Dominion Diamond Ekati Corporation

EKATI DIAMOND MINE
2012 WEMP Addendum
Wildlife Camera Monitoring Summary Report

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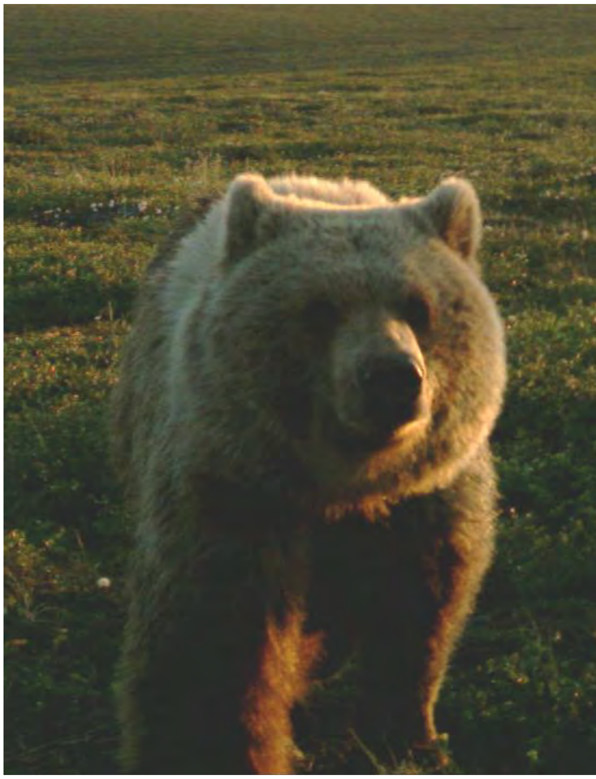

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EKATI DIAMOND MINE

2012 WEMP ADDENDUM WILDLIFE CAMERA MONITORING SUMMARY REPORT

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Executive Summary

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Executive Summary

Monitoring caribou is a priority at the Ekati mine site, and is a significant component of the Wildlife Effects Monitoring Program (WEMP). Camera based monitoring of caribou was initiated in 2011 with the deployment of 50 cameras around the mine site, and continued in 2012 with the purchase of 40 additional cameras. Data on caribou numbers, movements, and behaviours were collected from 76 cameras that were placed around Project infrastructure such as roads and impermanent fencing. The primary objectives for the 2012 camera monitoring program were to:

1. Determine and compare temporal trends in caribou abundance around the Ekati mine site;
2. Determine and compare which locations has the highest numbers of caribou, and which may be avoided;
3. Determine and compare relative frequencies of behaviours in caribou among locations;
4. Determine if the structure of tundra roads deters caribou from crossing;
5. Determine if alert behaviours near the road are associated with traffic; and
6. Determine if plastic fencing causes adverse behavioural reactions.

The data from 2012 show several key results:

A. The highest encounter rates at locations monitored around the Ekati Project occurred in August and October.

B. Significantly lower encounter rates of caribou occurred in association with Misery Road during the August and October high season, compared to encounter rates at other monitored locations. This trend persisted when data were sub-divided into different group sizes and times of day and compared among locations. The highest encounter rates were seen at Sable Road in August and at Pigeon Stream Diversion (PSD) Access Road and Pigeon Fence in October.

C. Rates of six behaviours differed significantly among monitored locations, which may provide insight into how caribou are using different locations to meet different life history requisites. Foraging, walking on/along road, crossing, and stopping behaviours were all highest at Sable Road, and were lowest at Misery Road. Walking, on the other hand, was highest at the PSD Access Road and Pigeon Fence, but still lowest and Misery Road.

D. Deflections occurred, but infrequently. Of the caribou that attempted to approach or interact with roads, approximately 7.9% (19/242) displayed an adverse reaction (deflection or running from road) as opposed to a positive reaction (climbing onto or crossing the road).

E. Several behaviours were observed in response to fences that may warrant more study. Caribou adults deflected from, or jumped over, fences, the latter of which could result in tripping and leg injury. Cows and calves were also occasionally separated by fences, which could increase the susceptibility of separated calves to predation and herd disorganization.

Table of Contents

EKATI DIAMOND MINE
2012 WEMP ADDENDUM WILDLIFE CAMERA MONITORING SUMMARY REPORT

Table of Contents

List of Figures

List of Tables

List of Plates

1. Introduction

1. Introduction

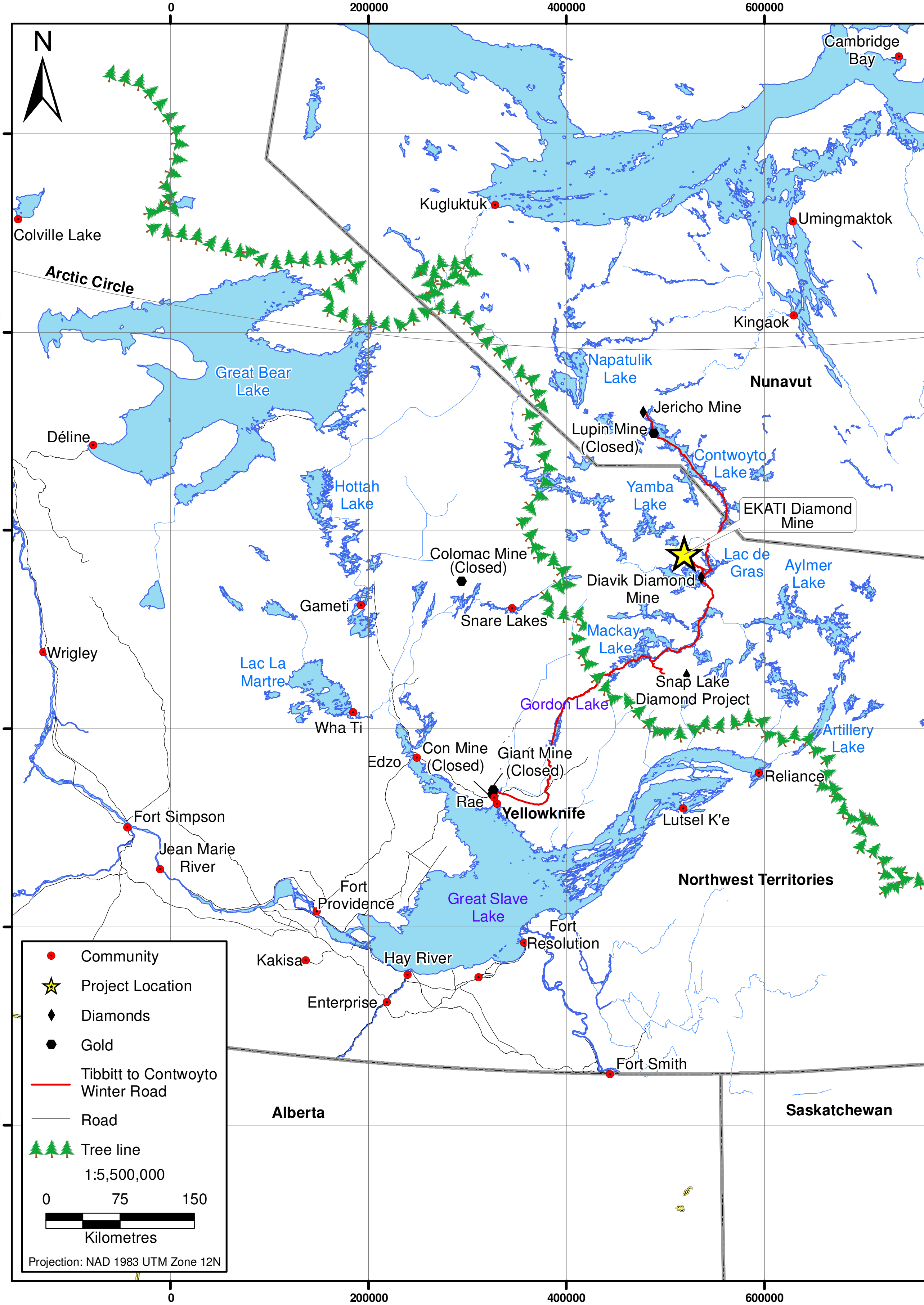
1.1 EKATI DIAMOND MINE

The Ekati Diamond Mine (Ekati), currently owned and operated by Dominion Diamond Corporation (DDC), is located in the Southern Arctic Ecozone of the Northwest Territories, approximately 300 km northeast of Yellowknife between Yamba Lake and Lac De Gras (Figure 1.1-1). Construction of Ekati began in 1997 and officially opened in October, 1998. In 2012, Ekati had two operational pits throughout the year (Fox and Misery Pits), and two operational underground mines (Koala Underground, and Koala North Underground) (Figure 1.1-2).

Several roads have been constructed at Ekati. The longest is the Misery Road that connects Main Camp to Misery Camp located approximately 26 km to the southeast. Misery Road is an all-season haul road constructed of gravel crush with berms of varying heights and rock composition. Construction of Misery Camp was completed in 2012 to support 115 on-site personnel in preparation for renewed development of Misery Pit, which started with stripping in 2011. As a result, traffic along Misery Road is expected to increase substantially during the operation of Misery Pit as ore rock will be hauled to Main Camp for processing. Northern communities have expressed concern that Misery Road may impact caribou safety and movement patterns, and these effects may increase with the anticipated future vehicle traffic along the road to service Misery Camp and Pit.

The monitoring of roads (and other mine infrastructure) is a significant component of the WEMP because they are generally considered the primary mechanisms for potential direct impacts to wildlife via vehicle collisions and as barriers to movement. Roads may act as potential deterrents or attractants for wildlife (Trombulak and Frissell 2000). Wildlife behavior relative to roads varies between species and within species such that certain populations, age groups, genders, or individuals react either positively or negatively to roads (Stuart-Smith and James 1996). The list of effects of roads is extensive, but one of the major effects involves a change in wildlife movement patterns. In some cases, movement patterns change as a result of wildlife avoiding roads (Klein 1991), while in other cases, wildlife use roads as travel corridors, refuge habitat, or food sources (Forman and Alexander 1998).

Several monitoring programs have been implemented as part of Ekati's Wildlife Effects Monitoring Program (WEMP) to address concerns about road impacts, including road side surveys and snow track surveys, with varying degrees of success. The WEMP is a monitoring requirement of the original Environmental Agreement (Articles V and VII) and the Wildlife Effects Monitoring Plan. The WEMP was developed through extensive consultation with stakeholders, including regulators, scientists, and Aboriginal people, and has been conducted since 1997. The WEMP focuses on wildlife species and habitats that were identified during the Environmental Assessment Review Process (EARP) (the regulatory regime that preceded *The MacKenzie Valley Resource Management Act* of 1998) as being of social or economic importance or of particular ecological or conservation concern (i.e., Valued Ecosystem Components [VECs]). The WEMP uses scientific methodology and traditional knowledge as a source of information regarding wildlife and local ecology.



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Location of the EKATI Diamond Mine, Northwest Territories

Figure 1.1-1

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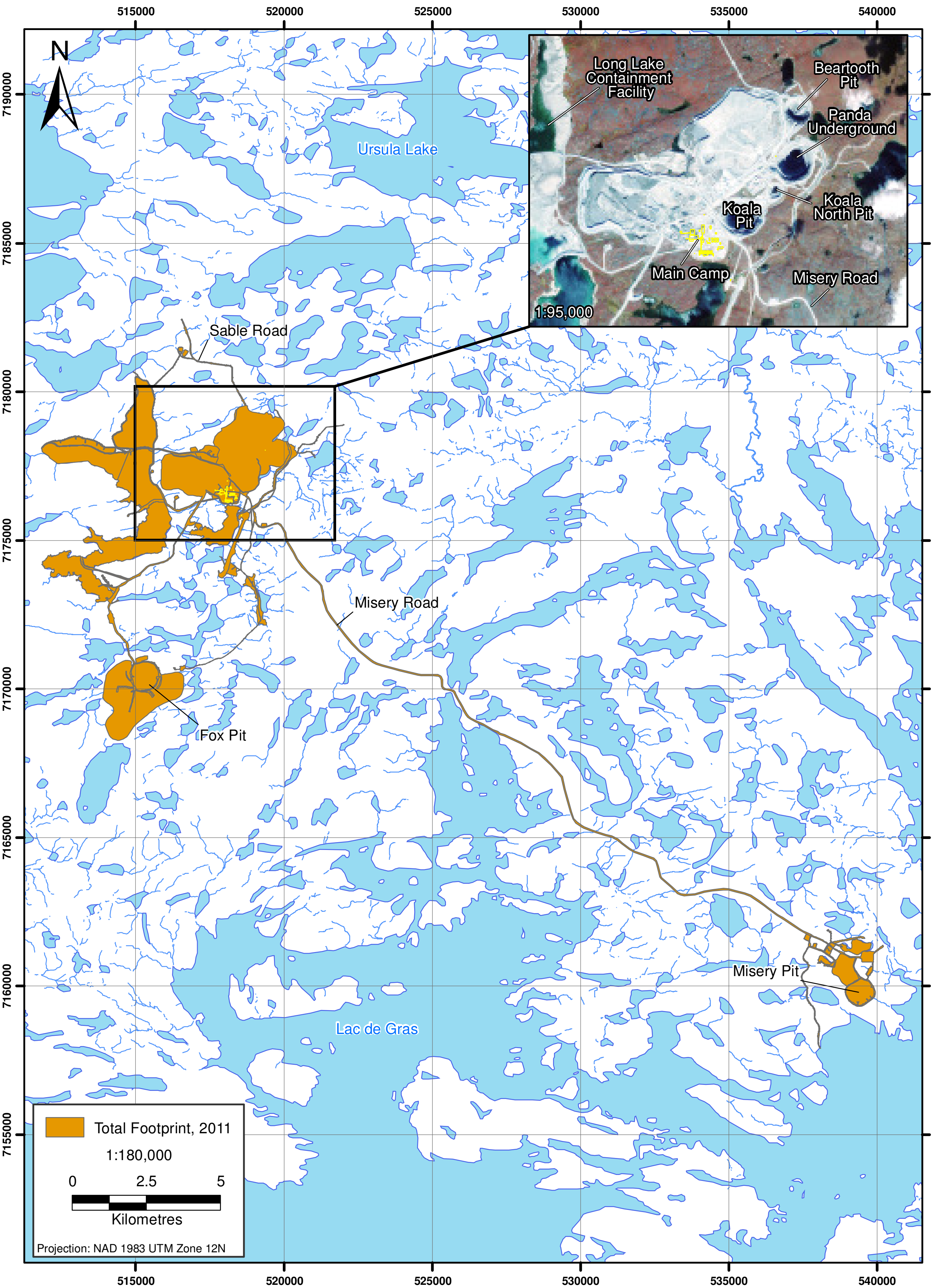

Figure 1.1-2

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EKATI Site Map

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1.2 CARIBOU AND EKATI

Caribou were identified as a Valued Ecosystem Component (VEC) in the Ekati study area through consultation with government, aboriginal groups, and other stakeholders (BHP Billiton 1995). Information from satellite collared cows collected by the Government of the Northwest Territories – Department of Environment and Natural Resources (ENR) indicates that both the Bathurst herd, and to a lesser extent the Ahiak herd, have seasonal home ranges that overlap with the Ekati claim block. The most recent survey, conducted in June 2012, estimated the Bathurst herd to be approximately 35,000 individuals (J. Adamczewski, ENR, pers. comm.). The last census for the Ahiak herd was in 1996 and estimated at approximately 200,000 individuals (ENR 2006). A census was planned in 2010, but was subsequently cancelled. Both traditional and scientific knowledge indicate that caribou herd size cycles relatively regularly with climate patterns (ENR 2006). Caribou herds also exhibit periodic changes in seasonal migration routes and in calving and winter ranges (Boulanger et al. 2004). During periods of decline and as migration patterns shift, potential risks associated with road encounters may pose additional pressures on caribou populations.

