

Monitoring Mammals with Camera Traps: 2012-13 Summary and Recommendations



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31 January 2014
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Summary

The Alberta Biodiversity Monitoring Institute (ABMI) is evaluating the feasibility of monitoring mammals using camera trap surveys. This report summarizes preliminary results and recommendations from pilot initiatives undertaken during 2012-13.

A strategy document was prepared to establish criteria and guide transition from snow tracking to camera trapping, with pilot surveys designed to inform decisions on protocol development under the strategy.



The principal pilot study summarized in this report focused on grassland, parkland and mixedwood habitats in central and southern Alberta. Data were obtained from 87 camera stations sampled for ~6,000 trap-days across 9 sites between June and October 2012. Eighteen mammal species were detected, with deer and coyote being most common. Species coverage suggests that camera surveys can be an adequate replacement for snow tracking. Species accumulation curves imply that 4-6 cameras (or more) should be deployed at a site for at least 2-3 months to increase the probability of detecting less common species. There was no indication that cameras spaced relatively closely (e.g. few hundred meters) had more highly correlated mammal detections than those spaced much farther apart (e.g. several kilometers). Scent lure did not have a strong effect on detection rates of common species but increased detections of less common species (such as smaller carnivores) and is therefore recommended. Some natural attractants also appeared to increase detections rates in this study (e.g. trails, wetlands), but effects were less clear and targeting such features will likely be more difficult to standardize in the ABMI context (relative to lure).

The ABMI Monitoring Centre undertook an operational pilot in north-central Alberta, with 30 cameras deployed across 5 grid sites between May and September 2013. Operational challenges have been summarized (e.g. timing, access, animal damage) and a data processing protocol implemented. Data are not yet available for analysis, but preliminary results suggest at least 12 species were detected, with deer being most common.

A study was undertaken with partners in the Kananaskis area of southwestern Alberta, with data collected from 22 paired camera stations between July and November 2013 (~4700 trap-days). Seventeen mammal species were detected, and scent lure significantly increased detection rates of carnivore species (but not ungulates).

No effect of an alternative lure (dog food and sardines) on mammal detections was seen in a pilot survey conducted with partners in the Athabasca oil sands area. Sixteen paired camera stations were deployed for ~300 trap-days between May and July 2013, and only three species

were detected (black bear, moose and deer). The relatively short sampling duration and randomly selected locations likely led to the insufficient number of detections for reliably testing the effect of this lure. Longer camera deployments are recommended for the ABMI program.

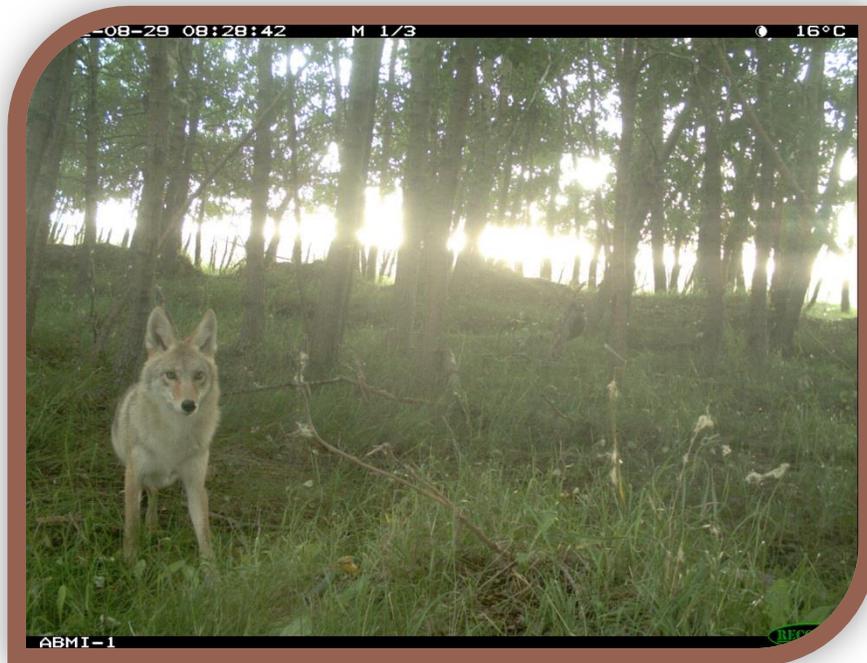
A winter sample was obtained with partners in the Cold Lake area of northeastern Alberta, with 16 camera stations deployed between January and May 2013. Twelve species were detected, and woodland caribou and lynx were among the most commonly detected; however, overall detection rates seemed relatively low and detailed analysis has not been undertaken.

