be obscured by ground cover, or may disintegrate quickly if deposited in wet areas. While some of this can be accounted for during the sample design (e.g., avoid sampling in wet areas), some variability in detection probability likely remains in all field studies. Occupancy models allow variables affecting both presence of animals (i.e., occupancy) and the ability to detect animals when they are present (i.e., detection) to be modelled simultaneously to estimate true occupancy from sampled data (MacKenzie et al. 2006). Repeated sampling (i.e., four transects) within each survey block allowed for site specific variability in detection to be estimated, while surveying multiple blocks allowed for factors affecting species presence across the road alignment to be estimated and extrapolated to parts of the road that were not surveyed.

Occupancy models were based on a zero-inflated binomial model containing an occupancy state component and a detection component (MacKenzie et al. 2006, Royle and Dorazio 2008). Covariates of both occupancy and detection were modelled using the logit link function (MacKenzie et al. 2006, Royle and Dorazio 2008).

A set of models were defined *a priori* based on factors shown to be important for mountain caribou in Polfus et al. (2013). The *a priori* model set was defined to represent the decreasing hierarchy of site information from sampling design strata, to calculated HSI scores, to covariates used to build the HSI models. Akaike's Information Criterion (AIC) was used to assess the best fit among these models; AIC is a statistical metric that represents the difference between a modelled estimation and the true state. The model with the lowest AIC among the set of candidate models is thought to be the closest representation of a theoretical true model, or the top model (Burnham and Anderson, 2008). Under an AIC framework, *p* values are not examined to determine statistical significance. Instead, the weight of evidence for tested models is examined to find the best representation of the data. Models within four AIC points are considered equally likely representations of the data. All *a priori* models were compared to a null model, containing only the mean of the response and no detection covariates, to determine if any covariates describe the variation in occupancy better than the mean (Anderson 2008).

Data were analyzed using the unmarked package in the R programming statistical environment (R Core Team 2012, Fiske and Chandler 2011).

3.4.2 Model covariates

Detection Process

Scat decay rates, land cover type, and seasonal changes in ground cover can all influence whether scat is detected during sampling (Theuerkauf et al. 2008). The land cover types in the study area include alpine shrub, alpine tundra, lodgepole pine/lichen, krummholz, low valley willow, mixed wood, burned pine, spruce/fir, rock/talus, water edges, and the existing road alignment. The greatest difference in detectability based on ground cover is expected for sites that are on the existing road alignment, compared to sites that have some level of ground cover. The ground cover may include scrub birch (*Betula glandulosa*), mountain heather (*Cassiope* spp.), crowberry (*Empetrum nigrum*), and *Cladina* and *Cladonia* lichen species, while the existing road alignment is hard packed gravel. The total length of each land cover type occurring in each transect was summed and transects were assigned to either an 'on road' or an 'off road' category based on the coverage in the majority of the transect. Models were run with and without the detection covariate.

Occupancy State

The strata defined in the sampling design to inform the division of sampling effort was included as a categorical covariate in occupancy models, with the high category as the reference category. The strata compile multiple factors known to influence presence of caribou in northwest British Columbia (Polfus et al. 2014).

The area of HSI categories in each block was also included as a covariate to better represent the heterogeneity in suitability within survey blocks. Models were run that included the area of high, high and medium, or only low HSI category to assess both selection (positive relationship with the area of high or high and medium HSI category) and avoidance (negative relationship with the area of low HSI category).

Finally, the variables used to calculate the HSI (i.e., land cover, aspect, and elevation) were included as model covariates. High elevation areas, with an aspect between northwest to southeast in a clockwise direction, in alpine tundra, alpine shrub, krummholtz, or rock land cover types were graded higher on the HSI scale than other areas. Univariate models were run to determine whether categorical variables (e.g., whether the maximum area of the block is above or below an elevation of 1150 m) or continuous variables (e.g., area of the block that is below 1150 m elevation) best fit the data. Multivariate models were then run combining all three variables and bivariate combinations.

3.4.3 Occupancy Prediction

To estimate the probability of caribou occupancy along the entire length of the road, the final model equation was calculated for all blocks in the study area.

4.0 RESULTS

4.1 Sampling

A total of 139 transects were sampled in 35 blocks across the study area, between September 16 and September 21, 2014 (Table 1, Figure 2).

Table 1: Distribution of Sampling Effort along the Proposed Prairie Creek Mine All-Season Road

Strata	Total Blocks in Stratum	Blocks Surveyed	Proportion of Blocks Surveyed
High	17	16	0.94
Moderate	23	11	0.48
Low	34	8	0.24
Total	74	35	0.47

Caribou or caribou sign were detected in 20% of sampled blocks (Table 2, Figure 3). Dall's sheep, grizzly bear, grey wolf, moose and bear sign was also detected during surveys, with moose being the most abundant species detected (Table 2).