Caribou are important prey for Arctic carnivores, such as wolves and grizzly bears, and are an important food source for northern communities. During the spring, Bathurst barren-ground caribou migrate north (in April and May) from their wintering grounds below the treeline to calving grounds near Bathurst Inlet by early June, and disperse southward in late summer and autumn. Pregnant cows lead the northern migration to the calving grounds, followed by juveniles and bulls (Miller 2003). During summer months, they move extensively, often 500 km or more (Miller 2003). Caribou from the Bathurst herd are regularly observed around the Ekati mine site. Relatively few caribou are observed around the mine site during the northern migration period, and typically several hundred animals may be recorded during the post-calving and late summer period in July and August. By far the greatest numbers of caribou are typically recorded during the fall southern migration when over 15,000 animals may be observed in September and October.

1.3 CAMERA TRAPPING

Camera trapping of wildlife has a long history in ecological research (Cutler and Swann 1999), but over the past couple decades, camera traps have become much more readily available and affordable. The result has been a rapid and diverse growth in their application (Rowcliffe and Carbone 2008). Increasingly, wildlife cameras are being used to monitor wildlife activity around roads and other human infrastructure. Of particular interest has been monitoring the success of mitigation measures along roadways and other linear features that may act as barriers to wildlife movement. Crossing structures, such as overpasses and underpasses (or alternatively, caribou crossing ramps along Misery Road), are intended to enable wildlife to cross these linear features, minimizing habitat fragmentation and reducing the risk of vehicle collisions.

Cameras have been used effectively to monitor crossing structures along roads (Olsson et al. 2008; Braden et al. 2008) and pipelines and other oil and gas infrastructure (Dunne and Quinne 2009; Noel et al. 2006). Remote photography has replaced traditional methods of visual surveys, drive counts, radiotelemetry, and track counts (Silviera et al. 2003). Additionally, remote photography can be used year-round versus the limitations of snow-track methods (Bull et al. 1992), such as those used previously at Ekati. Cameras provide the distinct advantage of providing data 24 hours per day, and combined with 1-year battery life and memory storage that can accommodate over 30,000 photos, data collection opportunities increase significantly over traditional techniques with minimal human involvement.

1.4 CARIBOU MONITORING AT EKATI

While motion-trigger camera photography can provide information about a suite of VEC species, northern communities are particularly concerned about potential additional impacts to caribou in light of the significant population declines observed over the past couple decades (Adamczewski et al. 2009). The WEMP includes several monitoring programs specific to the Bathurst caribou herd as it moves through the Ekati study area to measure the potential effect of the mine on caribou. Ekati is committed to the ongoing evaluation of its wildlife programs to ensure those programs utilize the best information and techniques available to monitor and mitigate impacts to wildlife. Cameras are a potentially effective tool to monitor caribou at the Ekati mine site because they are resilient to a wide range of weather conditions, and therefore, can be deployed and programmed to capture changes in seasonal movement patterns of caribou (ie, April to October). Further, cameras can record information 24 hours per day, removing observer bias in data collection while recording substantially more observations.

This report presents the statistical results for the second year of the camera monitoring initiative at Ekati, which began in 2011 as a pilot project, and was fully executed in 2012. This program utilizes motion-triggered cameras to monitor caribou activity near Misery Road. The monitoring program also distributed some cameras along other roads and sites, including Sable Road, Pigeon Road, Pigeon Stream Diversion Access Road) Beartooth Fence, and Pigeon Fence, all of which could potentially influence caribou movement.

2. Objectives

2. Objectives

The overall objectives of the camera monitoring program are to:

- Determine temporal and seasonal trends in caribou abundance around the Ekati mine site;
- Determine which roads/locations monitored recorded the highest and fewest encounter rates of caribou;
- Determine the behavioural frequencies of caribou among locations;
- Explore if there are any patterns in road crossing behaviours;
- Determine whether tundra roads deter caribou from crossing, and if so, explore why;
- Explore potential behavioural impacts of plastic fencing on caribou; and
- Use data from 2012 to provide suggestions to improve the monitoring program and management of data for 2013.

3. Methods

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3. Methods

3.1 CAMERA DEPLOYMENT AND BEHAVIOURAL SCORING

In 2012, 90 infrared motion-triggered cameras (PC800 Hyperfire Professional Semi-Covert IR; ReconyxTM LLP, Holman, WI) were deployed around the Ekati mine site (Figure 3.1-1). The majority (55) were deployed along Misery Road, with additional cameras placed along Pigeon Road (8), Sable Road (5), and the Pigeon Stream Diversion Access Road (4). Cameras were also set up to monitor activity at Pigeon Fence (2) and Beartooth Fence (2), for a total of 76 cameras. The remaining 14 cameras were set at various other locations; however, discrepancies in programming precluded their use in statistical analyses. Instead, photos derived from the remaining 14 cameras were examined for incidental wildlife data. The distribution of cameras along Misery Road was determined by habitat, where fewer cameras were placed in areas where caribou activity was expected to be lower. Along Km 1-10, for example, where predominantly boulder fields are found adjacent to the road, cameras were placed approximately 500 m to 1 km apart and focused on areas where gaps may enable access to the road. Between Km 11 and 25, where adjacent habitat was primarily heath tundra, cameras were placed approximately 300 m apart to maximize opportunities to document caribou activity along the road.

Cameras were relatively well spread out, with a couple of areas with higher densities of camera in the northwest and southeast where camera numbers overlap the most.

Cameras were set to the highest sensitivity for the motion detection trigger. When triggered, cameras were programmed to take eight pictures at a rate of 1/s, with a 20 s delay between triggers. Additionally, a timed camera was scheduled to take a photo every 10 minutes. When data were entered, each photo event was labeled as either a motion triggered photo (M) or timed photo (T). These two types of data were treated differently in statistical analyses. Caribou were classified by sex (Male, Female or Unknown) and age (Adult, Yearling, or Unknown), and their behaviour was also recorded (Table 3.1-1).

Table 3.1-1. Caribou Coding Information Use for 2012 Camera Data

Caribou Behavioural Codes	Description
CC	Crossing/crossed
D	Deflected or deterred from path of motion
CW	Climbed and walked on or along road
WR	Walking near road
FR	Foraging near road
RER	Resting near road
ROR	Run off road
S	Stop and Stand
U	Unknown
IC	Investigated Camera
RAR	Run along road

(continued)

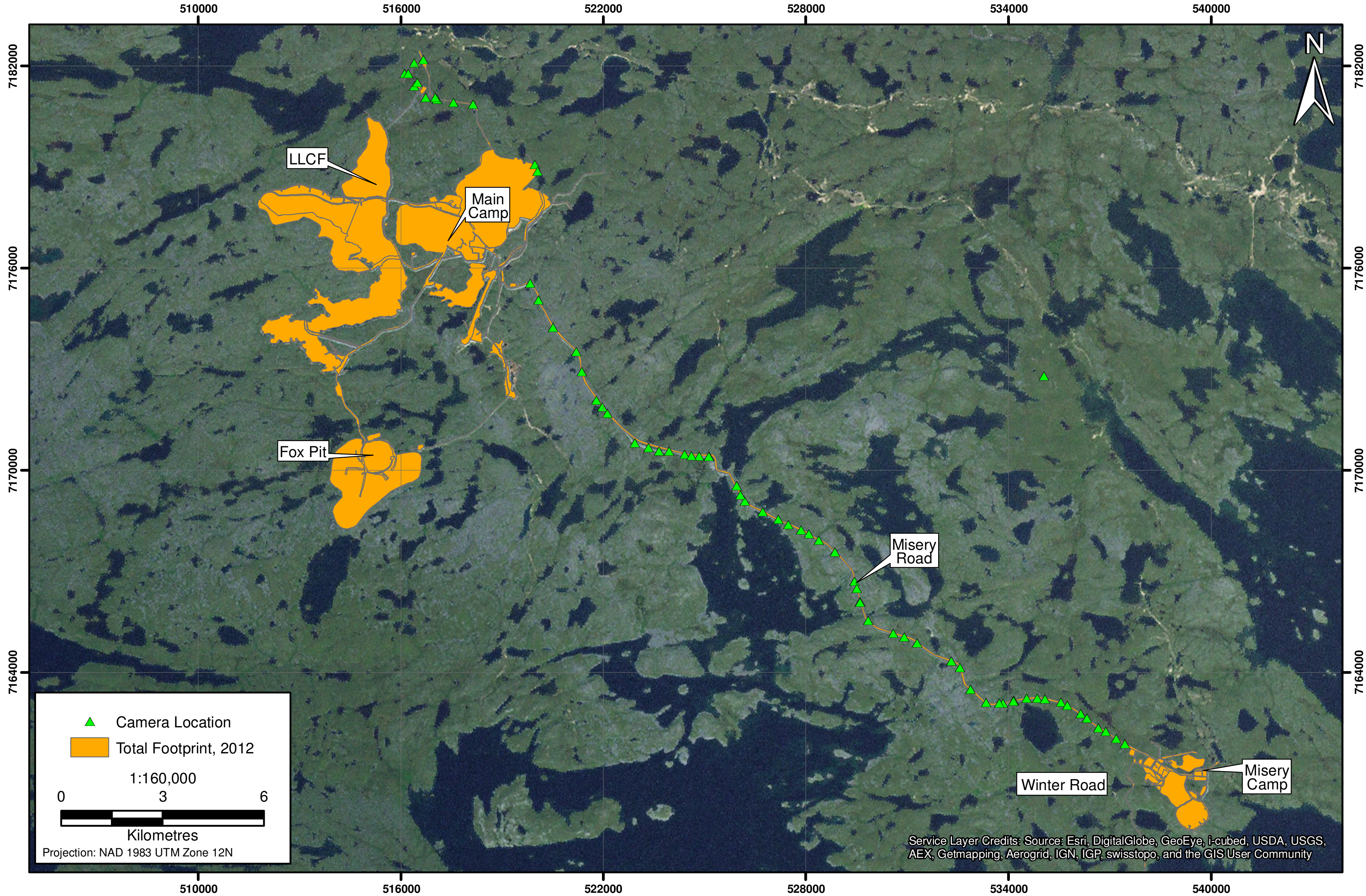
Table 3.1-1. Caribou Coding Information Use for 2012 Camera Data (completed)

Fence only Behaviours	**Description**
CO	Jumped over orange fence
SEP	Cow and Calf Separated by Fence
Sex	**Description**
M	Bulls
F	Cows
U	Unknown
Y	Yearlings/Calves
Alert Behaviour	**Description**
Y	Saw evidence of startle or stress (tail flick, head went up, quick run or change of direction)
N	No stress response obvious
U	Difficult to tell with visibility
Vehicle Present	**Description**
Y	seen in frame, or seconds before or after
N	Absence of detection of vehicle (not the same as absence, as some frames did not allow you to see much of the road/traffic)
Placement within Location Note: Pertains to the relative location of caribou of interest in the frame- could be a covariate, but might not need	
r	On road
rs	Roadside
rst	Roadside, but closer to open tundra
t	Far enough from road to be considered tundra
lt	Lake and tundra
rt	Road and tundra (for mixed herds with individuals on both)
t-f	Tundra at fence
lt-f	Lake tundra at fence

Note: The Codes FR and WR are still used for data entry at sites with no roads, or fences only. For these sites, these terms simply mean foraging or walking. In analyses, these are pulled apart by segregating between site types.

Each photo or photo series was examined, and the number of caribou belonging to each identifiable age and sex class were counted. In addition, the behaviour(s) of each individual in the photo was documented, and up to 3 behaviours were assigned per individual. Since caribou may not act independently when they are part of a group or herd, each member of a herd was given a group identification number that distinguished it as belonging to that herd. Therefore, data from a photo (or photo series) where more than one caribou is visible required entering data in multiple rows, where each row represented another animal in the photo (or group of animals that belong to the same age/sex class and are exhibiting the same behaviours), and the relationship between those animals is represented by their shared group ID number.

