Restoring Functional Caribou Habitat: Testing Linear feature Mitigation Techniques in Northeast BC

2014/2015 Annual Report


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EXECUTIVE SUMMARY

Boreal caribou (*Rangifer tarandus caribou*) populations are declining in many parts of their distribution due to increasing rates of predation. In western caribou ranges, increasing predation has been linked to linear features from industrial activity (e.g. seismic lines and pipelines), which are hypothesized to increase caribou-predator spatial overlap and enhance predator hunting efficiency. Because of this suggested relationship, reducing the impact of linear features on caribou-predator dynamics has become a management priority. To that end, we initiated this project in 2014 to develop effective mitigation techniques for limiting predator use of lines. We conducted an extensive literature review of potential predator-exclusion methods then using this information, we selected snow fencing for testing in a pilot study. We deployed snow fencing across linear features on 15 treatment sites within our study area near Fort Nelson, BC. Sites consisted of two intersecting seismic lines and we installed fencing at 25, 65, and 105 meters from the intersection on each line. To assess treatment response, we also selected 15 control sites and we stratified all 30 sites based on land cover. We recorded potential predator occurrence by installing two to three remote cameras at the line intersection of each site. To increase the odds of predators visiting sites, we placed wolf (*Canis lupus*) lure at the center of each line intersection. Cameras were deployed for approximately four months (end-August to mid-January).

In January 2015, we retrieved the data cards from the deployed cameras and analyzed the recorded images, separately summarizing data for treatment and control sites. We compared results over all cameras for the complete monitoring period (before and after snow) as well per month and per land cover type. In total, control sites were monitored for 3618 camera-days and the treatment sites for 3975 camera-days. We detected 286 wildlife encounters at treatment sites while 132 encounters were recorded at control sites. Almost half of all encounters happened prior to full snow cover (~ end-October). Across all sites, detected species were caribou, moose (*Alces alces*), wolf, black bear (*Ursus americanus*), lynx (*Lynx canadensis*), wolverine (*Gulo gulo*), coyote (*Canis latrans*), fox (*Vulpes vulpes*), grouse (*Phasianidae spp.*), snowshoe hare (*Lepus americanus*), unidentified birds, unidentified canids and unknown species. When correcting for the number of camera-days deployed, more occurrences were recorded at treatment sites for all species except caribou, coyotes, and undefined canids. Moose were the most detected species in both treatment and control sites and were detected throughout the entire monitoring period. Caribou were recorded primarily in September. Predator occurrence was highest immediately after lure deployment, except for wolverine. The highest number of wildlife encounters occurred at upland sites, a trend that also held true when looking specifically at predators.

Results of our pilot study suggest that snow fencing was ineffective in excluding predators from line intersections although our analysis might have been limited by small sample sizes. Moreover, our analysis is restricted to predator presence / absence and did not evaluate whether the fencing altered predator behaviour or movement when travelling on or near the line. Potential effects of the snow fencing as a movement barrier appear to be limited to the snow-free season as fences were buried or damaged by snow.

In 2015 we plan to deploy GS radio-collars (*n* = 10) distributed among two wolf packs. Movement data from these wolves will be used to further assess predator response (i.e. changes in movement behaviour) to mitigation techniques. Based on results from the project's first year, we are considering the following avenues of investigation for 2015:

1. Collaborating with current line mitigation projects in Alberta to assess different designs for limiting wolf use of lines. These projects are currently using coarse woody debris or mounding methods
2. Excluding predators from areas versus specific lines
3. The use of electric fencing to limit or exclude wolf use of roads

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INTRODUCTION

Boreal caribou, an ecotype of woodland caribou are federally listed as *Threatened* due population declines throughout much of their distribution (Environment Canada 2008). Increasing predation is believed to be the main proximate cause of population declines with elevated predation rates ultimately linked to landscape alteration within and adjacent to caribou range (Environment Canada 2008, Festa-Bianchet et al. 2011) Landscape alteration may facilitate increased predation through two processes. First, alteration can indirectly increase predator numbers, a response tied to the increasing numbers of non-caribou ungulates (e.g. moose [*Alces alces*]) that respond favourably to the early seral conditions (i.e. young forest) created by alteration (Seip 1992, Latham 2009). Second, linear features (e.g. roads and seismic lines) related to industrial activity can enhance the movement efficiency of predators (McKenzie et al. 2012) and facilitate their movement into and within caribou ranges (Latham et al. 2011, Tigner et al. 2014). Both processes lead to increased encounter rates between caribou and their predators (e.g. wolves and black bears). Because of these mechanistic links between caribou population declines and landscape alteration, a primary focus of the federal recovery strategy for boreal caribou is the restoration or mitigation of altered areas within caribou range (Environment Canada 2012).

For this project, we focus on the role of linear features in facilitating predator movement and spatial overlap with caribou. Specifically, we are evaluating potential mitigation / de-activation techniques for limiting predator use of existing linear features. Such techniques would be complementary to, and not in place of, landscape restoration. The development of effective mitigation techniques, however, is necessary in the short-term as regenerating linear features to pre-alteration states may take longer than 50 years (van Rensen et al. 2015), a time frame that may be too long to prevent extirpation of some caribou populations (Schneider et al. 2010). For 2014, our primary objectives were to: i) conduct a literature review on potential mitigation techniques for deterring predator use of linear features; ii) use these results to develop mitigation methods that can be applied on a large scale; and iii) test promising techniques on a small scale to assess their ability to hinder wolf movement on linear features. These initial objectives will directly inform the direction of the project's second and third years.

METHODS

Literature Review

The literature review extracted information from technical reviews, unpublished work through the University of Alberta, and scientific literature found through on-line databases. The following terms were used in various combinations to search for all techniques used to exclude wildlife from any feature: mitigation, linear features, mitigating use, wildlife, predators, wolves, seismic lines, roads, road block, line blocking, road ecology, deterrent, exclusion fence, screens, carnivore-livestock conflicts, deter, exclude, linear corridors, tree felling, scent deterrent, biofence, flagging, woody debris, slash, and tree planting. Based on the results of the review, snow fencing was the most practical technique to be tested for large scale application.

Site Selection

In July 2014, we used a helicopter to identify potential sites within the Dilly Creek study area of Northeast BC (Fig. 1). All sites were restricted to be within Nexen lease boundaries. Sites consisted of two intersecting seismic lines or old pipelines (Fig. 2). We selected only lines with minimal re-growth to ensure a distinct contrast between the line and the surrounding forest. Of the 44 suitable sites found, we randomly selected 30 sites – 15 treatment sites and 15 control sites. We further stratified sites based on land cover type (bog, upland, fen, and swamp) and used a balanced design to ensure an equal number treatment and control sites within a given land cover type (Fig. 3).

Figure 1: Dilly Creek study area near Fort Nelson, BC.

Figure 2: An example of treatment site with installed snow fencing. Sites consisted of an intersection between two seismic lines. Three segments of snow fencing were deployed on each line leading to the intersection.