Table 2: Species Detections during Sign Surveys Conducted Along the Proposed Prairie Creek Mine All-Season Road

Species	Number of Blocks with Detections	Occurrence Rate by Block	Number of Transects with Detections
Caribou	7	0.20	8
Bear species	2	0.11	4
Dall's sheep	3	0.09	3
Grey wolf	6	0.17	6
Moose	26	0.74	65

4.2 Modelling

The area of continuous covariates used in occupancy models ranged from 0 to 300 ha (i.e., from the feature not occurring in the block, to the feature covering the entire block) (Table 3). Low valley willow and the 'other' land cover category, which included willow communities not found in low elevation valleys, did not cover the maximum areal extent of any sampling blocks (Table 3).

Table 3: Summary of Continuous and Categorical Covariates Used to Estimate Probability of Caribou Occupancy along the Proposed Prairie Creek Mine All-Season Road

Covariate	Levels	Area within block			Number of Blocks with Level as the Max Area
		Min Area (ha)	Max Area (ha)	Mean Area (ha)	
Strata	Low HSI	0	300	104.6	16
	Moderate HSI	0	289.4	103.8	11
	High HSI	0	225.1	91.6	8
Aspect	Aspect between SE and NW in a clockwise direction	3.2	237.2	123.3	25
	Aspect NW and SE in a clockwise direction	62.8	296.9	176.7	10
Elevation	Above 1150 m	0	300	105.8	13
	Below 1150 m	0	300	194.2	22
Land Cover	Alpine tundra	0	209.6	67.1	6
	Conifer	0	259.8	63.3	10
	Deciduous	0	151.6	10.6	1
	Krummholz/ alpine Shrub	0	221.2	45.2	6
	Low valley willow	0	45.2	3.8	-
	Lodgepole pine/lichen	0	250.4	36.8	4
	Other	0	122.5	14.1	-
	Rock/talus	0	197.3	57.9	8
	Water	0	21.8	1.2	-
Detection	Majority of transect not on road	-	-	-	127
	Majority of transect on road	-	-	-	12

The distribution of land cover areas was strongly skewed for all land cover types; however, low valley willow, and deciduous land cover types were only present over small areas within the blocks, rarely covered more than half of the blocks and were thus excluded from models.

The *a priori* model set contained 23 models (Table 4).

Table 4: Occupancy Models Tested to Explain the Probability of Caribou Occupancy along the Proposed Prairie Creek Mine All-Season Road

Model Group	Detection Model	Occupancy Model	Description
Null	1	1	Null
Detection	road	1	majority of the transect on or off the gravel road
Strata	1	strata	strata categories
	road	strata	strata categories
	road	high	area of high HSI category in block
	road	high and medium	area of high and medium HSI category in block
	road	**low**	**area of low HSI category in block**
	1	low	area of low HSI category in block
Aspect	road	maximum aspect by area	aspect category covering the most area of the block
	1	aspect SE - NW (clockwise)	area of block between southeast to northwest (clockwise) aspect
	road	**aspect SE - NW (clockwise)**	**area of block between southeast to northwest (clockwise) aspect**
Elevation	**road**	**maximum elevation by area**	**elevation category covering the most area of the block**
	1	maximum elevation by area	elevation category covering the most area of the block
Land cover	road	maximum cover by area	land cover category covering the most area of the block
	1	maximum cover by area	land cover category covering the most area of the block
	road	alpine tundra	area of alpine tundra in the block
	road	conifer	area of conifer in the block
	road	lodgepole pine/lichen	area of lodgepole pine/lichen in the block
	road	**krummholz alpine shrub**	**area of krummholz/alpine shrub in the block**
	1	area of krummholz alpine shrub	area of krummholz/alpine shrub in the block
Combinations	1	land cover + aspect	top land cover and aspect variables
	road	land cover + aspect	top land cover and aspect variables
	1	land cover + aspect + elevation	top land cover, aspect and elevation variables
	road	land cover + aspect + elevation	top land cover, aspect and elevation variables

Note: Bolded models indicate the top model in each model group

The top model in all model groups included the detection covariate (Table 4). There was roughly equal support for a final combined model without (47% chance it is the top model) and with (25% chance it is the top model) the detection covariate (Table 5). Typically, models within 4 AIC points of each other are considered equally likely (Anderson 2008). Adding an elevation parameter to the top model increases the AIC by exactly 2 points, which is the penalization for each additional parameter under an AIC framework. The 2 point change in AIC and the lack of change in the coefficient of determination (Rsq) between these two models means the elevation covariate did not explain any additional variation in the data, once aspect, land cover, and detection were included.