PROJECT #0194118 GIS # EKA-23-166 May 8, 2013



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Remote Camera Locations, 2012

Figure 3.1-1

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Figure 3.3-1

3.2 CAMERA EFFORT

After summarizing the frequencies of count data, the next step was to calculate camera effort among sites. Since differences in caribou numbers among locations could be due to variation in the amount of time that cameras were deployed among sites, all count data had to be adjusted by the camera effort. Setup and take down dates of all cameras used in the monitoring program were examined first for a general understanding of seasonal coverage (Figure 3.2-1). Cameras were primarily deployed between May and November; therefore, the results of this report necessarily focus on the summer and fall periods, and should not be extrapolated to other seasons.

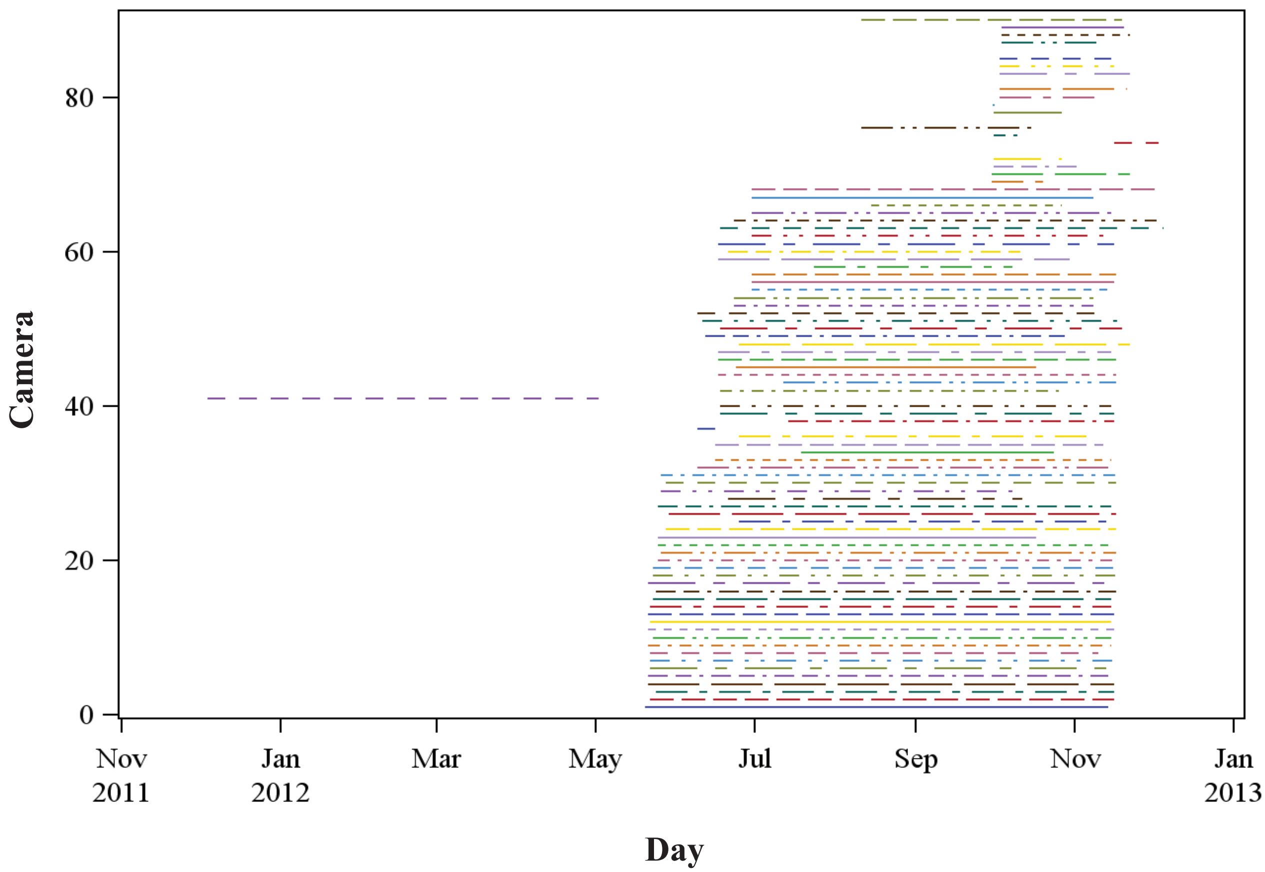
While these dates provide an idea of seasonal coverage, camera effort cannot be inferred based on start and stop dates alone, as not all cameras were operational for the entire period. To account for gaps in coverage, camera effort was calculated as the number of days per month that each camera was in operation. Camera effort by month was used to correct count data to standardize statistical comparisons between locations; therefore, parameters for comparison are expressed as rates (e.g., herds per day where day is a 24 hour period).

3.3 STATISTICAL ANALYSES

The GENMOD procedure in SAS 9.3 was used for most comparative analyses, while select tests used BioStat 2007 or SPSS 13. The GENMOD procedure fits generalized linear models. The class of generalized linear models is an extension of traditional linear models that allows the mean of a population to depend on a linear predictor through a nonlinear link function, and allows the response probability distribution to be any member of an exponential family of distributions. Many statistical models can be formulated as generalized linear models by the selection of an appropriate link function and response probability distribution. For statistical comparisons of caribou encounter rates conducted in this report, a Poisson distribution was used with a log link function and an offset term to account for camera effort. Poisson regression analyses are appropriate for modeling count and rate data, and the statistical programs used have a number of useful extensions. Statistical tests comparing behaviours, where a behaviour could be occurring or not (yes/no), were conducted using logistic (binomial) models with a log link function. Finally, a Fisher's Exact Test was used to examine the relationship between alert behaviours and traffic.

A Type 3 Likelihood Ratio (LR) Statistic was most often selected in the GENMOD procedure, which is similar to the Type III sums of squares used in PROC GLM, except that likelihood ratios are used instead of sums of squares. First, a Type III estimable function is defined for an effect of interest in the same way as in PROC GLM. Then maximum likelihood estimates are computed under the constraint that the Type III function of the parameters is equal to 0, by using constrained optimization. In a Type 3 analysis, PROC GENMOD produces a table that contains the likelihood ratio statistics, degrees of freedom, and *p*-values based on the limiting (LR Statistics for Type 3 Analysis) chi-square distributions for each effect in the model. The *p*-value was considered significant if it was ≤ 0.05 for that effect (e.g., location, month). Variations to these tests are done as appropriate.

In some cases, too few observations in certain locations, periods, or behavioural classes precluded statistical comparisons due to low statistical Power. In these cases, frequencies and anecdotal information are summarized. The results that follow in Section 4 summarize the highlights of all tests conducted. Details for all statistical tests upon which conclusions are based are available upon request.



Seasonal Coverage of Caribou Monitoring Cameras at the Ekati Site

Figure 3.2-1

4. Results and Discussion

4. Results and Discussion

A total of 6,399 caribou were detected and classified in the camera monitoring study during 2012. The majority of these caribou were not identified by age or sex class as they were difficult to distinguish in large herds (6,090 unknown, 87 females, 178 as males, and 42 yearlings/calves), during certain times of the year, and when caribou were far away; therefore, analyses do not compare between males, females, and young caribou. Section 4.1 summarizes and compares trends in caribou distribution by location, season, and time of day. Section 4.2 summarizes and compares trends in caribou behaviours among locations, and in response to roads and fences.

4.1 CARIBOU POPULATION ANALYSIS

These analyses dealt with caribou herds, or groups, as single units in months when caribou numbers were sufficiently large to enable statistical comparisons. Caribou were assigned to the same group if they occurred in the same photograph or series of photographs. These analyses focused on the number of groups moving through particular locations at particular times (e.g., during migration). It was important to analyze data using herd or group as the sample unit rather than individual caribou, because caribou do not move independently when part of a group. Herd data were adjusted for camera effort and separated by period and location to examine when and where encounter rates (i.e., herds per day) were the highest and lowest. For some models, only 1 location level was recorded, and as a result, no statistical test could be conducted. The detailed statistical results can be found in the respective appendices for each subsection.

4.1.1 Encounter Rates among Months

Average daily encounter rates were compared by month (Table 4.1-1). Across sites, encounter rates were highest in August, followed by October. In August, the highest encounter rates occurred near Sable Road and Pigeon Fence, while rates were lowest at Misery road. In October, the highest encounter rates occurred near Pigeon Fence, the PSD Access Road, and Pigeon road, and the lowest encounter rates were again at Misery Road. Statistical comparisons were restricted to August and October, as there were not enough data from the other months.

Table 4.1-1. Average Monthly Encounter Rates (herds/day) by Location, Adjusted by Camera Effort

	Month									
Location	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Beartooth Fence										
Misery Road	0	0	0.009	0	0.001	0.011	0	0.012	0	.
PSD Access Road	.	.	.	0	0	0.321	0	0.075	0	.
Pigeon Fence	.	.	.	0	0	0.597	0	0.081	0	.
Pigeon Road	.	.	.	.	.	.	.	0.056	0	.
Sable Road	.	.	.	0	0	0.832	0.007	0.021	0	.

Numbers reflect herds per day

4.1.2 Encounter Rates among Locations

A Poisson regression model using a log link function was used to model encounter rate (response variable) as a function of location (explanatory variable) in August and October. The model included an offset term to adjust for herd size and camera effort. A statistically significant result from this test shows that the encounter rate of herds passing through the area varies by location (*August:* Chi-Squared=578.48, DF=4, P<0.0001; *October:* Chi-Squared=46.51, DF=5, P<0.0001) (Figure 4.1-1). Overall, when adjusted by camera effort, encounter rates were consistently lowest at Misery Road in both August and October. Encounter rates were the highest at Sable Road and Pigeon fence in August, and at Beartooth fence and Pigeon fence in October. These results are not unexpected given habitat and terrain features surrounding these sites. To the west and south of Ekati main camp, and including approximately the first 10 km of Misery Road, extensive boulder fields may limit caribou detections in these areas or concentrate these detections in areas where gaps exist that enable movement through these areas. To the north and northeast, where the Pigeon Road, PSD Access Road, and Sable Road are located, extensive areas of heath tundra and upland meadows provide opportunities for foraging and ease of travel. Traditional knowledge further indicates that a migration route occurs along the north side of camp where caribou will typically travel near the Sable culvert and down to the shores of Fay Bay, north of the Long Lake Containment Facility (LLCF).

4.1.3 Encounter Rates by Locations and Herd Size

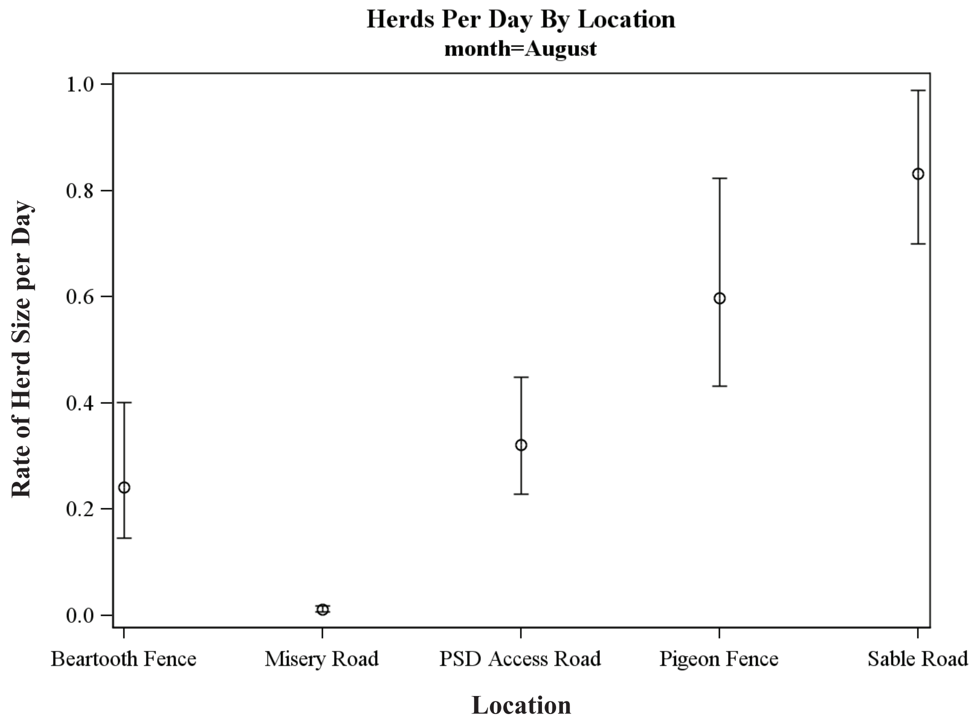
As Misery road had significantly lower caribou encounter rates, the analysis was refined to account for differences in herd size. For instance, even if a site has a low encounter rate (few herds per day), it is possible that those herds are larger, potentially influencing conclusions about caribou distribution around the mine site (i.e., several small groups in one area versus few large groups in another). The purpose of this analysis was to test if encounter rates at different locations varied by group size. Quantile analysis determined the main group sizes that should be used in this comparison. Poisson regression models using log link functions were used to model encounter rates of herds of different sizes (response variable) by location (explanatory) in August and October. An offset term was included to adjust for camera effort. For many of the group sizes, encounter rates differed significantly among locations (Table 4.1-2).