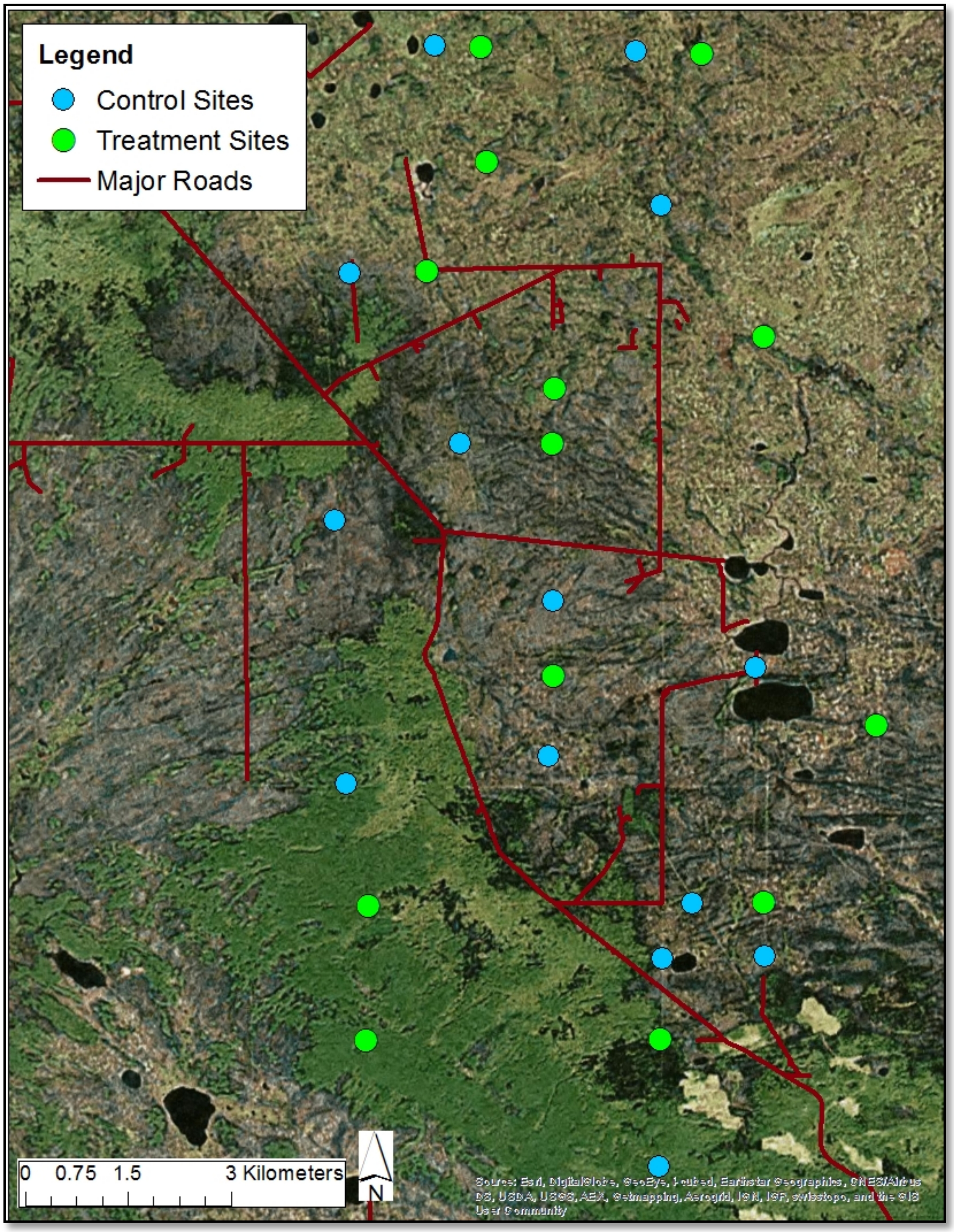

Figure 3: Treatment and control sites in the Dilly region in Northeast BC.

Fence Design and Camera Deployment

We deployed snow fencing on treatment sites during August 21-25, 2014. All fencing supplies and workers were off-loaded at each site by helicopter except Control Site 9 which was accessible by road. At each site, we installed three fences on each line at 25, 65, and 105 meters from the intersection (Fig. 4). Slight variations in distance were made depending on available trees for tying off the ends of the fence. Each fence was 15.24 meters wide and stretched across the line with the ends zip tied to trees in the surrounding forest (Appendix: A.1). The length of fence extending into the forest varied from less than one meter to three meters depending on the width of the line. Fencing was reinforced in the middle by wood stakes.

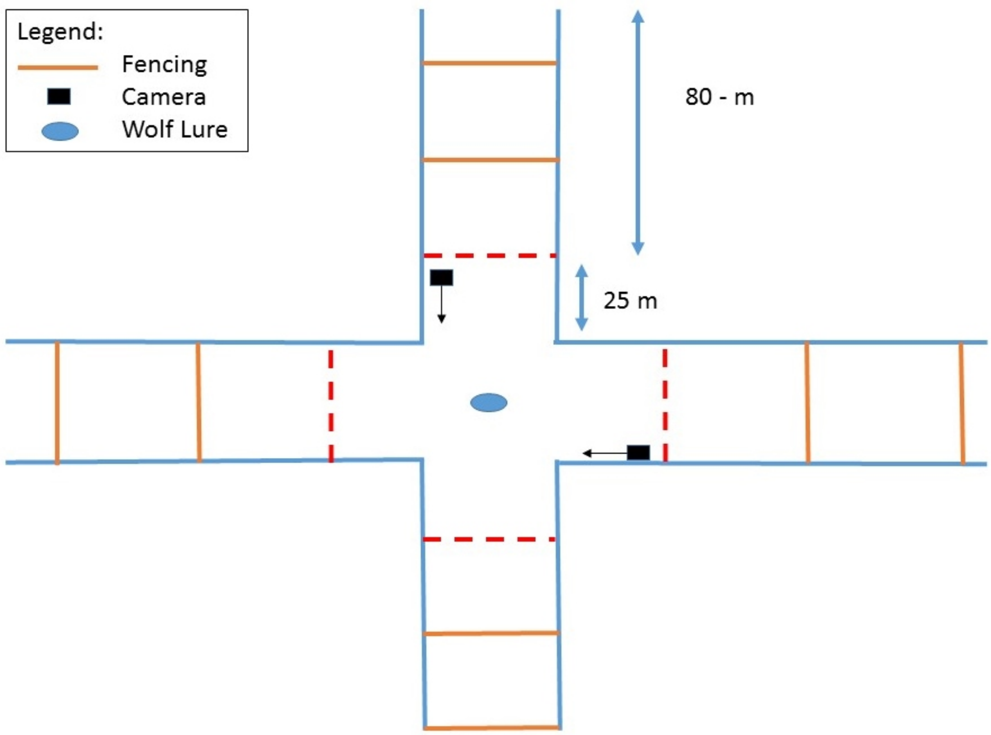

Figure 4: Schematic representation of a treatment site.

To record wolf use at each site, two or three PC900 Hyperfire RECONYX™ Professional cameras were placed at the line intersection. Camera location was determined on a site by site basis for optimal detectability for wolf movement on each line. To increase the odds of wolves visiting sites, we strategically placed wolf lure (urine and gland paste) at the center of the line intersection across from each camera.

Data Collection

For each site the following data was collected: date, site number and type, site coordinates, presence or absence of a game trail, land cover type, camera locations, and vegetation stage. Vegetation stage was classified into three categories: 1) Sparse or cryptogam (e.g. moss): less than 10% vegetation cover or moss / lichen dominated, 2) Herb: greater than 50% herbs, or 3) Shrub/Herb: shrub dominated. For treatment sites, fence distance from intersection and data describing accessibility around fence ends was also recorded.

Retrieval of Image Data

During January 21-23, 2015 we revisited all sites by helicopter and exchanged data cards and batteries of the deployed cameras. Two cameras were found disturbed (site T14 and C5) and at two sites only one camera out of two was found (T2 and C3). Two sites were not visited because of logistic problems. We reactivated all cameras for spring data collection and any missing cameras were replaced.

Data Analysis

For each camera, we downloaded and viewed image data from the recovered data card, tagging each image with keywords using Reconyx MapView Professional Software. Keywords described which species were detected, the number of individuals, if the same individual was found in sequential images or if the images was triggered by moving vegetation.

To explain animal presence / absence across sites, we recorded the following data to be used as explanatory variables (Appendix: Tables 3 and 4):

i. Number of days the camera was in the field (days from deployment date to revisit date).
ii. Number of days actually monitored (days from deployment to date of last picture).
iii. Time to first wildlife detection.
iv. Total number of pictures taken.
v. Total number of encounter events with wildlife.
vi. Date of first and last image.
vii. Date of full snow cover as determined by the snow cover seen in each image. We recorded both the total number of encounters and the encounters occurring before full snow cover.
viii. Site type (control versus treatment).
ix. The general location of the camera within the site (i.e. the corner of the site at which the cameras was placed).
x. Land cover type
xi. Battery and data card status

An encounter event was defined as any image where wildlife was detected. To prevent double counting of animals, we used a 3 hour time cut off between pictures of the same species to determine a new encounter. Because the main interest of this study was the general use or avoidance of a specific linear feature, the number of animals of the same species during one encounter was not considered. Further, we did not identify specific individuals to determine if the same individual revisited a site at different times. To correct for different numbers of cameras at control and treatment sites and differences in per-camera monitoring time, the total number of encounters was divided by the number of cameras and number of days monitored for treatment and control sites, respectively.

We separately summarized data for treatment and control sites and compared results over all cameras for the complete monitoring time (before and after snow) as well per monthly and per land cover type.

RESULTS

At control sites, we retrieved data from 25 cameras. Twenty-four worked for the full deployment period while one camera was operational for only a portion of the monitoring period. At treatment sites, we retrieved data from 30 cameras. Two cameras failed on the first day of deployment and two cameras later on in the monitoring period. Reasons for cameras failures were disturbance by black bears (2 cameras), battery failure (2 cameras), and data card error (1 camera). The length of the per-camera monitoring period ranged between 148-153 days (August 2014 – January 2015). In total, control sites were monitored for 3618 camera-days and the treatment sites for 3975 camera-days. Across all sites, detected species were caribou, moose, wolf, black bear, lynx, wolverine, coyote, fox, grouse, snowshoe hare, unidentified birds, unidentified canids and unknown species.