Table 5: AIC Summary Table

Model	nPars[a]	AIC[b]	delta[c]	AICwt[d]	cumltvWt[e]	Rsq[f]
Land cover + aspect	4	45.6	0.0	4.7E-01	0.47	0.6
Land cover + aspect + detection	**5**	**46.9**	**1.3**	**2.5E-01**	**0.72**	**0.6**
Land cover + aspect + elevation	5	47.6	2.0	1.7E-01	0.9	0.6
Land cover + aspect + elevation + detection	6	48.9	3.3	9.2E-02	0.99	0.6
Land cover + detection	4	54.9	9.2	4.7E-03	0.99	0.4
Aspect + detection	4	55.5	9.9	3.4E-03	1.0	0.4
Land cover	3	56.9	11.3	1.7E-03	1.0	0.3
Aspect	3	58.0	12.4	9.7E-04	1.0	0.3
Area of low strata + detection	4	60.7	15.0	2.6E-04	1.0	0.3
Detection	3	61.7	16.0	1.6E-04	1.0	0.2
Strata + detection	5	62.7	17.0	9.5E-05	1.0	0.3
Area of low strata	3	62.9	17.2	8.5E-05	1.0	0.1
Elevation + detection	4	63.6	18.0.	6.0E-05	1.0	0.2
Strata	4	64.8	19.2	3.2E-05	1.0	0.1
Null	2	65.0	19.3	2.9E-05	1.0	0.0
Elevation	3	65.6	20.0	2.2E-05	1.0	0.1

[a] number of parameters
[b] Akaikie Information Criterion
[c] change in AIC between the given model and the first model listed
[d] weight of evidence that the model is the best of the set of models
[e] cumulative weight of evidence
[f] coefficient of determination, which expresses the proportion of variance in the dependent variable that is 'explained' by the independent variable
Note: the bolded model indicates the top model overall

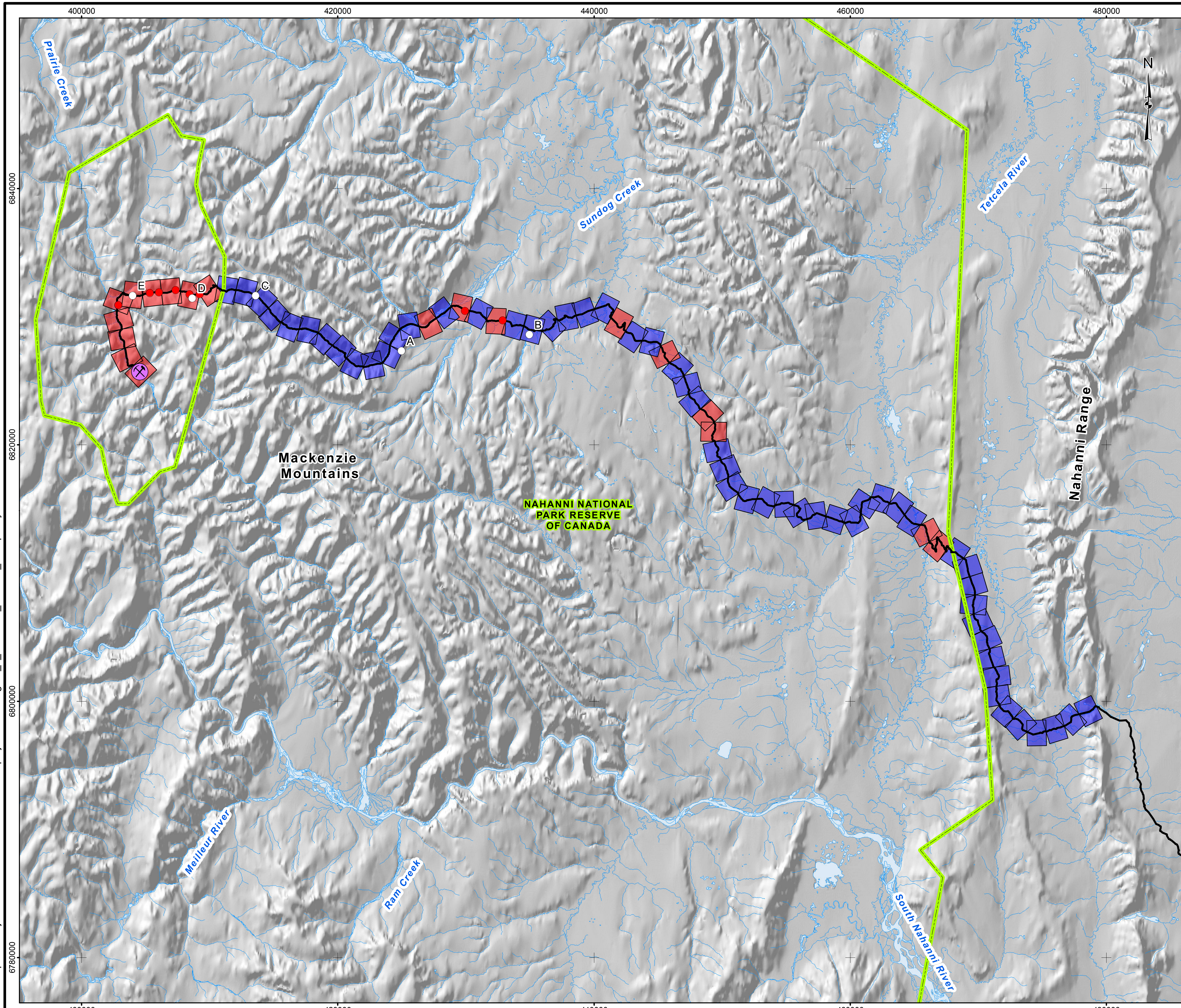
The model used to gain inference across the un-sampled portion of the road included the detection covariate, a continuous covariate for aspect, and the area of krummholz/alpine shrub within the block (Table 6).