A new camera trap database is being developed through the ABMI's Information Centre and will be ready for extensive testing and use in 2014. Future work will continue addressing components of ABMI's camera transition strategy, including evaluation of response variables and analytical approaches for camera trap data, and calibration with snow track data for trend analysis.

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Burton, A.C. 2014. *Monitoring mammals with camera traps: 2012-13 summary and recommendations*. Alberta Biodiversity Monitoring Institute, Edmonton, Canada.

Acknowledgements

This work was funded by the Alberta Biodiversity Monitoring Institute (ABMI) and supported by contributions from many individuals. From the ABMI: Science Co-Directors Stan Boutin and Jim Schieck provided motivation and guidance for the camera program; Dave Huggard and other members of the Science Centre gave feedback during Science meetings; Colin Twitchell provided insight into operational considerations; Tyler Muhly supplied the scent lures and provided input on sampling design; QiYong (Joan) Fang supported data management and Turar Sandybayev developed the new database; Stephanie Luider managed the Monitoring Centre camera pilot; Pamela Foster, Monica Kohler, and Susy Cote provided administrative and logistical support.



From the University of Alberta, Dario Moreira and Eric Neilson played major roles in planning, field work and data entry. Erin Bayne provided feedback and assisted with design and implementation of sampling at Calling Lake, Meanook, and Foster Creek. Members of the Bayne lab assisted with field work and logistics, including Alex MacPhail, Logan McLeod, Frank Pouw, and Hedwig Lankau. Graeme Nordell helped with data entry and produced an undergraduate class report. Holger Bohm provided advice and managed the WHEC sampling and data entry by WHEC staff (including Amanda Droghini).

John Packzkowski of Alberta Tourism, Parks & Recreation helped direct the Kananaskis sampling and provided logistical support. Many of his staff and volunteers assisted in the field, particularly Tom Partello and Arca Arguelles, and Sandra Code processed the image data. Jason Fisher (Alberta Innovates – Technology Futures), Jon Jorgenson and Jay Honeyman (Alberta Environment and Sustainable Resource Development) facilitated sampling in the Kananaskis area, and Nikki Heim assisted with planning and field work. The work was conducted under Research and Collection Permit No. 13-129 issued by Alberta Tourism, Parks and Recreation, Parks Division. Geoff Sherman (Woodlands North) undertook the winter sampling at Foster Creek.

The 2012 field work was conducted under General Permit 52373 and Collection Licence 52372 issued by the Alberta Fish and Wildlife Division. Several land owners and managers generously provided permission and support for the sampling in 2012, including George Gagne, Derek and Dustin Muise, Barry Irving and Vern Erickson (Kinsella), Dick Purveen (Ellerslie), Lee Foote (Devonian Botanic Garden), Don Armitage and Edward Bork (Mattheis), Neal Wilson (Antelope), and Brandon Nichols (Meanook).