Overall Summary

Across the length of the monitoring period, 286 wildlife encounters were detected at treatment sites while 132 encounters were recorded at control sites (Fig. 5). Encounters corrected for camera numbers and deployment duration show more visits at treatments sites for all species except caribou, coyotes, and undefined canids. Moose were the most detected species in both treatment and control sites.

Prior to snowfall, 142 encounters were recorded at treatment sites while 60 were recorded at control sites. (Fig. 6). Wolves, wolverines, and moose were mostly detected in the snow season whereas black bears only visited the sites before full snow cover was established.

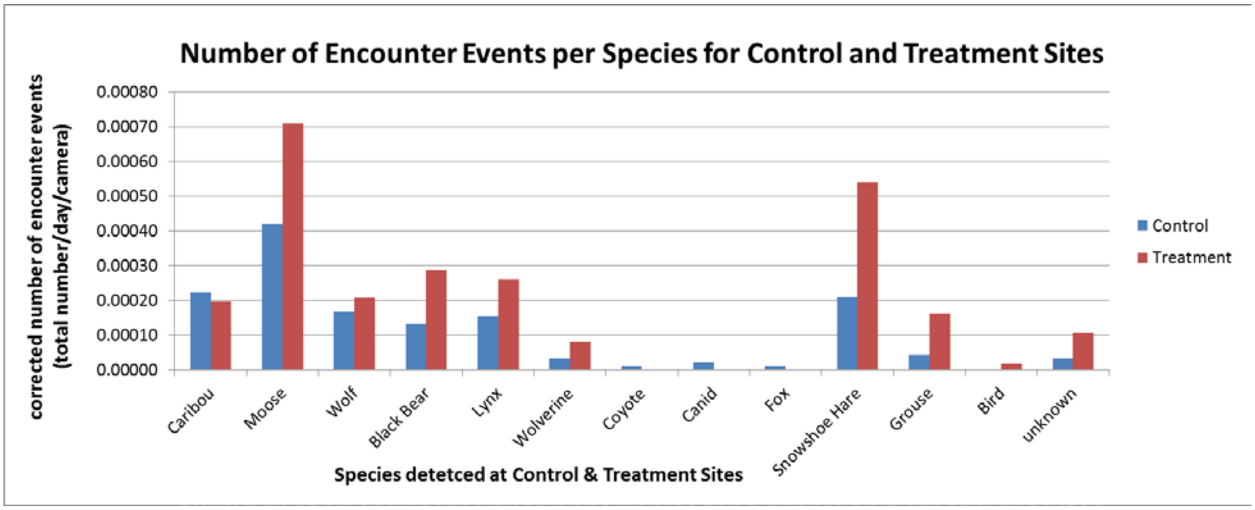

Figure 5: Number of encounters per species for control and treatment sites corrected for camera numbers and days monitored.

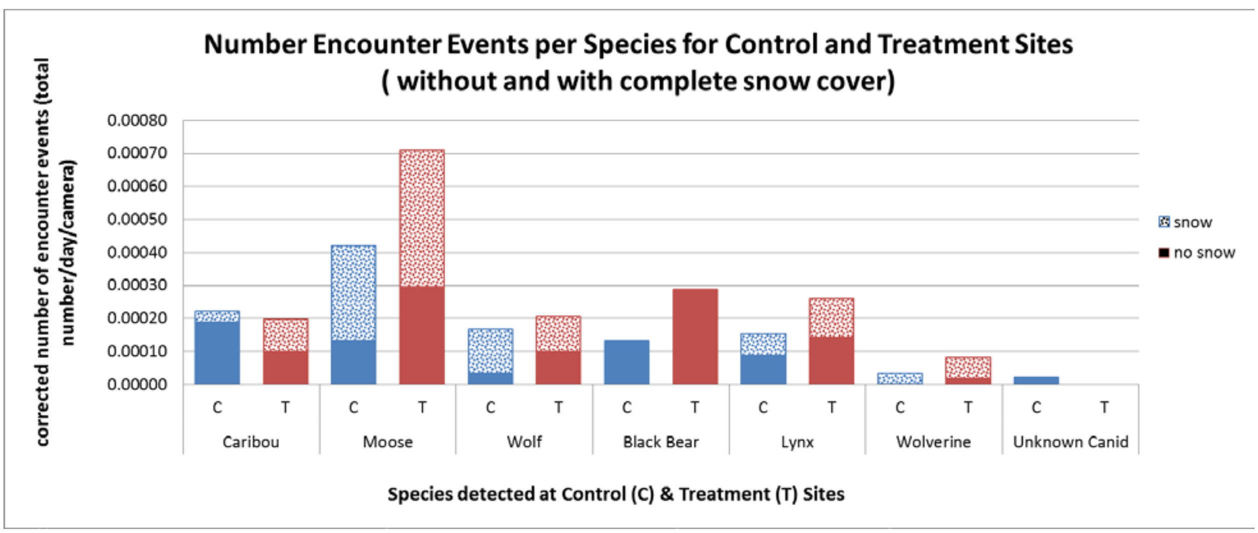

Figure 6: Number of encounters per species for control and treatment sites before and after full snow cover. Numbers are corrected for camera numbers and days monitored.

Summary by Month

Caribou were recorded mostly between September and November with a considerable spike in visits in September (Fig. 7). Moose was detected throughout the whole monitoring period, with the exception of August when no moose was recorded at the control sides (Fig. 8).

Highest encounter rates for wolves were found in August (Fig. 9). Detections were higher in treatment sites throughout the year, except for August directly after lure deployment.

Black bears only occurred before the snow season with the majority of encounter events at the treatment sites (Fig. 10). Highest detection rate was also right after lure deployment.

Detection of lynx was highest in August after lure deployment at both site types (Fig. 11). Encounter events decreased over the following months. Overall control sites saw less lynx activity than the treated sites except December.

Wolverines were only recorded in three of the monitored months (September, November and January) and were apparently not attracted to the deployed lure (Fig. 12).

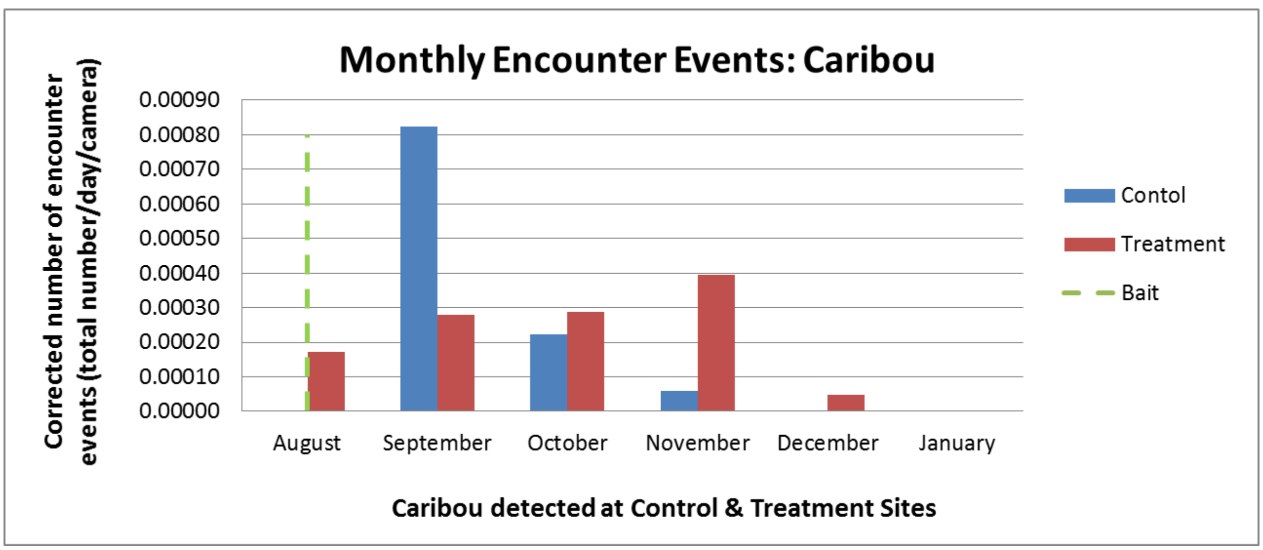

Figure 7: Number of caribou encounters per month for control and treatment sites corrected for camera numbers and days monitored.