Table 6: Final Model Estimates

Model Component	Parameter	Estimate	SE[b]	z[c]	p[d]
Occupancy	Intercept	-73.7	141.2	-0.5	0.6
	Area of block with krummholz/alpine shrub	0.3	0.8	0.4	0.7
	Area of block with aspect SE - NW (clockwise)	0.4	0.7	0.5	0.6
Detection	Intercept	-1.4	0.5	-2.9	0.0
	Transect on the road	0.7	0.9	0.9	0.4

[a] estimated relationship between occupancy and parameter
[b] standard error
[c] test statistic
[d] p-value

Model predictions along the Road were very near 1 or 0 (i.e., occupied or unoccupied), resulting in a dichotomous prediction surface (Figure 3). Overall, 26% of the study area is predicted to be occupied. Caribou occupancy is predicted for the western portion of the road, up to km 10, and for portions of the Sundog Creek drainage, portions of the Ram Plateau, and the Silent Hills (Figure 3).



LEGEND

CARIBOU DETECTION
- INCIDENTAL*
- TRANSECT
- PRAIRIE CREEK MINE
- PRAIRIE CREEK MINE ALL-SEASON ROAD ALIGNMENT
- PARK BOUNDARY
- WATERCOURSE
- WATERBODY
- SAMPLE BLOCK

PREDICTED OCCUPANCY
- 0.0 - 0.1
- 0.9 - 1.0

NOTE

*REFER TO TABLE 7 FOR THE DESCRIPTION OF INCIDENTAL SIGHTINGS.

REFERENCE

WATER FEATURES OBTAINED FROM CANVEC © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
DIGITAL ELEVATION MODEL OBTAINED FROM GEOBASE®.
DATUM: NAD83 PROJECTION: UTM ZONE 10

6 0 6
SCALE 1:300,000 KILOMETRES

PROJECT
CANADIAN ZINC CORPORATION
PRAIRIE CREEK MINE
NORTHWEST TERRITORIES

TITLE
ESTIMATE OF CARIBOU OCCUPANCY IN EACH SAMPLE UNIT IN THE PRAIRIE CREEK MINE ALL-SEASON ROAD ALIGNMENT STUDY AREA

Golder Associates

PROJECT		09-1422-5007	FILE No.	
DESIGN	KD	03 Dec. 2014	SCALE AS SHOWN	REV. 0
GIS	CDB	03 Dec. 2014		
CHECK	KD	04 Dec. 2014	**FIGURE: 3**	
REVIEW	MJ	23 Dec. 2014		

N:\Bur-Graphics\Projects\2009\1422\09-1422-5007\GIS\projects\2014\Figure_3_Predicted_Caribou_Occupancy.mxd

4.3 Incidental Observations

Additional wildlife sightings recorded during sign surveys are listed in Table 7. Incidental sightings provide a qualitative test of model predictions because they are independent of sightings recorded within the study design. Three of the five incidental sightings of caribou were in areas predicted to have low probability of occupancy (Figure 3) but proximal to areas predicted to have high probability of occupancy.