1. Introduction

The Alberta Biodiversity Monitoring Institute (ABMI) monitors a broad range of taxonomic groups and landscape elements across the province of Alberta (www.abmi.ca). The current ABMI mammal monitoring protocol uses winter snow track surveys along 10-km transects to assess the occurrence and relative abundance of mid- to large-sized mammals (ABMI 2012). This protocol was developed by the University of Alberta's Integrated Landscape Management program (Bayne et al. 2005) and was modeled on the Finnish wildlife triangle program (Linden et al. 1996). Bayne et al. evaluated other mammal monitoring methods but concluded at the time that winter tracking was the most cost-effective method. However, shortcomings of the snow tracking methodology have led ABMI to reconsider camera trapping as an alternative approach to mammal monitoring. Specific limitations of snow tracking include: a requirement for suitable snow conditions (i.e., 3-6 days after a track-obliterating snowfall); exclusion of hibernating species of management interest (e.g., bears); difficulty in distinguishing among species with similar tracks (e.g., marten and fisher) and high potential for observer error across the many trackers and large spatial and temporal scales of ABMI monitoring.



Fisher and Burton (2012) reviewed potential benefits of camera trapping as an alternative to snow tracking for ABMI mammal monitoring. They summarized recent literature and results from camera trap surveys in Alberta (Fisher et al. 2011) and suggested the method could reliably detect the range of focal species of interest to the ABMI program. However, they recommended a pilot study to further assess species detection rates (particularly in other parts of Alberta) and the influence of sampling design considerations, such as use of attractants, survey timing and duration, and number and spacing of camera stations.

This report describes several efforts made during 2012-13 to test and further develop camera trap sampling for the ABMI, with a particular focus on a 2012 pilot survey in central and southern Alberta. Several different surveys were undertaken opportunistically in collaboration with other researchers and institutions, with the goal of providing quantitative information to facilitate decisions regarding development of the camera program. The work is part of broader (and ongoing) efforts to develop and implement a camera trap strategy for the ABMI program (see section 2 below). **It should be noted that results presented in this report are based on preliminary analyses, so interpretations and recommendations could be subject to change dependent on more detailed statistical analyses and/or further data collection.**

2. ABMI Camera Transition Strategy

Following the recommendation report in February 2012 (Fisher & Burton 2012), several discussions on evaluating and developing an ABMI camera trap program were held at Science Centre meetings and draft strategy documents were circulated internally (Appendix). Key components contained in the May 2013 ABMI Camera Trap Strategy were as follows:

1. **Cost:** The cost of a new program must not exceed that of the existing snow tracking program (i.e., it must be manageable within ABMI budget constraints).
2. **Species:** The camera program must provide data of equivalent or better quality to the snow tracking program for monitoring trends in occurrence and relative abundance of mid- and large-bodied mammals.
3. **Spatial Design:** A sampling design using multiple cameras (e.g. 4) deployed near the locations of existing ABMI sampling points (e.g. bird point counts) was proposed to facilitate operational logistics.
4. **Temporal Design:** A sampling time frame that overlaps with other terrestrial protocols was proposed to minimize costs and operational constraints (e.g. spring deployment and summer or fall retrieval).
5. **Detection Probability and Bias:** A protocol that maximizes detection rates across target species (to increase precision in trend estimates) and minimizes potential sources of bias over space and time is desired.
6. **Response Variable:** The camera program should produce an index of species abundance that is robust to sampling error and adequately sensitive to change.
7. **Data Management:** Processing and managing the large volumes of image data must be done in a timely and cost-effective manner.
8. **Snow track Calibration:** Given the protocol change, the new camera trapping data should be calibrated against existing snow tracking data to allow trend assessment across both protocols.
9. **Coordinated “Off-Grid” Sampling:** Monitoring inferences from an ABMI camera trap program may be cost-effectively strengthened by promoting standardized off-grid sampling by partnering organizations (such as industry monitoring programs).
10. **Peer Review:** The ABMI camera trap program should be defensible within the scientific community.

Pilot surveys described in this report were primarily designed to assess points 2-5 and 7 of the Strategy (i.e. species detection rates, spatio-temporal sampling design, data management). Other efforts are being undertaken or planned to further address components of the strategy (e.g. simulation modelling, operational assessment by the Monitoring Centre; Appendix).