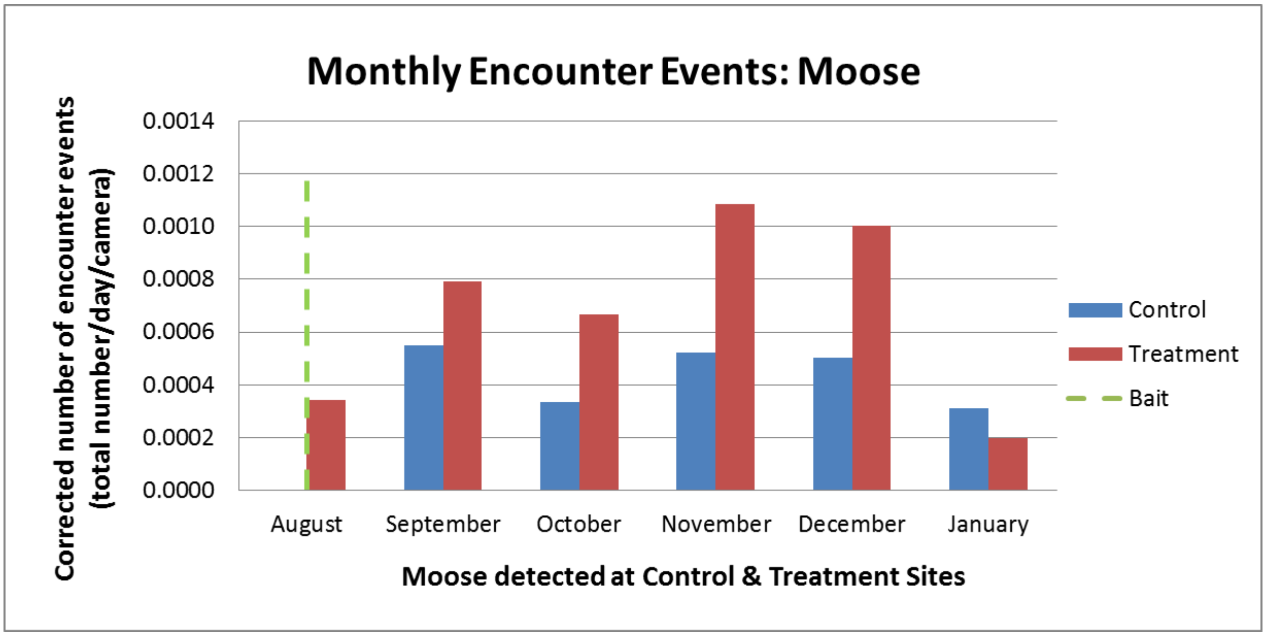

Figure 8: Number of moose encounters per month for control and treatment sites corrected for camera numbers and days monitored.

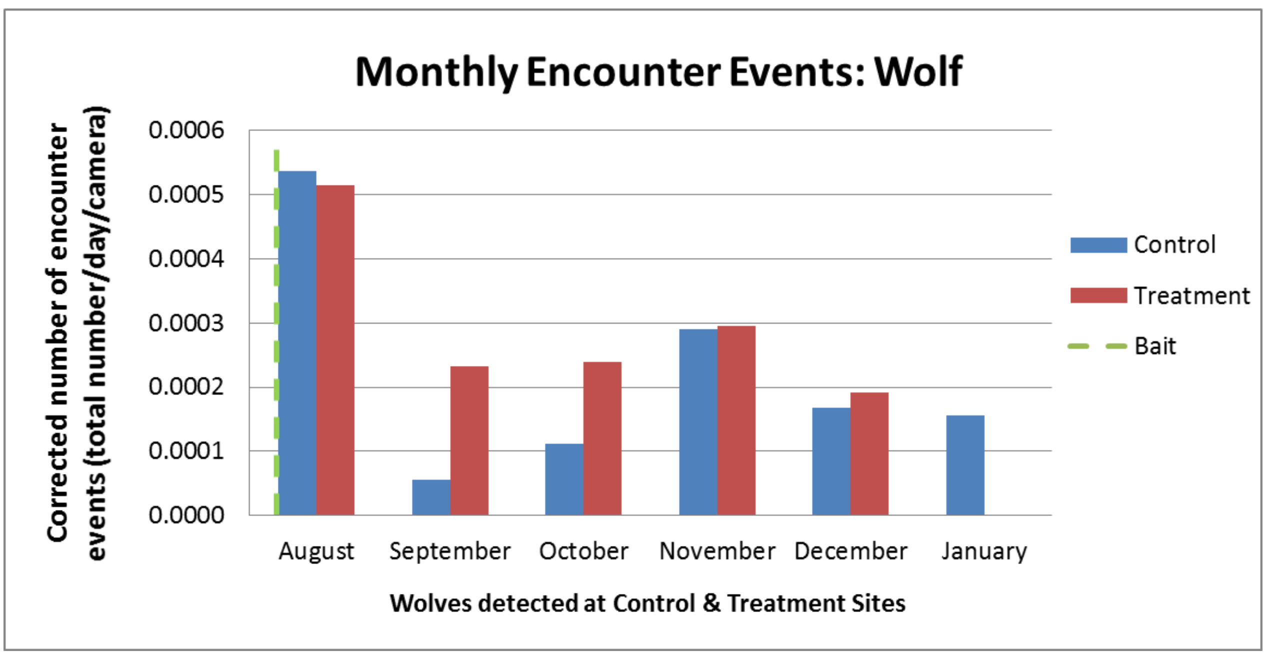

Figure 9: Number of wolf encounters per month for control and treatment sites. Numbers are corrected for camera numbers and days monitored.

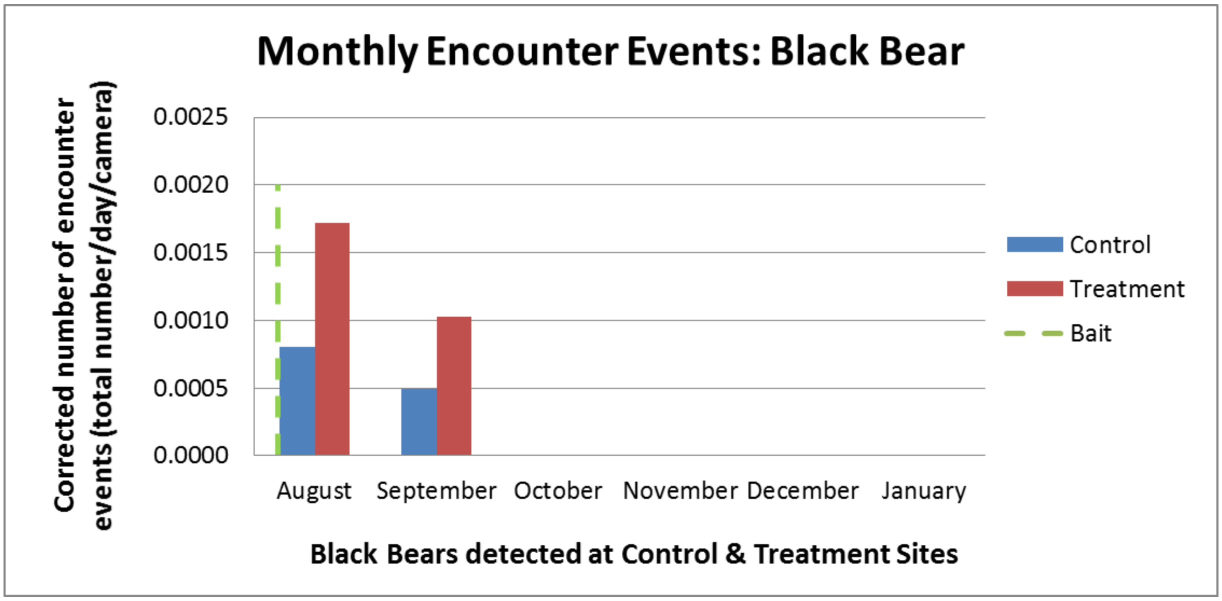

Figure 10: Number of black bear encounters per month for control and treatment sites corrected for camera numbers and days monitored.