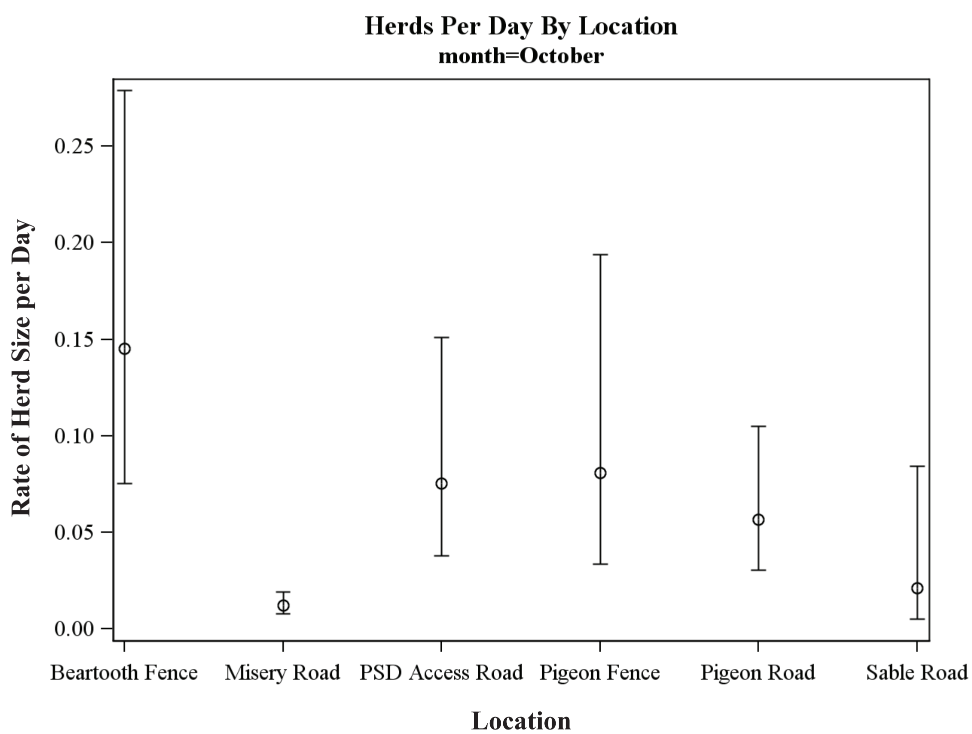
Table 4.1-2. Type 3 LR Statistics that Test Whether Encounter Rates by Herd Size Varies by Location

Month	
August	**October**
* **Size 1**: Chi-squared=615.27, DF=4, Pr=0.0001	**Size 1:** Chi-squared=6.99, DF=3, Pr=0.0722
* **Size 2**: Chi-squared=241.03, DF=4, Pr=0.0001	**Size 2**: No test done
* **Size 3-5**: Chi-squared=258.48, DF=4, Pr=0.0001	* **Size 3-5**: Chi-squared=12.23, DF=3, Pr=0.0066
* **Size 6-22**: Chi-squared=124.04, DF=4, Pr=0.0001	* **Size 6-22:** Chi-squared=14.26, DF=4, Pr=0.0065
* **Size 23+:** No test done	* **Size 23+:** Chi-squared=28.75, DF=5, Pr=0.0001

** Indicates a statistically significant result.*

Across herd sizes, there were significantly fewer encounters of caribou along Misery Road relative to the other locations (Figures 4.1-2a and b) in both August and October. Causes of lower encounter rates at Misery Road may be partially due to habitat, but it may also in part be due to increased use of the road by vehicles associated with construction and operations at Misery Camp and Pit during 2012. The influence of traffic type and volume requires further testing.





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Average Encounter Rate by Location, Adjusted by Camera Effort

Figure 4.1-1

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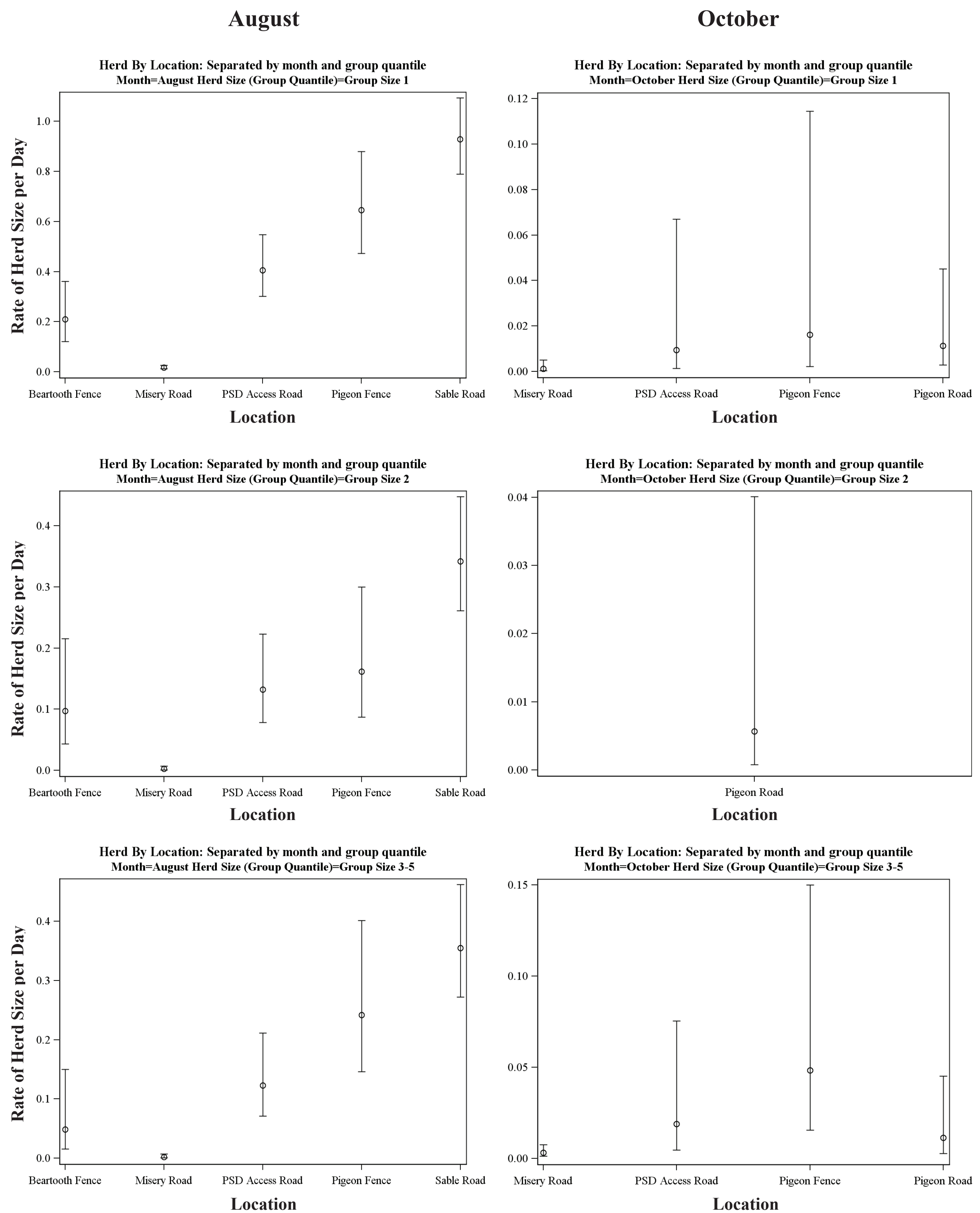

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Figure 4.1-2a

Caribou Encounter Rates by Group Size and Location, 2012

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August **October**

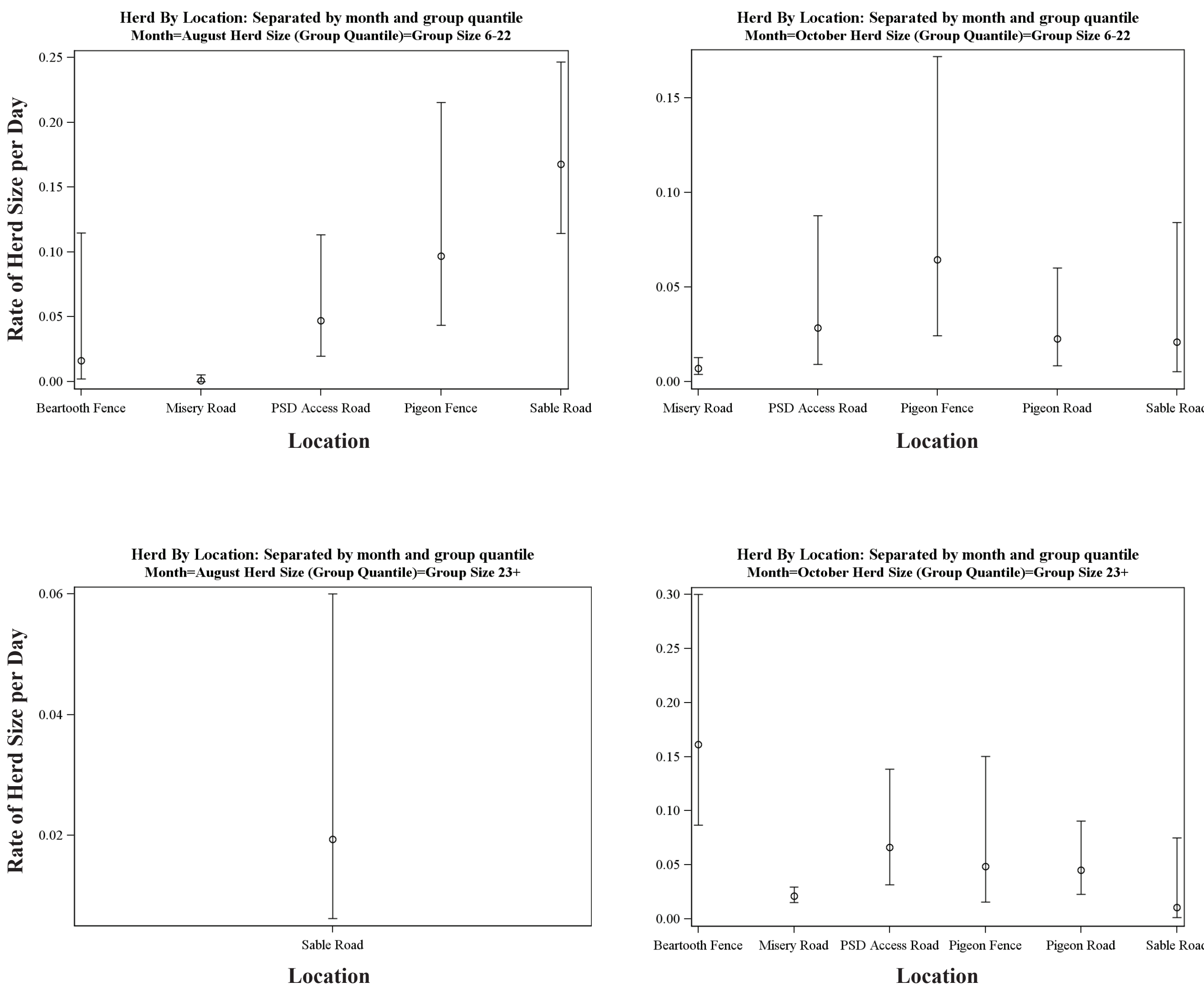

Figure 4.1-2b

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Caribou Encounter Rates by Group Size and Location, 2012

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4.1.4 Encounter Rates By Location and Time of Day

Data were divided into four main time periods (24:00 to 06:00, 06:00 to 12:00, 12:00 to 18:00, and 18:00 to 24:00) to determine if encounter rates varied with time of day. Poisson regression models using log link functions were used to model encounter rates of herds across locations (response), at different times of the day (explanatory) in August and October. An offset term was included to adjust for camera effort. Encounter rates were found to differ significantly among locations at multiple times of the day in both months (Table 4.1-3).

Table 4.1-3. Type 3 LR Statistics to Test Whether Encounter Rates of Caribou of Various Caribou Group Sizes Varies by Location

Month	
August	**October**
***Midnight to 6 am:** Chi-squared=75.61, DF=4, Pr<0.0001	**Midnight to 6 am:** No Test-1 site
***6 am-Noon:** Chi-squared=384.42, DF=4, Pr<0.0001	***6 am-Noon:** Chi-squared=17.31, DF=5, Pr<0.0039
***Noon-6 pm:** Chi-squared=534.69, DF=4, Pr<0.0001	***Noon-6 pm:** Chi-squared=33.77, DF=5, Pr<0.0001
***6 pm- Midnight:** Chi-squared=258.09, DF=4, Pr<0.0001	**6 pm- Midnight:** Chi-squared=1.41, DF=1, Pr=0.2352

** Indicates a statistically significant result.*

Encounter rates of caribou did not vary by time period at a particular location (Figures 4.1-3a and b), and dividing data by time period did not alter the general patterns described in previous sections. Across locations and time periods, encounter rates were significantly lower at Misery Road in both August and October (P<0.0001) during each time period. Differences in encounter rates among sites during both months were most pronounced between 12:00 and 18:00.

4.2 CARIBOU BEHAVIOURAL ANALYSES

4.2.1 Relative Behavioural Frequencies

Caribou behaviours were initially summarized as the total number of caribou engaged in particular behaviours at each location, irrespective of herd membership and camera effort (Table 4.2-1). While these values cannot be used to compare behaviours among locations, as behaviours are not independent within a group and data need to be corrected by camera effort prior to comparisons, they do provide information on the relative frequencies of each behaviour. Overall, 11,013 behaviours were recorded from 6,399 individual caribou.

The most common behaviours were foraging (5647 observations), walking (2689 observations), and standing (2404 observations) (Table 4.2-1). These data also show that 223 caribou either crossed roads, or climbed onto and walked on roads, compared to 19 that were either deflected from the road or ran off a road, suggesting that roads at Ekati are, for the most part, passable. Of the caribou that attempt to approach or interact with roads, approximately 7.9% (19/242) display an adverse reaction (deflection or running from road) as opposed to a positive reaction (climbing onto or crossing the road). This is consistent with results from 2011 that demonstrated 3% (9/286) of animals were deflected from roads in some manner.

Since behaviours of individuals within a herd are not independent of one another, behaviours were summarized by group and adjusted for camera effort. This conversion produced average daily encounter rates of particular behaviours, which could then be compared among locations. These data are summarized in frequency tables for roads in Table 4.2-2 and fences in Table 4.2-3. Cameras with different programming or in areas with insufficient coverage could not be used to adjust behaviours, and so not all behaviours listed in Table 4.2-1 could be converted to rates.