3. Grassland & Parkland Pilot Survey 2012

3.1 Objectives

During early planning discussions for the ABMI camera program, grassland and parkland habitats of southern Alberta were identified as key areas for which effective implementation of camera trap surveys was considered uncertain and potentially problematic due to extensive agricultural footprint, lack of tree cover for camera deployment, private land owner concerns, etc. A pilot study was therefore initiated to assess the feasibility of deploying camera traps to meet ABMI multispecies monitoring objectives across a range of land uses in southern and central Alberta. Specific objectives included:



- a) Evaluating detection rates for medium- and large-bodied mammal species (i.e., approximately ≥ 2 kg) during a summer sampling period.
- b) Assessing the effect on detection rates of using scent lure and of the number, spacing and location of cameras within a site.

3.2 Methods

3.2.1 Study Sites and Sampling Design

Ninety-two camera stations were deployed across nine sites in southern and central Alberta between 18 June and 12 October 2012 (Fig. 1). These sampling areas were chosen opportunistically based on relative ease of access (including land owner permission) and varied considerably in size, habitat and land use (Table 1).

Each site represented one or more trial sampling units analogous to an ABMI grid site, and multiple camera stations were established within each site to evaluate the following sampling design features:

- A. Camera location:
 - i. Within each site, one or more camera stations were deployed as close as possible to a randomly chosen point (simulating an ABMI terrestrial grid point), and one or more stations were set within a targeted land cover feature (e.g. forest patch, wetland, fenceline, significant trail; Fig. 2).
 - ii. At three sites (Calling Lake, Meanook, and Mattheis), a cluster design was used in which paired camera stations were set ~ 300 m apart within clusters such that one station in a pair was set at a particular feature expected to attract wildlife

(e.g., fenceline, seismic line) and the other was set in the surrounding habitat (e.g., forest or field). Four or five clusters were set, with the distance between them increasing from ~1-5 km (Fig. 3).

- B. Scent lure: We used two designs to examine the effect of scent lure on detection rates (lure described below under Camera Protocol):
- i. We used a “before-after” design at 36 stations whereby cameras were initially deployed without lure (“pre-lure” period, mean = 22.8 days), and lure was subsequently added (“post-lure” period).
 - ii. We also matched 28 pairs of camera stations within the cluster design (Fig. 3), with pairs separated by ~ 300 m and only one station in the pair receiving lure.
- C. Number of cameras: A minimum of 3 camera stations were deployed within each site, with larger sites having more and the 3 cluster design sites have ≥ 20 cameras (Table 1).
- D. Distance between cameras: A minimum distance of ~ 300 m was maintained between all camera stations (corresponding to the distance between ABMI point count stations), but within sites a range of larger distances between stations was evaluated (e.g. Fig. 3).

In assessing the effects of these design features in this report, I have only used relatively superficial exploratory statistical tests (e.g. paired t-tests or Wilcoxon non-parametric tests). I note that more robust statistical models should be considered for further analysis, including estimating effect sizes (e.g. generalized linear models combining multiple covariates per station).