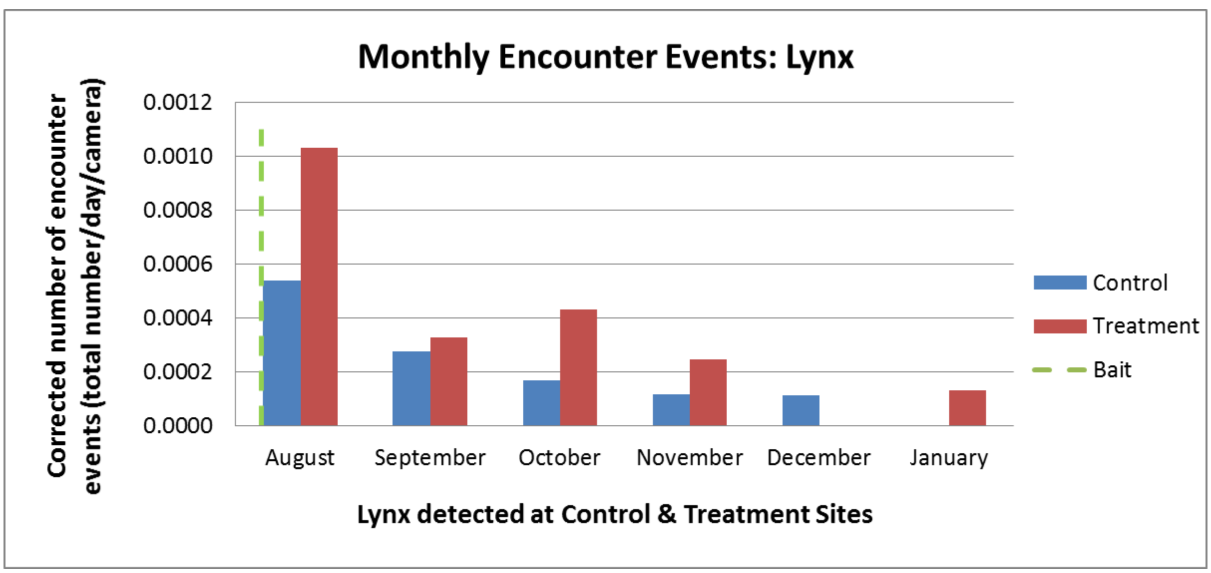

Figure 11: Number of lynx encounters per month for control and treatment sites corrected for camera numbers and days monitored.

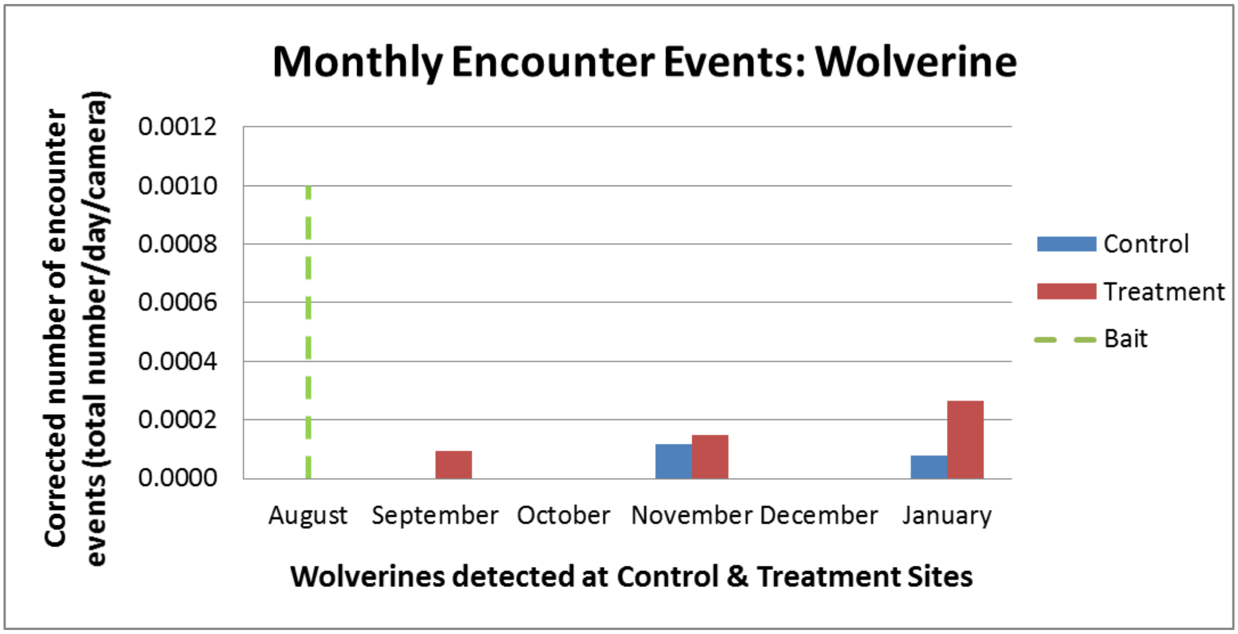

Figure 12: Number of wolverine encounters per month for control and treatment sites corrected for camera numbers and days monitored.

Summary by Land Cover

Upland sites saw the most activity at both site types, followed by bogs (Fig. 13). Fens were the only land cover with a slightly higher number of encounters at control sites. Wolf, black bear, lynx and wolverine had highest numbers of encounters in uplands, in both treatment and control sites (Figs. 14-15). Caribou were mostly seen in bogs. Moose had the widest distribution among land cover types but were least seen in bogs.

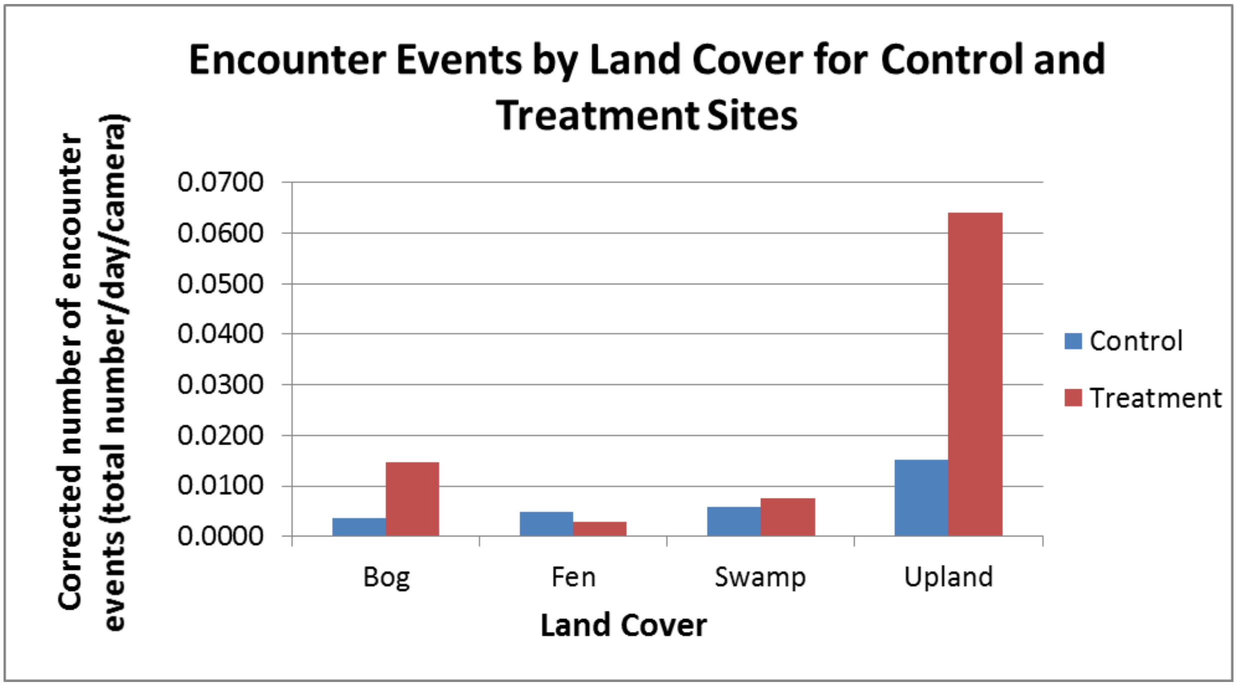

Figure 13: Number of encounters per land cover type for control and treatment sites. Numbers are corrected for camera numbers and days monitored.

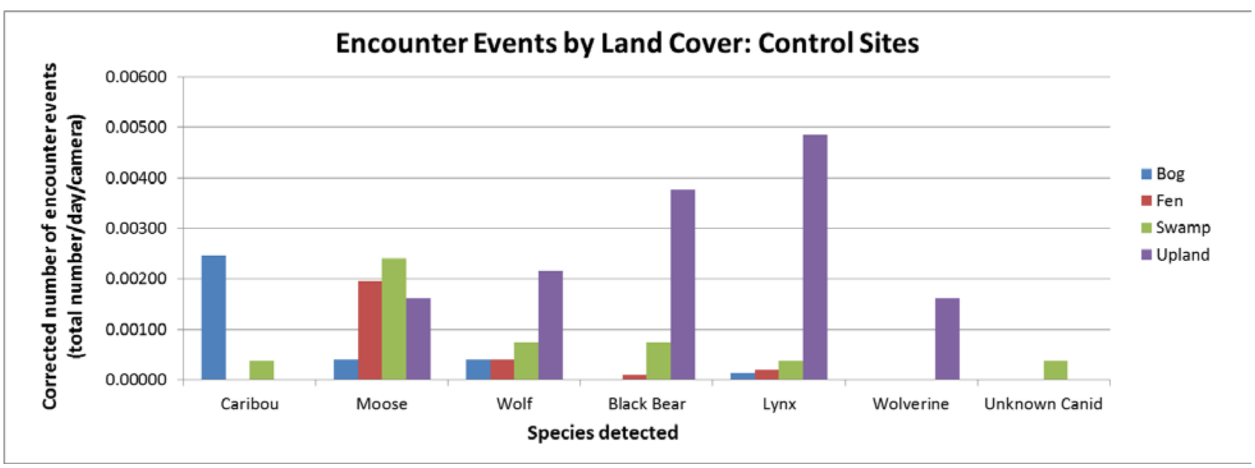

Figure 14: Number of encounters per species and land cover for control sites. Numbers are corrected for camera numbers and days monitored.