August

October

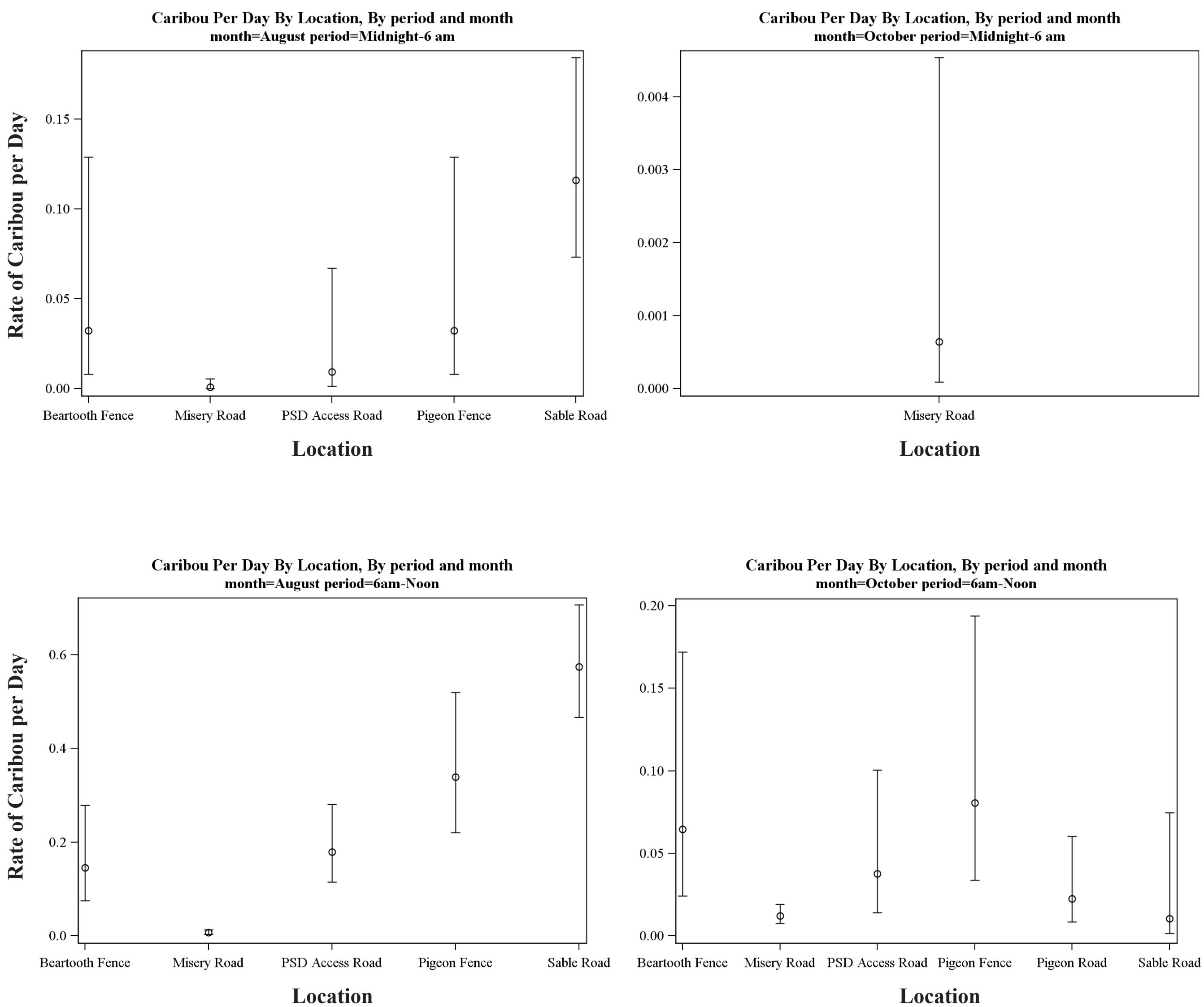

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Figure 4.1-3a

Caribou Encounter Rates by Location and Time Period, Adjusted by Camera Effort

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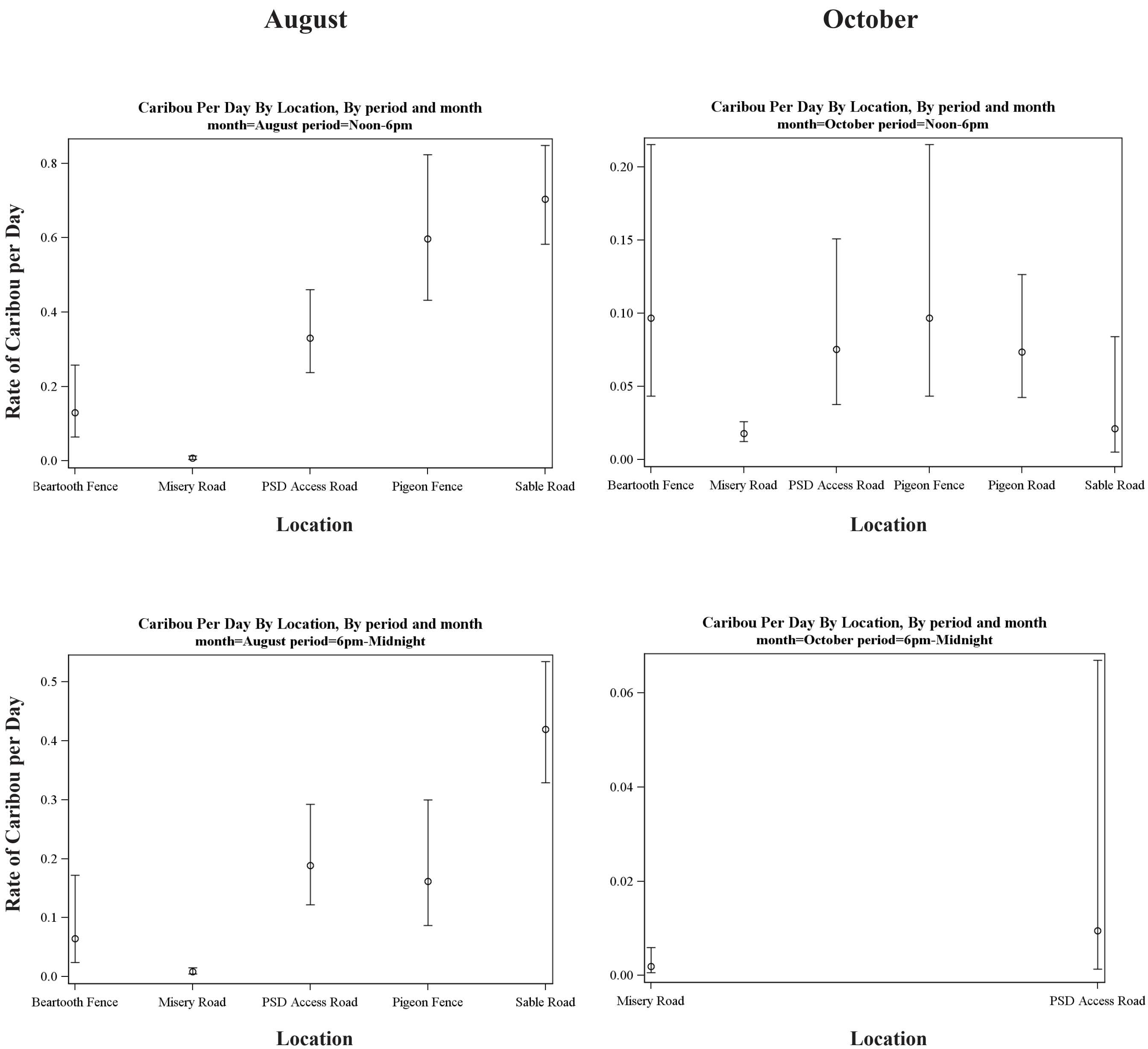

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Caribou Encounter Rates by Location and Time Period, Adjusted by Camera Effort

Figure 4.1-3b

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Table 4.2-1. Summary of the Total Number of Caribou Observed Engaging in Various Behaviours at Each Location Recorded by Monitoring Cameras

	Forage	Walk	Crossed Road	Run off road	Deflect from Road	Investigate Camera	Standing	Climbed and walked on road	Resting near road	Deflect from Fence	Cow-calf Separated by Fence	Jumped fence
Beartooth Fence	1293	859				33	12			4	8	6
End of Cell-A Rd	3	3	.	.	.	.	.	.	.	.	.	.
LLCF RD Cell B East	17	17	.	.	.	.	.	.	.	.	.	.
Misery Road	2643	394	43	2	6	3	2292	15	2	.	.	.
PSD Access Road	496	602	.	.	.	7	14	5	1	.	.	.
Pigeon Fence	256	171	.	.	.	2	24	.	1	.	.	.
Pigeon Inukshuk	9	14	.	.	.	1	3	.	.	.	.	.
Pigeon Road	418	511	4	.	.	.	.	.	.	.	.	.
Sable Road	512	118	74	3	8	5	59	82	10	.	.	.
Total	5647	2689	121	5	14	51	2404	102	14	4	8	6

Note: 'Unknown' behaviours are not included.

Table 4.2-2. Daily Rates of Behaviours by Caribou Groups at Road Locations, Adjusted by Camera Effort

	Foraging	Walking	Crossed Road	Run off road	Deflect from Road	Investigate Camera	Standing	Climbed and walked on road	Resting near road
Misery Road	0.0079	0.0024	0.0016	0.0003	0.0004	0.0004	0.0066	0.0012	0.0003
PSD Access Road	0.1382	0.1404	.	.	.	0.0088	0.0241	0.0088	0.0022
Pigeon Road	0.0559	0.0559	0.0035	.	.	.	.	.	.
Sable Road	0.2376	0.0683	0.0697	0.0043	0.0114	0.0071	0.0583	0.0811	0.0071
Total	0.4396	0.267	0.0748	0.0046	0.0118	0.0163	0.089	0.089	0.0096

Table 4.2-3. Daily Rates of Behaviours by Caribou Groups at Fence Locations, Adjusted by Camera Effort

	Foraging	Walking	Resting	Standing	Deflect from Fence	Cow-calf Separated by Fence	Jumped fence
Beartooth Fence	0.0667	0.0857	.	0.0190	0.0063	0.0127	0.0063
Pigeon Fence	0.2359	0.1021	0.0035	0.0493	.	.	.
Total	0.3026	0.1878	0.0035	0.0683	0.0063	0.0127	0.0063

Where sample sizes allowed, the rates of all behaviours were pooled by location (Figure 4.2-1), and analyzed statistically. For these tests, binomial (logistic) models were used with log link functions, as behaviours could be classified as observed/not observed. The models combine both August and October, and an offset term was included to adjust for camera effort. Only behaviours with sufficient sample sizes for comparisons by location were included in the analyses (Table 4.2-4).

Table 4.2-4. Type 3 LR Statistics to Test Whether Caribou Behaviours Vary by Location

Behaviour	LR Statistic
*Walking	Chi-squared=487.46, DF=5, Pr<0.0001
*Foraging	Chi-squared=853.55, DF=3, Pr<0.0001
*Stop and Stand	Chi-squared=111.58, DF=4, Pr<0.0001
*Walked on/Along Roads	Chi-squared=232.81, DF=2, Pr<0.0001
*Crossed Road	Chi-squared=185.76, DF=2, Pr<0.0001
*Investigating Camera	Chi-squared=48.36, DF=4, Pr<0.0001

**Indicates a statistically significant result.*

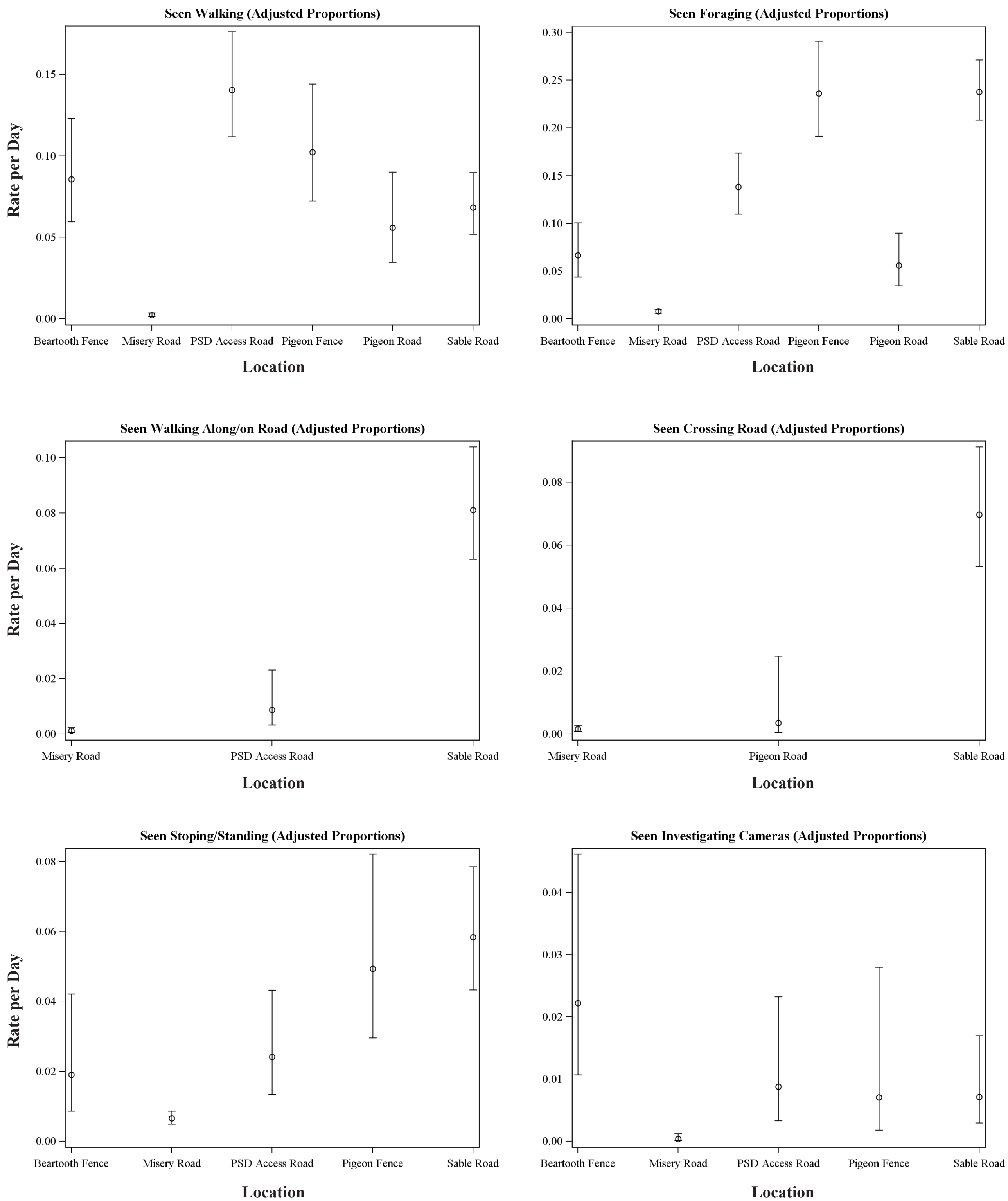
Results show statistical evidence for an effect of location on the frequencies of six behaviours (Table 4.2-4). Rates of walking, foraging, standing, walking along the road, crossing the road, and investigating the cameras were all lower along Misery Road. These results are not surprising due to the relatively lower encounter rates of caribou at Misery Road compared to other locations.