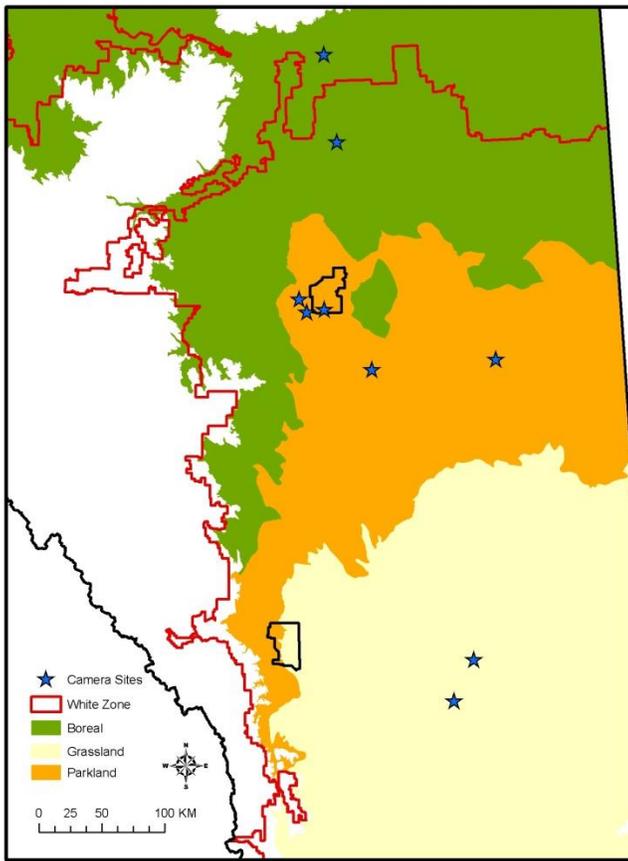


Figure 1. Location of sampling areas for 2012 ABMI camera pilot surveys in central and southern Alberta (details of sites in Table 1. Locations of Edmonton and Calgary outlined in black on map).





Figure 2. Example of camera station placements (red stars) within a sampling area (Stony Plain site), showing a “random” station in the centre, a station targeting forest habitat in the northwest, and a station targeting the fenceline in the southeast.

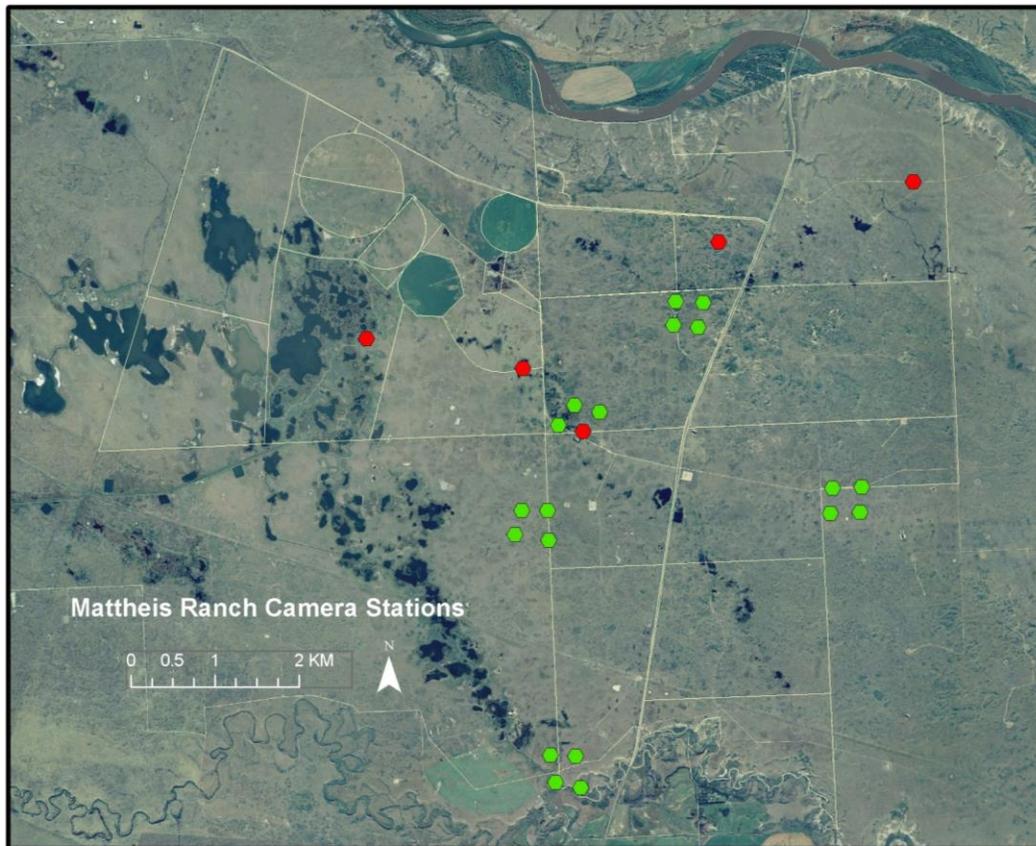


Figure 3. Example of camera station placements in the “cluster” design (green circles; Mattheis site). Each cluster included camera stations paired by treatment (e.g. lure vs. no lure, on vs. off fenceline), and outer clusters were separated from the central cluster by distances of 1, 2, 3 and 4 km. Red circles represent additional Reconyx stations set at different features (e.g. fenceline, wetland, “random”).