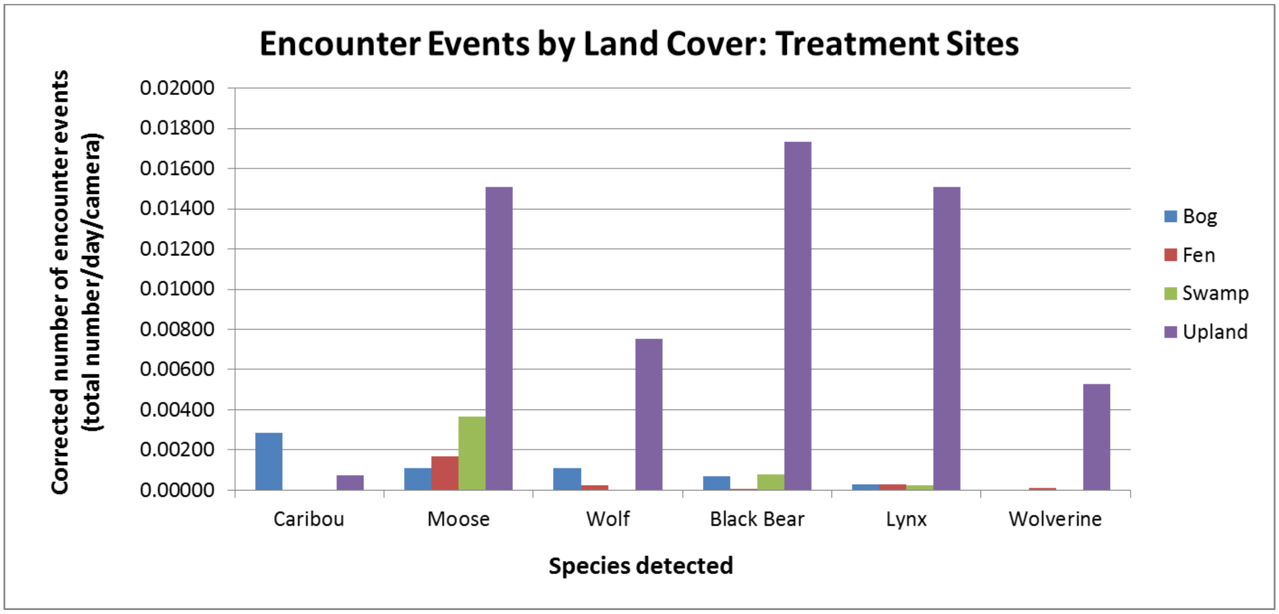

Figure 15: Number of encounters per species and land cover for treatment sites. Numbers are corrected for camera numbers and days monitored.

DISCUSSION / CONCLUSIONS

For 2014, we evaluated whether snow fencing could effectively inhibit wolf use of linear features in a cost-efficient manner. Results of our pilot study suggest this type of barrier may be insufficient to alter wolf use of lines, at least at a site-level scale and at our intensity of deployment. Rather than avoid treated lines, wolves appeared to move around the fencing to access line intersections. This finding may have occurred for two reasons. First, the lure placed at line intersections may have been too great of an incentive to wolves, overcoming any deterrent effect of the fencing. Second, wolves may have found it more energy efficient to simply move around the fencing rather than turning around and finding alternate travel routes. Note that we did not deploy cameras on the lines themselves so it is not clear if the fencing actually displaced wolves off of lines until the intersection was reached.

While our results suggest that snow fencing was ineffective in excluding wolves from line intersections, our inferences are limited by our small sample sizes. We recorded only 14 wolf encounters (three at control sites, 11 at treatment sites) prior to snowfall. This small sample size equates to low statistical power for evaluating differences between control and treatment sites. Nevertheless, treatment sites had more wolf occurrences than controls, which is opposite to our *a priori* predictions, suggesting that snow fencing had minimal to no effect on wolf presence at line intersections.

Our response metric also influenced our ability to assess the efficacy of snow fencing as a line mitigation technique. We evaluated snow fencing using the presence / absence of wolves at line intersections, a metric that was essentially an "all-or-none" evaluation of line treatments. Our results, therefore, do not indicate whether snow fencing decreased wolf movement rates on lines, only that treatments had limited to no effect on wolf presence on lines. If linear features are thought to increase wolf hunting efficiency by increasing movement rates (McKenzie et al. 2012), then line mitigation measures that effectively reduce wolf movement rates on lines – but not necessarily exclude line use – may still be a viable management lever. Assessing the effect of snow fencing on wolf movement rates would require a sample of GPS-collared wolves and more extensive treatment of individual lines, preferably over a predefined area. In this type of design, wolf movement rates could be compared within and outside the treatment area. For 2015, we plan to capture and collar a sample of wolves (n = 5) in the Dilly Creek study area as well as a sample of wolves (n = 5) in the Calendar caribou range. These collars will be programmed for 1-2 week intervals that acquire GPS locations every five minutes to effectively capture and evaluate wolf movements on lines. Depending on initial wolf movements recorded during the spring, we will determine whether further testing of snow fencing effects on wolf movement rates in 2015 is warranted (see *Project Outlook* below).

The effectiveness of snow fencing as a potential movement barrier appears to be limited to the snow-free season. Upon retrieval of the camera data in January, fences were found buried under snow, pushed over by snow and ripped, opening up the linear feature for easy travel again (Appendix: Figure A.2) . This suggests that significant portions of deployed fencing would need to be repaired on an annual basis. These costs should be factored into any cost-benefit analysis associated with this mitigation technique.

We structured this project in an adaptive management framework and results from this first year will inform further testing in the project's subsequent years. Going forward, any further testing of snow fencing will need to use a more intensive design; specifically, treating a larger proportion of the line and deploying the fencing at more tightly spaced intervals. Prior to testing such designs, feasibility and cost-benefit analyses will need to be conducted and compared with other line mitigation techniques (e.g. mounding and coarse woody debris). We further expect that testing of any potential mitigation techniques will be enhanced by the GPS location data from the sample of wolves anticipated to be radio-collared in our study areas in 2015.

PROJECT OUTLOOK

Finding cost-effective techniques for limiting predator use of linear features remains a priority for this project. Although results from the 2014 pilot study were counter to expectations, they still provide a basis for testing alternative techniques and designs in the project's second and third years. For 2015, our first priority is to deploy GPS radio-collars (n = 10) on two wolf packs: one in the Dilly study area and one in the Calendar caribou range. Using movement data collected in the spring from these wolves, we will consider the following avenues of investigation for the upcoming year:

1. Investigating different designs for limiting wolf use of lines
    a. This avenue would build off of insights gained from current line mitigation projects in Alberta where wolf line use has been limited by mounding techniques and the deployment of coarse woody debris (S. McNay, *pers. comm.*). These results have been obtained by treating the entire line, which results in relatively high treatment costs.

Here, we would investigate varying the proportion of the line treated to assess for potential treatment thresholds which could result in reductions of treatment costs.

2. Excluding predators from areas
    a. In 2014, we focused on excluding wolves from specific sites. Here, we would investigate excluding wolves from predefined areas. This would entail deploying line treatments at a larger scale than was tested this past year. Potential treatments could include snow fencing (though in a different design), mounding and coarse woody debris.

3. The use of electric fencing to limit or exclude wolf use of roads
    a. Soft linear features (e.g. seismic lines) are the current focus of most line mitigation projects yet the residual effects of hard linear features (e.g. roads and pipelines) may still impact caribou-predator dynamics. Here, we would investigate the use of electric fencing to limit predator use of roads. Electric fencing has been used to condition predators to avoid livestock pastures (Dorrance and Bourne 1980) but its efficacy for reducing road use had not been tested.

Table 1: Work plan for 2015.