The highest rates of walking were observed around the PSD Access Road and Pigeon Fence. Migration movements may occur through these areas, which would also explain the correspondingly high foraging rate. Considering the high walking rates at the PSD Access Road, but lower foraging (compared to walking) rates, the PSD Access Road area was most likely used during migration in 2012. Pigeon Fence, on the other hand, had relatively high walking rates, but even higher foraging rates, suggesting this site may have been used for the quality of the forage. Foraging rates were also relatively high at Sable Road, and far exceeded walking rates, again suggesting higher quality habitat for foraging in this area.

The highest rates of walking along or on the road, and crossing roads, were found at Sable Road. There may be features in the area that promote frequent crossings and walking on roads that require further investigation to determine why caribou interact most heavily with this road. In the absence of traffic, Sable Road may be used similarly as an esker. Finally, standing behaviour was highest at Sable Road and Pigeon Fence, which may support the idea that these sites are used for foraging, while stop and stand behaviours are occasionally used to scan for predators.

When potentially problematic behaviours associated with fences were examined (e.g., climbing over fences, cow-calf separations, and deflections), all occurred at Beartooth fence (Table 4.2-3), indicating the placement or structure of Beartooth Fence may be problematic relative to Pigeon Fence, which had no such problematic events despite higher walking rates.

Due to their importance, the following sections discuss the following behaviours in more detail, and include the locations of where they tended to occur: crossing roads, deflections from roads, jumping over fences, and cows and calves being separated by fences.



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Comparison of Rates of Behaviours by Caribou Groups across Locations

Figure 4.2-1

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4.2.2 Crossing Roads

Locations of road crossings were plotted to assess whether crossings were more common at certain locations than others, and to determine if there were any areas where clustering of road crossings were observed (Figures 4.2-2, 4.2-3, 4.2-4, 4.2-5). Crossings by individual caribou were more spatially dispersed than larger groups; however, some degree of clustering is apparent for road crossings in most group sizes. Regions associated with red clusters may suggest preferred crossing locations, one of which appears to exist in the northwest. This relationship may suggest areas where road crossings are preferred (i.e., road structure or traffic rates conducive to crossing), or crossings may occur in those locations due to avoiding other sections of road. Further investigations into whether or not there are attributes of that particular area which promote crossing, or if this result is an artifact of other selection processes, may be warranted.

Other studies have suggested that larger caribou herds (e.g., 100+) are less likely to cross roads (Smith and Cameron 1983); therefore, the relationship between group size and road crossing was explored (Figure 4.2-6). Binomial (logistic) models were used with log link functions, as behaviours could be classified as observed/not observed for animals from each group size. The model combined both August and October, and an offset term was included to adjust for camera effort and a Type III LR Statistic was derived.

Road crossing rates varied by group size (Chi-Squared=11.72, DF=4, Pr=0.0196). This effect was due to a significantly lower road crossing rate by the largest group size (23+). This result supports findings of Smith and Cameron (1983) that large groups of caribou are less likely to cross roads. This analysis will be revisited as sample sizes increase during future monitoring years. With sufficient data, it may be possible to add other group sizes, including 100+, to test whether this pattern persists at larger group sizes.

4.2.3 Deflections from Roads

Deflection locations were plotted to indicate where they were occurring, and to identify any patterns (Figure 4.2-7). More deflections tended to occur in the northwest, with a few occurring in the southeast. Given road crossings also occurred more frequently in the same northwestern section, there is likely a higher probability of deflections where many caribou attempt to cross.

To determine whether road deflections were a function of traffic activity rather than road composition, a two-sided Fisher's exact test was performed to explore the relationship between alert behaviours and traffic activity (Figure 4.2-8). The results were significant ($P < 0.0001$), meaning that there was statistical evidence that alert behaviours were dependent on vehicles. Given the relationship between alert behaviours and vehicles, and considering the similar pattern seen between deflections and alert behaviours, it is possible that some level of vehicle activity may contribute to deflections. The relationship between vehicular data collected along Misery Road and the presence and absence of caribou, crossing, and deflecting behaviours of caribou, will be conducted to explore this relationship in more depth.

Plate 4.2-1 illustrates a typical deflection event as a caribou approaches the verge of a road, and then turns 180 degrees and runs in the opposite direction. In this example, the caribou also exhibits a tail and jump excitation response, which was classified as an alert behaviour, and a vehicle was discovered to have been approaching from other photographs around that location at a similar time.

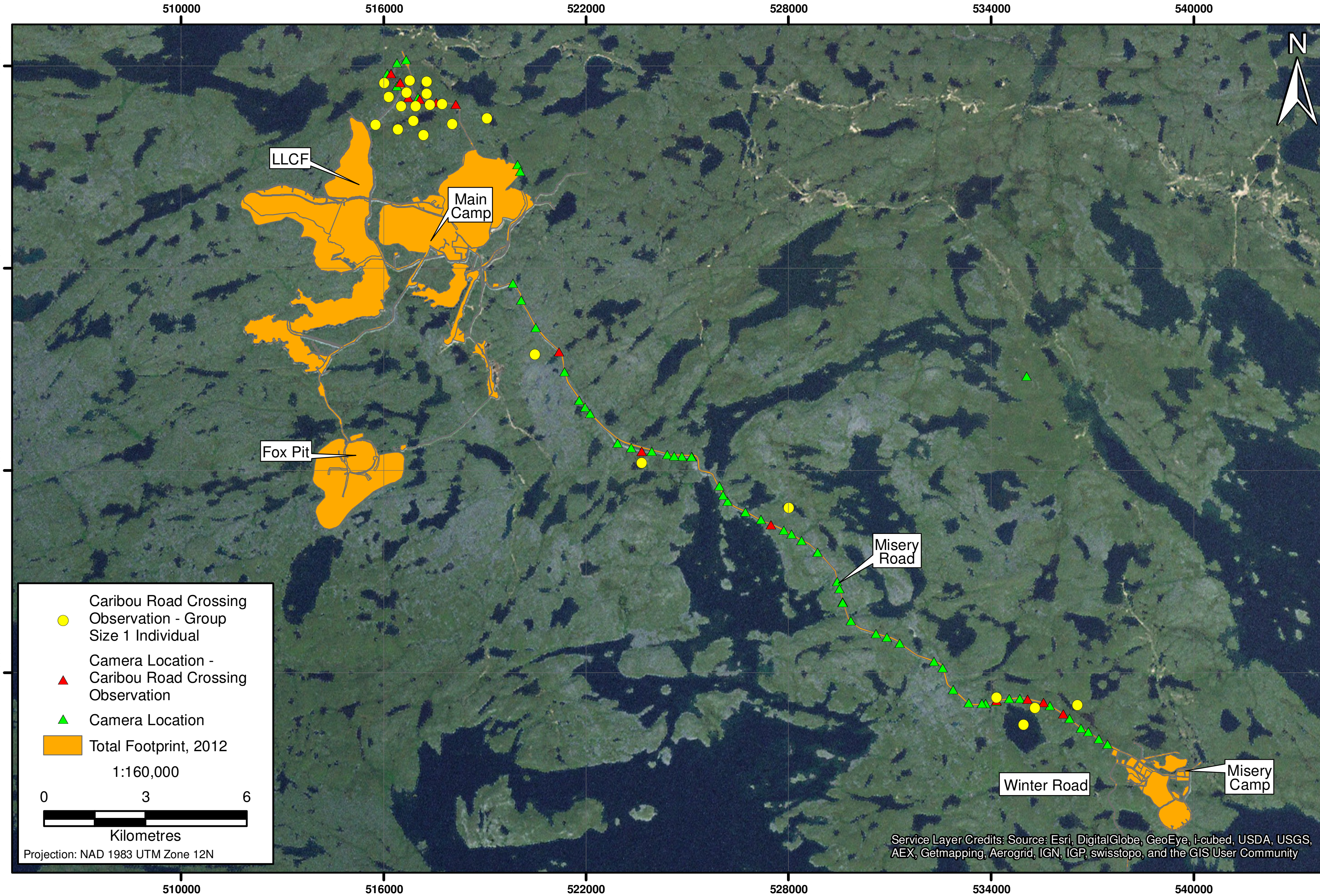

Figure 4.2-2

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Caribou Road Crossing - Group Size 1 Remote Camera Locations, 2012

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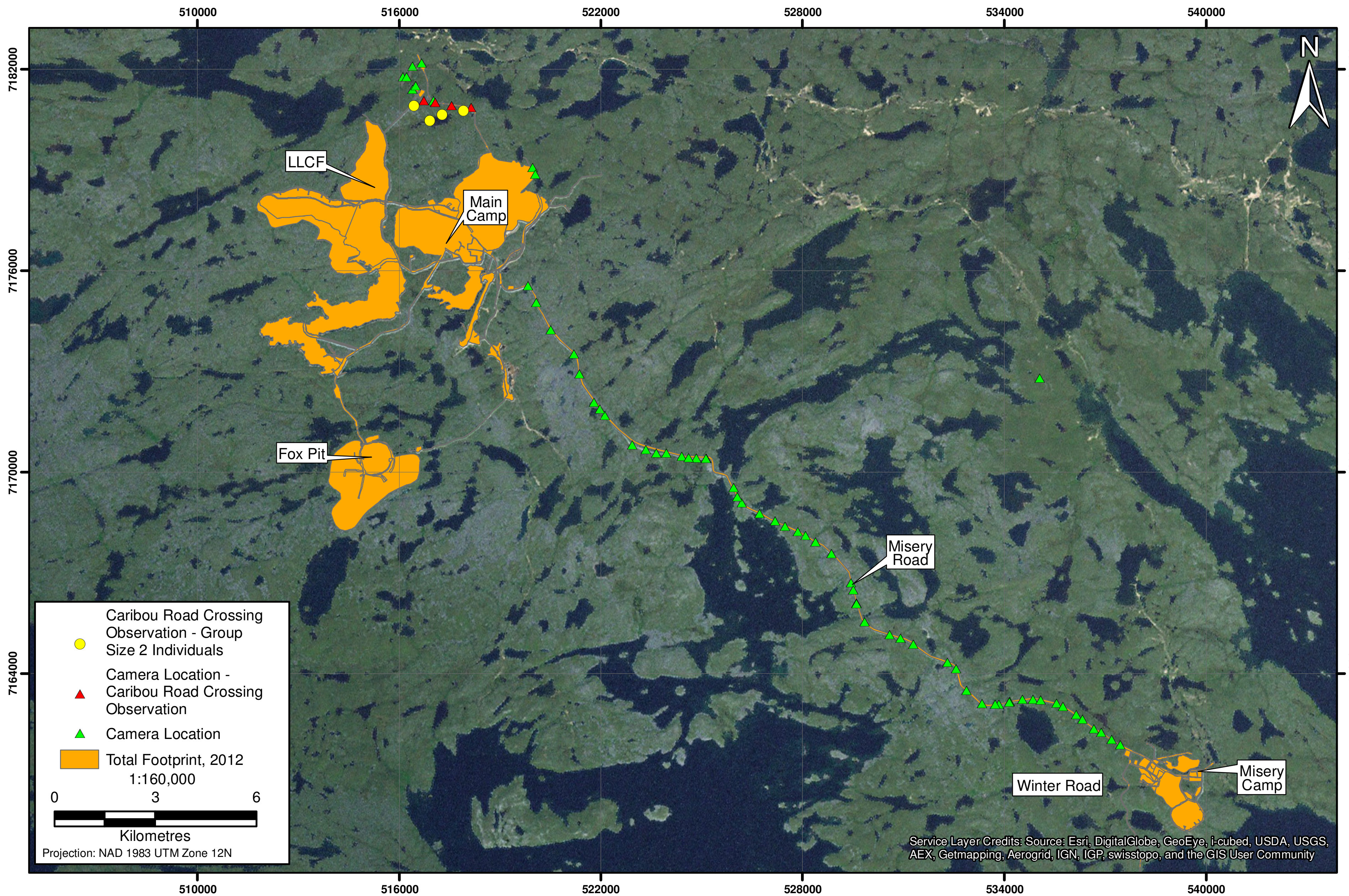

Figure 4.2-3

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Caribou Road Crossing - Group Size 2
Remote Camera Locations, 2012