Table 7: Incidentals Sightings Recorded along the Proposed Prairie Creek Mine All-Season Road

Figure Code	Species	Observation Type	# Observed	UTM	
				Easting	Northing
A	Caribou	Visual	3	424980	6827333
B	Caribou	Bones	1 skull	434966	6828597
-	Bear (possibly grizzly)	Tracks	1	413606	6831634
C	Caribou	Tracks	2	413606	6831634
-	Dall's sheep	Scat	2	410061	6832013
D	Caribou	Tracks	1	408654	6831431
E	Caribou	Scat	1 (clumped, old)	403999	6831646

5.0 DISCUSSION

Based on the results of this sign survey, the areas with the highest likelihood of caribou use during the non-winter period are the Mackenzie Mountains near the Mine site, the lower Sundog Creek drainage, west of the Ram Plateau, and Silent Hills. Previous wildlife surveys conducted as part of the Mine permitting process indicated that caribou inhabit the lands surrounding the Mine and winter road alignment (CZN 2014); however, little information existed on the extent of caribou distribution and area of occupancy along the proposed Road alignment, particularly during the non-winter period. This occupancy survey was designed to collect caribou occurrence data over a large area in a relatively short period of time. This survey technique identified not only the extent of caribou distribution along the proposed Road, but also core areas of occupation, in addition to providing a probability of occurrence for each sampling unit.

The study area covers a landscape with mountainous terrain in the west, and lowlands in the east and caribou occupancy largely follows this separation. Caribou are predicted to occupy sampling blocks with higher area of krummholz/alpine shrub landcover, and higher amounts of area with an average southwestern exposure (an aspect between southeast and northwest in a clockwise direction). Detection of caribou was higher for sampling on the existing road bed. The existing road bed is sparsely vegetated in the mountainous region and thus, the detection covariate condition of 'on road' was only available in the western part of the study area. This does not bias the estimates however, as the occupancy model framework allows the estimated detection correction to be applied to the rest of the study area (MacKenzie et al. 2006). Krummholz/alpine shrub habitat was also more abundant in the western portion of the study area, with conifer species dominating the low lying areas in the lower Sundog Creek and Tetcela River regions (Figure 3). While this leads predominantly to prediction of caribou occupancy for the western region of the road, small areas of high probability of occupancy are predicted in elevated terrain east of the Mackenzie Mountains as well. Based on the landscape, it is likely that these areas represent movement corridors along ridges oriented north-south.

The summer caribou HSI model of Polfus et al. (2013) did not fit the data in the study area as well as individual covariates, which may be due to variability in habitat selection among caribou herds and variability in landscape characteristics (e.g., the orientation of the mountains). While the Polfus et al. (2013) HSI graded aspects between northwest to southeast in a clockwise direction as higher suitability for caribou, our model with the individual covariates found selection for the opposite aspect. As a result, we predicted high probability of occupancy in some blocks ranked as low HSI (Figure 2, Figure 3).

Incidental sightings can be helpful as qualitative checks of model prediction, provided caution is applied. Incidentals marked A to C in Table 7 and Figure 3 were detected in areas predicted to have low probability of caribou occupancy. The first incidental (A) was a visual of 3 caribou detected along the ridge tops while flying from the mine site. Because the GPS coordinates were taken from a moving helicopter, they contain location error. It is useful to recognize, however, that caribou present on the ridge above the road do have potential to interact with the road if they move into the valley bottom, although steeper slopes tend to be avoided (Jones et al. 2006). The area surrounding the road alignment may be suitable for caribou, even if the region on the alignment itself is not. Investigating this further would require a broader scale field design that was beyond the scope of this work.

The second incidental (B) was a caribou skull. This may be from the winter season as, unlike tracks and pellets, it would persist on the landscape across seasons. Winter caribou surveys conducted for Parks Canada in this region showed a similar pattern of occupancy across the study area, with detections on both the north and south sides of the road alignment in the Sundog Creek region (Golder 2014).

Finally, the third incidental (C) is a set of tracks that were confirmed to be caribou, indicating some uncertainty in occupancy predictions. There is uncertainty associated with any model and it is important to consider this during interpretation. The road goes through a steep valley in the MacKenzie Mountains, such that caribou would have to move over steep terrain to move north-south through this area. While this is possible, it is also likely that they would move along the valley bottom, suggesting that some caribou presence may be expected throughout that area. Similarly, sample blocks are only 1.5 km wide, and thus, caribou may also be expected to be present in the region around blocks with higher predicted occupancy, to some extent.

6.0 CLOSURE

We trust that this report and the attachments are sufficient for your present requirements. If you have any questions, please do not hesitate to contact the undersigned at 604-296-4200.

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