Time Period	Activity	Deliverable
Feb. – Mar.	Radio-collar 2 wolf packs – one in Dilly and one in Calendar	Status report by May 1, 2015
Apr. – Jun.	Monitor wolf movements and identify potential testing areas for line treatments. Retrieve data cards from deployed cameras. Removal of snow fencing.	Status report by July 1, 2015
Jun. – Sept.	Pilot study of line mitigation techniques. Techniques and location to be determined from monitoring wolf movements	Status report by Sept. 30, 2015
Sept. – Dec.	Data analysis and final report preparation	Final report by Dec. 15, 2015

STATEMENT OF EXPENSES

Revenues

Project revenues were higher than anticipated due to increased funding from Nexen (Table 2). For 2014, project revenues were **$501,920**. The funding agreement between Nexen and the University of Alberta was finalized in December 2014, a process that took much longer than anticipated.

Table 2: Expected and realized project revenues for 2014

Funding Partner	Funds Expected	Funds Committed
Nexen	$365,000	$404,670
SCEK	$97,250	$97,250
Total Funds for 2013	**$462,250**	**$501,920**

Expenses

Realized expenses were much lower than budgeted costs (Table 3), primarily due to a scaling back of pilot study costs for 2014 (see *Variance* below). The reduced pilot study also resulted in lower labour and travel costs. Realized costs for cameras and radio-collars were higher than originally budgeted as we elected to increase both the number of cameras (from 50 to 65) and the number of collars (from 8 to 10).

Variance

Realized expenses were lower than budgeted for 2014, resulting in a significant amount of residual funds. This variance was due to a reduction in scope of the pilot study, which resulted from unforeseen delays in the project consulting process and finalizing funding agreements between Nexen and the University of Alberta. Because our project has a multi-year timeline, we anticipate rolling over residual funds into 2015.

Table 3: Total project expenses to date for 2014/2015.

Cost Category	Description		Budgeted	Actual Expense
Equipment				
	Remote cameras, batteries & locks		$32,900	$51,356
	Misc. field equipment		$10,000	$2,809
	Radio-collars for wolves		$28,000	$33,790
		subtotal:	$70,900	$87,955
Pilot Study Costs				
Fence installment				
	Fencing supplies			$8,069
	Fence installation supplies			$240
	Contract worker for fence installment			$4,011
Flight				
	Site selection			$42,118
	Fence and camera deployment			$37,158
	Data card and battery exchange			$12,594
		subtotal:	$300,000	$104,190
Travel				
	Airfare			$2,871
	Accommodation		$6,000	$7,146
	Gas & car rental		$9,400	$5,020
	Snowmobile		$2,400	$0
	Food			$192
		subtotal:	$17,800	$15,229
Labour				
	Research Associate		$37,300	$26,155
	Required training			$171
	First Nations labour		$25,956	$10,279
		subtotal:	$63,256	$36,605
	Project extension		$10,000	$0
	Total		$461,956	$243,979.00

ACKNOWLEDGEMENTS

A special thanks to Fort Nelson First Nations (FNFN) and specifically William Needlay, who assisted in all of the field work and greatly contributed to the success of the project. FNFN Marilyn Norby and Geoff Kershaw coordinated First Nations support staff. Joel Valin Nexen Environmental Officer and Mark Hall, helped with field coordination, safety, and support. Rob Serrouya contributed to fencing design, remote camera installment, and overall field expertise. Laura Corbeil, Jim Wang, and Gilbert Capot-Balnc contributed greatly to fence installment. Andrew Panov was the helicopter pilot for fence and camera deployment and Blair Wilson for winter field work. Ainsley Sykes contributed administrative support throughout the project.

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APPENDIX

I. Photos of installed fences

Figure A.1: An installed fence on a treatment line in summer.

Figure A.2: An installed fence in winter: broken and crossed by tracks.

II. Site specific data

Table A.1: Treatment Site locations and line characteristics.

Deployment Date	Site	Easting	Northing	Game trail	Land Cover type	Line, Length, Accessibility (Easy/Hard)	Vegetation Stage
8/21/2014	T1	549960	6592001	Yes	Bog	N - 25 H, 40 H, 32 E	3
						E - 25 H, 30 H, 35 H	3
						S - 25 H, 55 H, 35 H	3
						W - 25 H, 35 E, 30 E	3
8/22/2014	T2	549174	6588734	No	Bog	N - 25 E, 40 E, 40 E	2
						E - 25 E, 40 E, 40 E	2
						S - 25 E, 40 E, 40 H	2
						W - 29 E, 40 E, 40 E	2
8/22/2014	T9	550053	6590330	Yes	Fen	NE - 25 H, 40 H, 40 H	1
						E - 25 H, 40 H, 40 H	3
						SW - 25 E, 40 E, 30 E	1
						W - 25 E, 40 E, 35 E	1
8/22/2014	T4	551048	6587019	No	Fen	N - 25 E, 40 E, 40 E	1
						E - 25 H, 40 H, 40 H	1
						S - 25 E, 40 E, 40 E	3
						W - 25 E, 40 E, 37 E	1
8/22/2014	T0	553189	6591910	Yes	Bog	NE - 25 H, 40 H, 40 H	2
						E - 25 H, 40 H, 40 H	3
						SW - 25 H, 40 H, 30 H	2
						W - 25 H, 38 H, 40 H	3
8/23/2014	T5	551032	6582841	No	Fen	N - 25 H, 40 H, 40 H	2
						E - 25 E, 40 E, 40 E	1
						S - 25 E, 40 E, 40 E	1
						W - 25 H, 40 H, 40 E	3
8/23/2014	T14	548321	6579482	Yes	Upland	N - 25 E, 40 E, 40 E	3
						E - 25 E, 40 E, 40 E	2
						S - 25 E, 40 H, 40 H	3
						W - 25 E, 40 E, 40 E	2
8/23/2014	T8	557639	6579950	Yes	Fen	N - 25 E, 40 H, 40 E	3
						E - 25 H, 40 H, 40 H	3
						S - 25 H, 40 H, 40 H	3
						W - 25 H, 40 E, 40 E	3

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Deployment Date	Site	Easting	Northing	Game trail	Land Cover type	Line, Length, Accessibility (Easy/Hard)	Vegetation Stage
8/23/2014	T11	558172	6579709	Yes	Swamp	N - 25 H, 40 E, 40 H	3
						E - 25 E, 40 H, 40 H	3
						S - 25 H, 40 H, 40 H	3
						W - 25 H, 40 H, 40 H	3
8/24/2014	T12	552588	6577533	Yes	Swamp	N - 25 H, 40 H, 40 H	3
						E - 25 H, 40 H, 40 H	2
						S - 25 H, 40 H, 40 H	3
						W - 25 H, 40 H, 40 H	2
8/24/2014	T10	555728	6582112	Yes	Swamp	N - 25 H, 40 H, 40 E	3
						E - 25 H, 40 H, 40 E	2
						S - 25 E, 40 H, 40 H	3
						W - 25 H, 40 H, 40 H	2
8/24/2014	T13	548298	6577513	Yes	Upland	N - 25 H, 40 H, 40 H	1
						E - 25 H, 40 E, 40 H	3
						S - 25 H, 40 H, 40 H	1
						W - 25 H, 40 H, 40 H	3
8/24/2014	T3	554085	6587782	No	Bog	N - 25 E, 40 E, 40 E	1
						E - 25 E, 40 E, 40 E	1
						S - 25 E, 40 E, 40 E	1
						W - 25 E, 40 E, 40 E	1
8/25/2014	T7	554090	6579525	No	Fen	N - 25 E, 40 E, 35 E	3
						E - 25 H, 40 E, 40 H	1
						S - 25 E, 40 E, 40 E	3
						W - 25 H, 40 H, 40 H	1
8/25/2014	T6	551008	6586215	No	Fen	N - 25 H, 40 H, 40 H	2
						E - 25 E, 40 E, 40 E	2
						S - 25 H, 40 H, 40 H	2
						W - 25 E, 40 E, 40 E	2

Table A.2: Control Site locations and line characteristics.