Rescan an ERM company

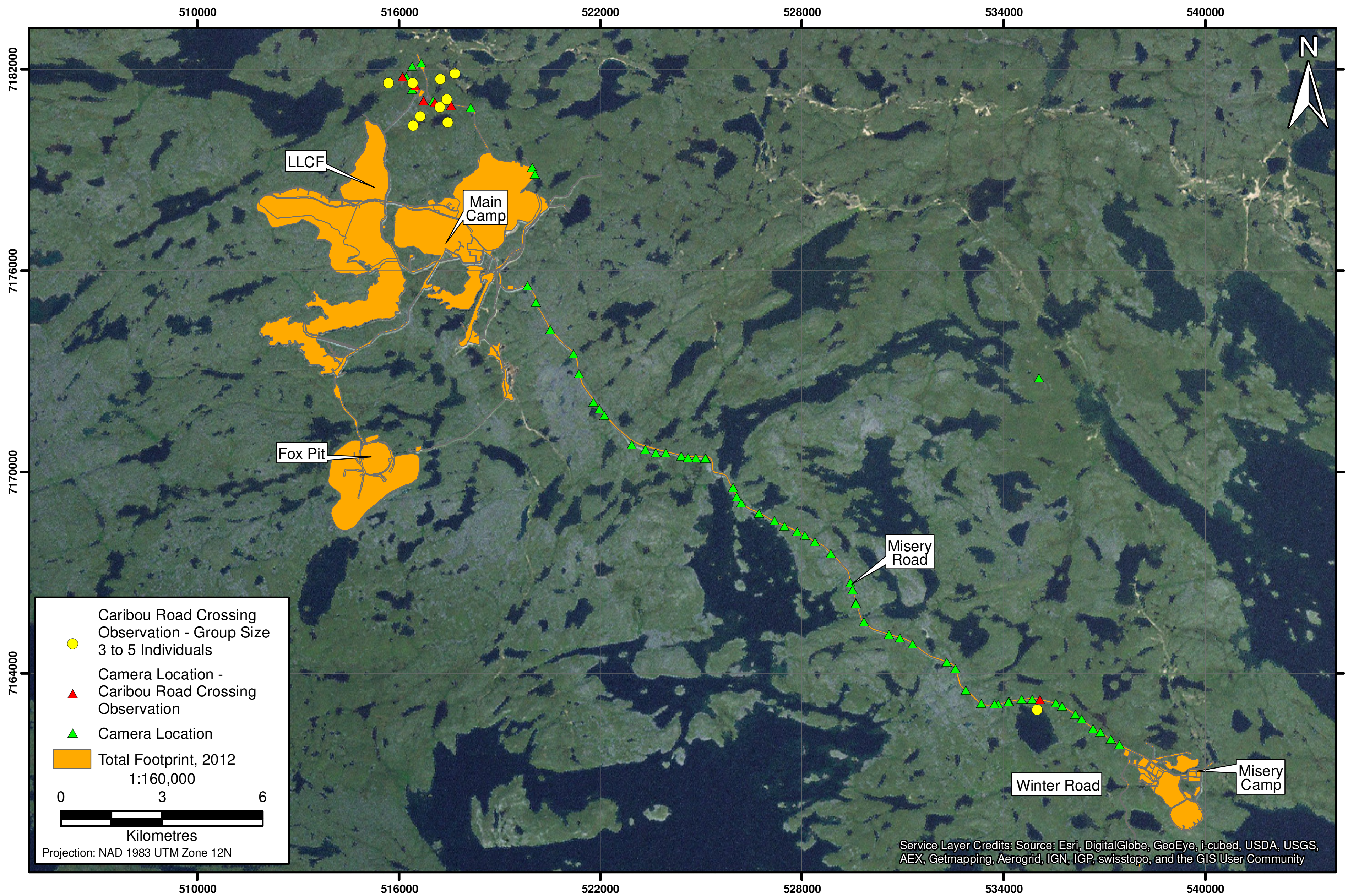

Figure 4.2-4

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Caribou Road Crossing - Group Size 3 to 5 Remote Camera Locations, 2012

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PROJECT #0194118-0132 GIS # EKA-23-167d May 8, 2013

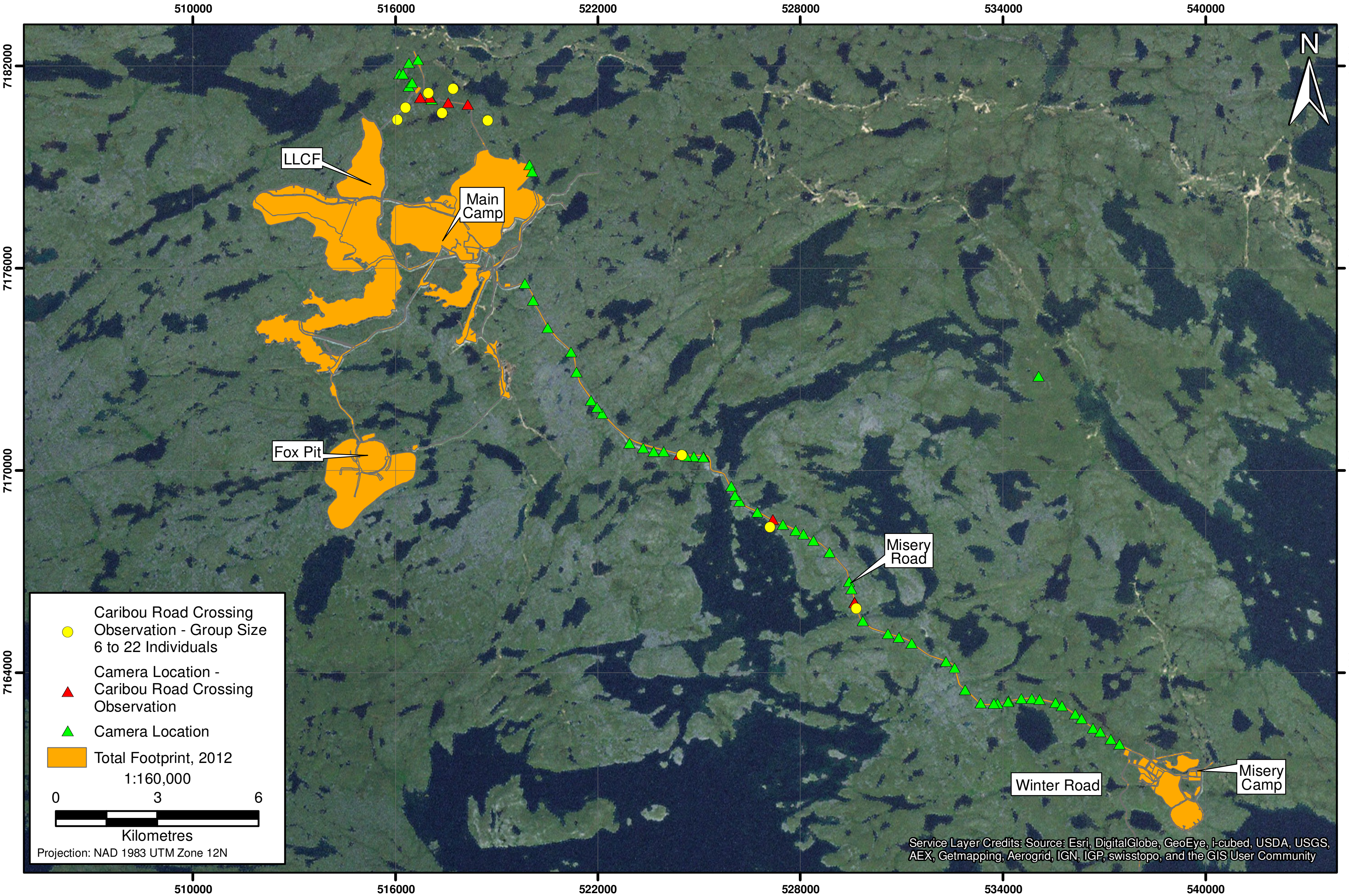


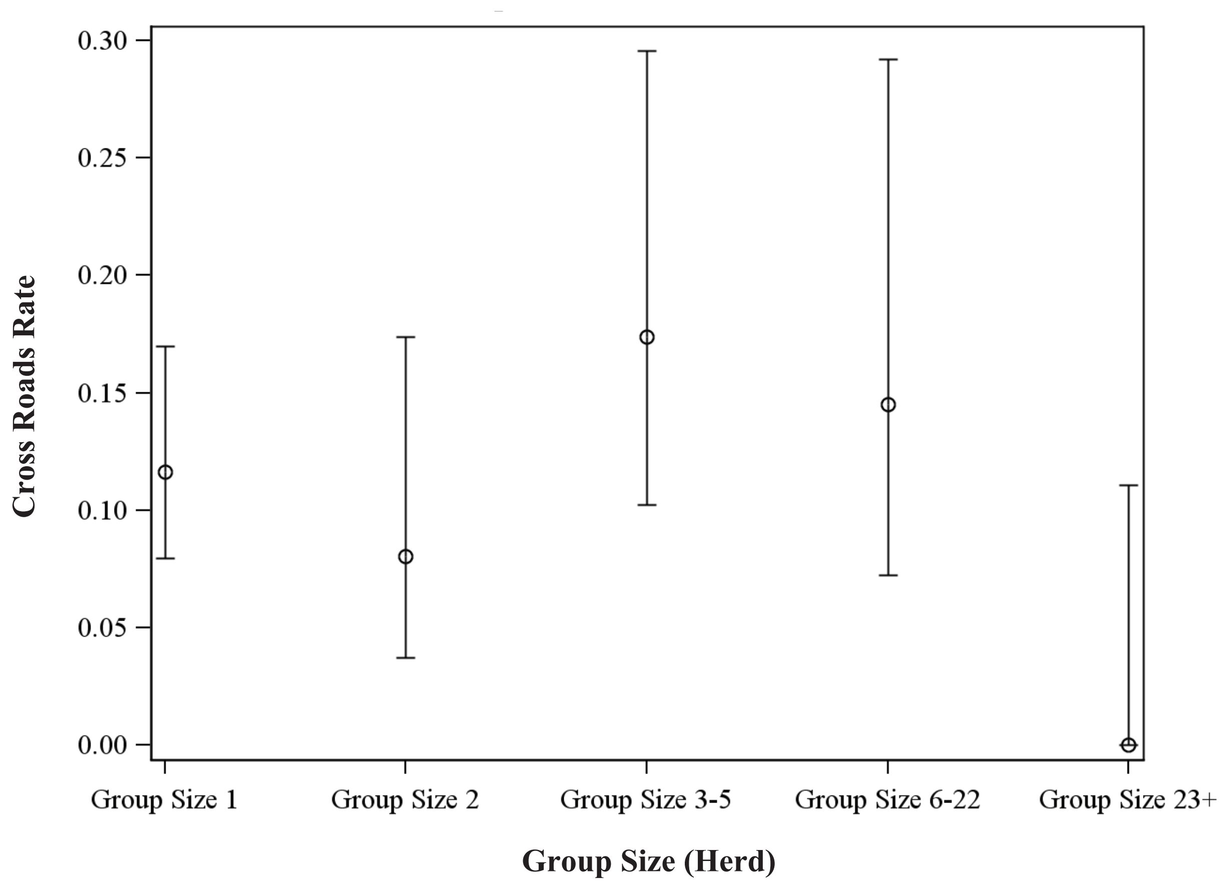
Figure 4.2-5

DOMINION DIAMOND

Caribou Road Crossing - Group Size 6 to 22 Remote Camera Locations, 2012

Figure 4.2-5

Rescan an ERM company



*Note: Group size 23+ has been adjusted to 0.01.
Confidence intervals for group size 23+ are approximate*

Figure 4.2-6

Road Crossing Rates by Group Size

PROJECT #0194118-0132 GIS # EKA-23-170 May 9, 2013

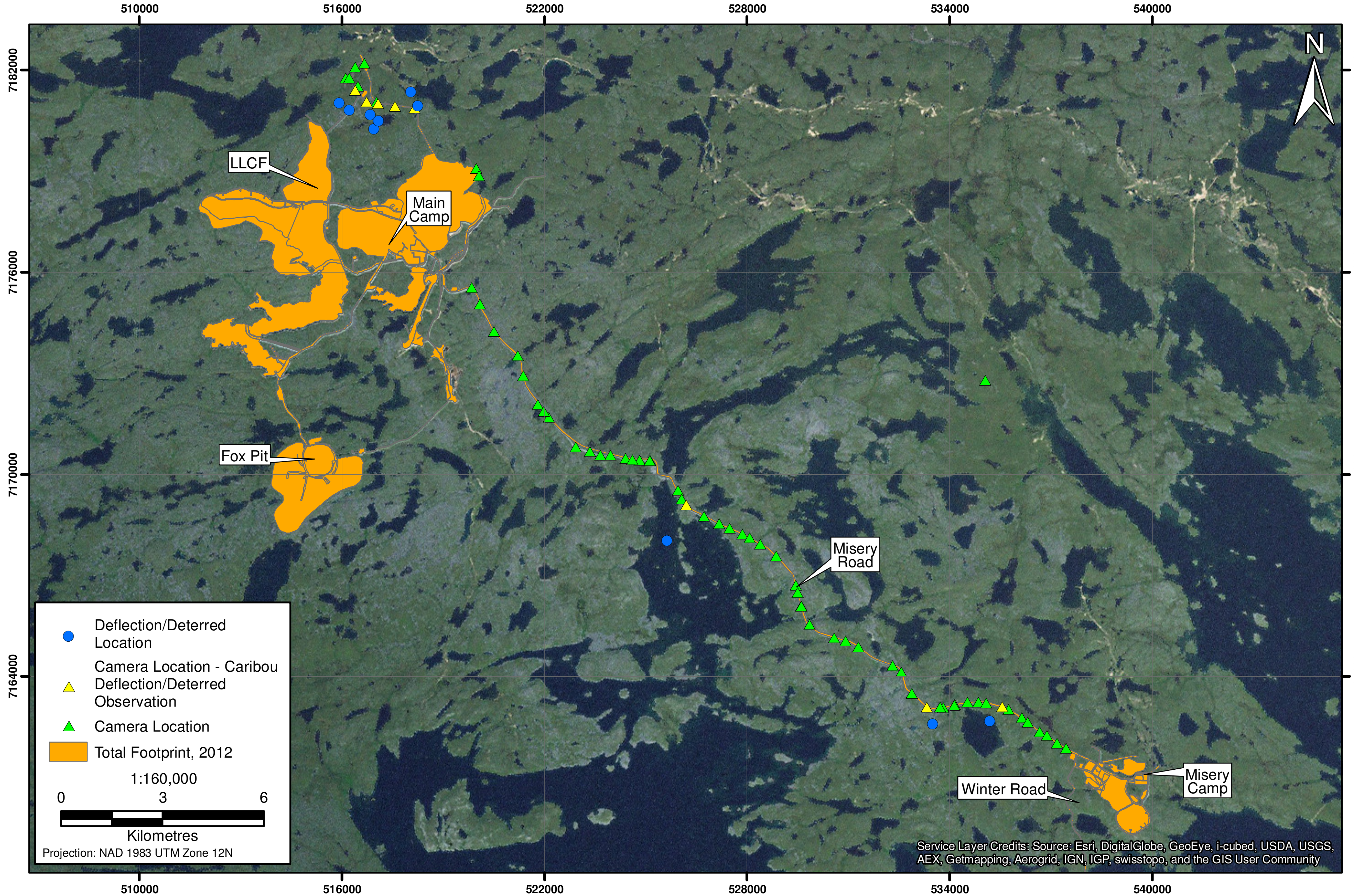


Figure 4.2-7

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Caribou Deflection/Deterred Locations