Date	Site	X	Y	Game trail	Land Cover type	Line	Veg. Stage
8/23/2014	C7	550962	6581662	No	Fen	N	2
						E	3
						S	2
						W	3
8/23/2014	C4	548062	6588704	Yes	Fen	N	1
						E	1
						S	1
						W	1
8/23/2014	C6	551027	6583920	…	Fen	N	2
						E	3
						S	2
						W	3
8/23/2014	C8	557655	6579687	Yes	Fen	N	1
						E	1
						S	1
						W	1
8/25/2014	C5	547837	6585102	Yes	Upland	N	2
						E	2
						S	2
						W	2
8/25/2014	C2	549667	6586213	Yes	Bog	N	2
						E	2
						S	2
						W	2
8/25/2014	C12	553052	6579510	Yes	Swamp	N	2
						E	3
						S	2
						W	2
8/26/2014	C10	549298	6592019	Yes	Swamp	N	3
						E	3
						S	3
						W	3
8/26/2014	C0	552227	6591930	Yes	Bog	N	3
						E	1
						S	1
						W	1

Cont'd

Date	Site	X	Y	Game trail	Land Cover type	Line	Veg. Stage
8/26/2014	C1	552599	6589683	Yes	Bog	N	2
						E	2
						S	2
						W	2
8/26/2014	C11	553979	6582954	Yes	Upland	N	2
						E	3
						S	2
						W	2
8/26/2014	C14	556342	6582183	Yes	Fen	N	3
						E	3
						S	2
						W	2
8/26/2014	C13	553510	6581909	No	Swamp	N	3
						E	2
						S	3
						W	2
8/26/2014	C3	554111	6591876	Yes	Bog	N	2
						E	3
						S	2
						W	3
8/26/2014	C9	552609	6578710	Yes	Fen	N	3
						E	2
						S	3
						W	2

III. Camera data

Table A.3: Camera deployment information for control sites

Camera ID	ecosystem	Date of Deployment	Date of SD Card Exchange	Days camera in the field	Days monitored	# of pictures	wildlife pictures	time to first detection (days : hours)	total # of encounter events	# of encounters before full snow cover	date of full snow cover
Control											
CO NE	Bog	26-Aug-14	22-Jan-15	149	149	1509	136	17:23	8	7	18-Nov-14
CO NW	Bog	26-Aug-14	22-Jan-15	149	149	122	78	7:9	8	7	27-Nov-14
C1 NE	Bog	26-Aug-14	22-Jan-15	149	149	33	9	15:22	1	1	22-Jan-15
C1 NW	Bog	26-Aug-14	22-Jan-15	149	149	48	8	93:11	1	0	1-Dec-14
C2 NW	Bog	25-Aug-14	22-Jan-15	150	150	90	0	n/a	0	0	
C2 SW	Bog	25-Aug-14	22-Jan-15	150	150	84	13	8:22	3	3	22-Jan-15
C3 SW	Bog	26-Aug-14	21-Jan-15	148	148	781	85	8:32	6	1	26-Oct-14
C3 SE	Bog		missing camera								
C4 NE	Fen	23-Aug-14	22-Jan-15	152	152	40	11	29:6	3	0	21-Oct-14
C4 NW	Fen	23-Aug-14	22-Jan-15	152	152	129	34	8:17	6	3	21-Oct-14
C5 NE	upland	25-Aug-14	22-Jan-15	150	14	52	40	2:18	3	3	no snow
C5 SE	upland	25-Aug-14	22/01/2015	150	150	92	54	4:12	10	5	1-Oct-14
C6 SWS	Fen	23-Aug-14	22/01/2015	152	152	159	100	44:3	18	1	22-Oct-14
C6 SWW	Fen	23-Aug-14	22/01/2015	152	152	23	6	44:15	1	1	28-Nov-14
C7 NE	Fen	23-Aug-14	22/01/2015	152	152	245	21	31:17	3	1	10-Nov-14
C7 SE	Fen	23-Aug-14	22/01/2015	152	152	92	8	110:23	1	0	10-Dec-14
C8	Fen		not recovered								
C8	Fen		not recovered								
C9 NE	Fen	26-Aug-14	23/01/2015	150	150	105	76	18:4	10	4	30-Oct-14
C9 SE	Fen	26-Aug-14	23/01/2015	150	150	51	13	34:1	4	1	9-Jan-15
C10 NEE	Swamp	26-Aug-14	22/01/2015	149	149	105	65	17:17	5	3	21-Oct-14
C10 NEW	Swamp	26-Aug-14	22/01/2015	149	149	110	61	2:6	5	4	10-Nov-14
C11 NE	upland	26-Aug-14	23/01/2015	150	150	171	127	1:18	8	5	24-Oct-14
C11 NW	upland	26-Aug-14	23/01/2015	150	150	161	109	1:18	7	5	2-Nov-14
C12 NE	Swamp	25-Aug-14	23/01/2015	151	151	123	75	35:15	6	1	28-Oct-14
C12 SW	Swamp	25-Aug-14	23/01/2015	151	151	114	47	14:59	6	3	20-Nov-14
C13 NW	Swamp	26-Aug-14	22/01/2015	149	149	96	29	24:7	3	1	24-Oct-14
C13 SW	Swamp	26-Aug-14	22/01/2015	149	149	96	48	78:21	6	0	10-Nov-14
C14	Fen		not recovered								
C14	Fen		not recovered								
# of cameras			total days monitored:		3618		total # of encounters:		132	60	

Table 4: Camera deployment information for treatment sites

Camera ID	ecosystem	Date of Deployment	Date of SD Card Exchange	camera in the field	Days monitored	# of pictures	wildlife pictures	time to first detection (days : hours)	total # of encounter events	encounters before full snow cover	date of full snow cover
T0 NW	Bog	22-Aug-14	21/01/2015	152	152	96	17	60:9	2	1	30-Nov-14
T0 SW	Bog	22-Aug-14	21/01/2015	152	152	180	93	10:12	10	5	18-Nov-14
T0 W	Bog	22-Aug-14	21/01/2015	152	152	78	19	100:1	3	0	27-Nov-14
T1 NE	Bog	26-Aug-14	21/01/2015	148	149	251	105	0:22	11	8	3-Nov-14
T1 NW	bog	26-Aug-14	21/01/2015	148	150	681	542	0:8	67	35	16-Oct-14
T2 SE	Bog		missing camera								
T2 SW	Bog	26-Aug-14	21/01/2015	148	0	2	0		0	0	
T3 NE	Bog	24-Aug-14	22/01/2015	151	151	722	460	1:15	8	3	27-Oct-14
T3 SW	Bog	24-Aug-14	22/01/2015	151	151	815	592	3:8	8	2	27-Oct-14
T4 NE	Fen	22-Aug-14	22/01/2015	153	153	330	45	8:22	9	3	19-Oct-14
T4 W	Fen	22-Aug-14	22/01/2015	153	153	332	24	103:3	3	0	21-Nov-14
T5 NE	Fen	23-Aug-14	22/01/2015	152	152	214	171	73:1	9	2	4-Nov-14
T5 SE	Fen	23-Aug-14	22/01/2015	152	152	159	82	93:3	4	0	10-Nov-14
T6 NW	Fen	25-Aug-14	22/01/2015	150	150	65	3	91:7	1	0	24-Nov-14
T6 SE	Fen	25-Aug-14	22/01/2015	150	150	125	41	81:13	4	0	15-Nov-14
T7 NW	Fen	25-Aug-14	23/01/2015	151	151	107	43	5:7	3	2	10-Nov-14
T7 SE	Fen	25-Aug-14	23/01/2015	151	151	128	82	4:13	11	9	27-Nov-14
T8 NE	Fen	23-Aug-14	23/01/2015	153	153	41	7	147:8	2	0	17-Jan-15
T8 NW	Fen	23-Aug-14	23/01/2015	153	153	42	0		0	0	
T9 NE	Fen	22-Aug-14	22/01/2015	153	153	503	71	23:13	9	5	10-Nov-14
T9 NW	Fen	22-Aug-14	22/01/2015	153	153	330	59	7:11	8	4	10-Nov-14
T10 SE	Swamp	24-Aug-14	23/01/2015	152	152	42	4	87:15	1	0	20-Nov-14
T10 SW	Swamp	24-Aug-14	23/01/2015	152	152	97	0		0	0	
T11 NW	Swamp	23-Aug-14	23/01/2015	153	153	123	42	48:23	9	1	23-Oct-14
T11 SE	Swamp	23-Aug-14	23/01/2015	153	153	171	38	10:16	9	4	8-Nov-14
T12 SE	Swamp	24-Aug-14	23/01/2015	152	152	213	151	17:6	10	5	24-Oct-14
T12 NW	Swamp	24-Aug-14	23/01/2015	152	0	30	0		0	0	
T13 NE	upland	24-Aug-14	23/01/2015	152	21	266	210	0:23	7	7	no snow
T13 NW	upland	24-Aug-14	23/01/2015	152	152	330	259	1:0	28	19	22-Oct-14
T14 SE	upland	23-Aug-14	23/01/2015	153	6	150	3	6:5	1	1	no snow
T14 SW	upland	23-Aug-14	23/01/2015	153	153	804	466	0:17	49	26	3-Oct-14
# of cameras			total days monitored:		3975			total # of encounters:	286	142	