Figure 4.2-7

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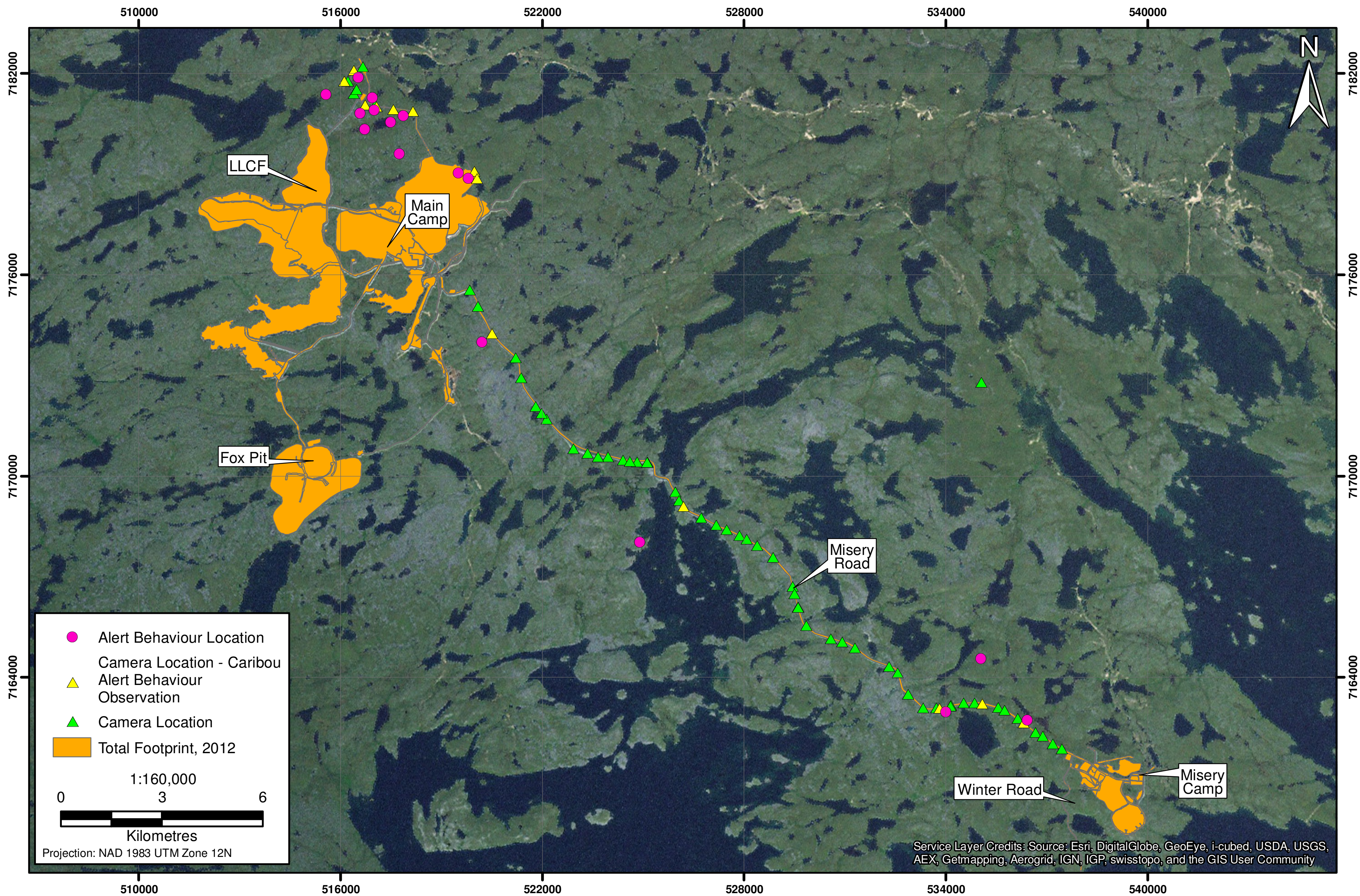

Figure 4.2-8

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Caribou Alert Behaviour Locations

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Plate 4.2-1. Example of a caribou approaching the road and then deflecting. Note the alert behaviour as the animal turns to run with its tail up.

4.2.4 Jumping over Fences

All incidences of caribou jumping over fences were observed at the Beartooth Fence. An example of an animal jumping over a fence is shown in Plate 4.2-2. It appears that the animal loses its footing (second frame) temporarily and then continues.

4.2.5 Cow-Calf Separations

All incidences of cows and calves being separated by fences occurred at Beartooth Fence. Plate 4.2-3 shows an example of a cow-calf separation event. A cow and calf approach a fence, parallel to it, and end up on either side of the fence. Both animals continue to walk or forage on either side of the fence, usually with alert behaviours displayed by the calf.

Plate 4.2-2. Example of caribou crossing Beartooth Fence.

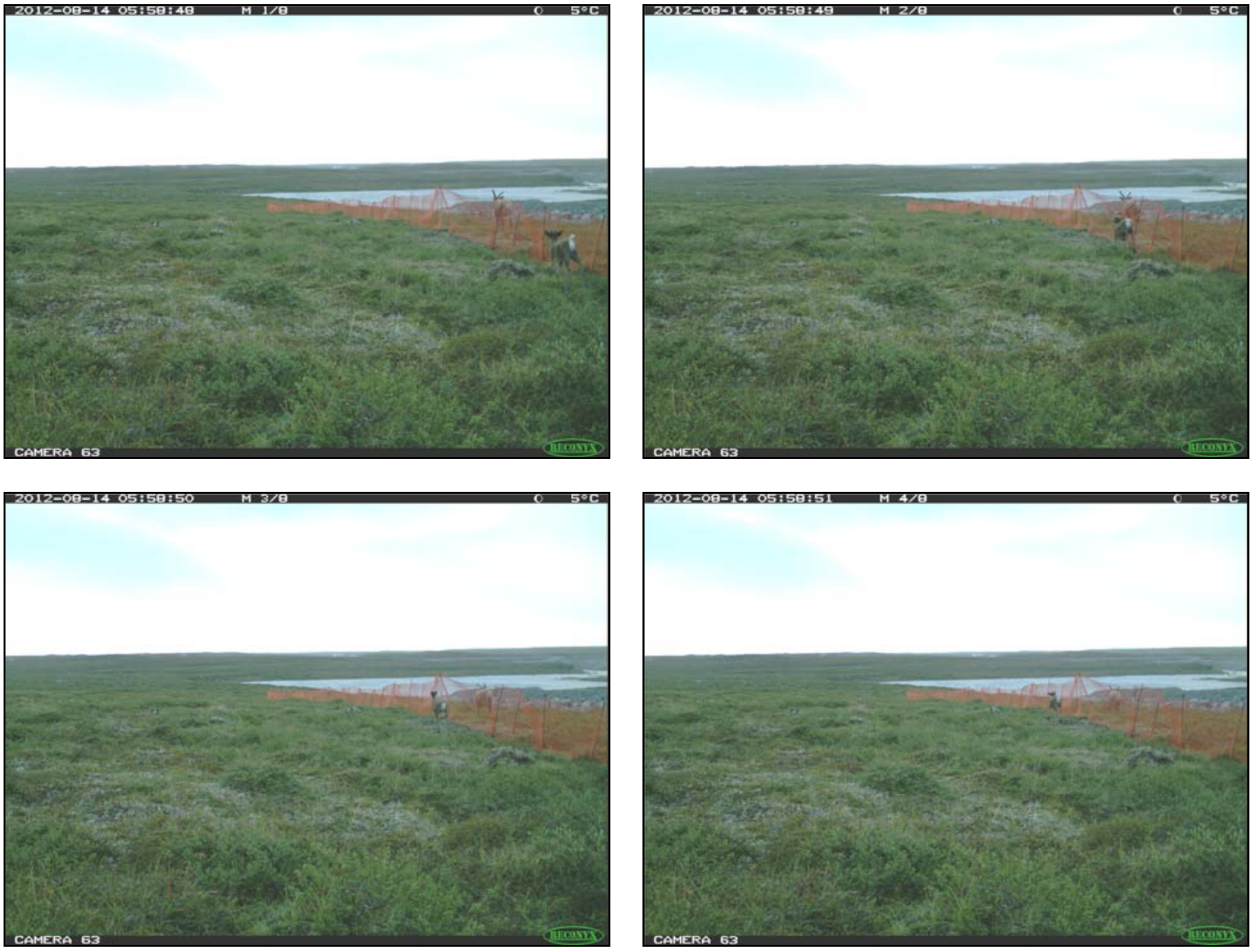

Plate 4.2-3. Example of a cow and calf separated by temporary fencing. Both cow and calf continued to walk in parallel on either side of the fencing, with the calf exhibiting alert behaviours at times.

5. Conclusions

5. Conclusions

The 2012 camera monitoring program at Ekati provided new information on seasonal, temporal, and behavioural patterns of caribou in the area. Statistical analyses suggest possible mechanisms for caribou responses to man-made infrastructure that warrant further investigation (e.g., role of vehicle traffic in deflection rates). Overall, 11,013 behaviours were recorded from 6,399 individual caribou, which allowed for some general inferences:

- **Caribou encounter rates were significantly higher in August and October than in other months:** This late summer and fall period was generally accepted as a period with high caribou abundance around the Ekati site in previous WEMP estimates using other methods, and so these results likely reflect the ecology of the area.
- **Caribou encounter rates were significantly lower along Misery Road compared to other sites:** This result is important as it suggests different movement patterns around the Ekati mine site during the 2012 season. This result remained when encounter rates were analyzed by group size and time of day. This result counters some studies that examined the responses of caribou to human infrastructure in Arctic environments and found no relationship (Armstrup *et al*. 1998, Bergerud *et al.* 1984). Other results have shown decreased use of areas with roads by caribou in response to oil field development and road construction in Alaska (Cameron *et al*. 1992). The relative contribution of habitat characteristics around the Ekati roads and mine site, and traffic activity to caribou movement patterns and encounter rates will be further explored in future monitoring years.
- **Caribou road crossing rates differed among locations:** Caribou had the highest road crossing rates at Sable Road, and the lowest rates at Misery Road. Based on visual analysis of data, there is a clustering pattern in road crossing rates, where more caribou were found to cross Sable Road, and other locations in the northwest. The reasons for a greater crossing rate in this area is unclear, but the attributes of the road will be examined further as it may be more conducive to crossing for a number of reasons (e.g., low traffic rates, road verge construction and height, distance from other human infrastructure and disturbance, landscape features, or adjacent and desirable forage). Sable Road is also in near proximity to traditional migration routes of the Bathurst caribou herd, and higher encounter rates (and therefore greater opportunities to cross the road) are expected in this area.
- **Caribou deflections are infrequent and may occur when animals are startled by vehicles:** These data show that of 242 caribou that directly interacted with a road, 19 (or 7.9%) were deflected or ran off the road. This suggests that Ekati roads are permeable to caribou movements, but that some mitigation may still be required to minimize deflections, particularly those caused by vehicles. Deflections correspond with alert behaviours, which are significantly dependent on the presence of vehicles on the road; therefore, future statistical analyses that make use of vehicle photographs collected along Misery Road will aide in exploring this relationship. Other studies have shown that vehicular traffic can decrease the permeability of roads to caribou (e.g., Dyer *et al*. 2000), and that a high proportion of barren ground caribou react to vehicles by running away (Horejsi 1981).
- **Evidence of behavioural disturbances in response to fences was found:** While the main focus of this study concentrated on the potential effects of roads, particularly Misery Road, on caribou, effects of fencing may require greater scrutiny. Fences were installed to specifically to exclude caribou from the Pigeon Test Pit and Beartooth Pit areas; however, caribou adults were shown to jump over fences, particularly when they are trying to keep up with a larger

herd. The possibility of tripping over fences may warrant further monitoring. Cows and calves were also shown to occasionally be separated by fences, and calves appeared unable to jump over fences. It is unknown whether or not prolonged separation of cows from calves could result in permanent separation or an increased risk of predation to calves. Finally, although jumping over the fencing was a more frequent response, there was also evidence of deflections.

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6. Literature Cited

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