Table 1. Details of sampling areas within which camera stations were deployed during the 2012 pilot study.

<i>Site Name</i>	<i>Location</i>	<i>Natural Region</i>	<i>Area (ha, approx.)¹</i>	<i>No. cameras²</i>	<i>Sampling period (2012)</i>	<i>Site Description</i>
<i>Mattheis Ranch</i>	N of Brooks	Grassland	5000	24 (8)	27-Jun to 20-Sep	Rangeland with some irrigated crops
<i>Antelope Creek Ranch</i>	W of Brooks	Grassland	800	5	27-Jun to 19-Sep	Ranching with some oil and gas
<i>Kinsella Research Farm</i>	N of Kinsella	Parkland	2000	6	19-Jun to 11-Oct	Cattle Ranch
<i>Ellerslie Research Farm</i>	S of Edmonton	Parkland	100	3	21-Jun to 12-Oct	Cropland
<i>Camrose area farms</i>	W of Camrose, S of Bittern Lake	Parkland	500	4	2-Jul to 8-Sep	Mixed land uses (crops, settlement)
<i>Devonian Botanic Garden</i>	SW of Edmonton	Parkland	100	3	21-Jun to 12-Oct	Natural cover, recreation area
<i>Stony Plain farm</i>	W of Edmonton	Parkland	50	3	18-Jun to 12-Oct	Crops and cattle pasture
<i>Calling Lake</i>	W of Calling Lake	Boreal	2500	20 (4)	7-Jul to 3-Oct	Fragmented boreal mixedwood forest
<i>Meanook Biological Station</i>	S of Athabasca	Boreal	900	24 (4)	10-Jul to 4-Oct	Fragmented boreal/parkland forest with some pasture

¹ Approximate area covered by a polygon encompassing all camera stations.

² The number of Reconyx PC900 cameras is given in parentheses, with remaining cameras being Bushnell units set in a design using clustered pairs.

3.2.2 Camera Protocol

We used Reconyx Hyperfire PC900 camera trap units at all sites (Reconyx, Inc., Holmen WI, USA, www.reconyx.com). In addition, Bushnell Scout camera units (Bushnell Corp. Overland Park KS, USA; borrowed from Erin Bayne) were deployed at the three cluster sites (Calling Lake, Meanook, and Mattheis; Table 1). Reconyx units were programmed on the “Normal” setting with trigger speed set to medium, high sensitivity, three pictures per trigger with one second delay between each and no further delay between consecutive triggers.

The field protocol (Appendix) involved attaching the camera to a suitable tree or fence post in the target area, or to a wooden stake pounded into the ground where no existing structure was available. Cameras were attached using a Python cable lock and in some case a C-bracket (Reconyx) or modified ammunition box (Bushnell) drilled into the tree or post. Cameras were set ~3-5 m from the target detection zone, at a height of ~70-90 cm, fairly flat but angled slightly down toward the target, and facing north if possible (to avoid sun glare). The specific target zone was determined subjectively based on expected animal movement (e.g., wildlife trail or natural opening with minimal vegetation to obstruct animal movement and camera field of view).

Camera stations were lured using two commercial scent lures purchased from O’Gorman (Broadus MT, USA): “coyote urine” (a liquid) and “long distance call” (LDC, a very pungent paste). These lures were chosen by Tyler Muhly based on expert recommendations, but we note that there are a great many different types of lures available, and little to no systematic research available on differences in their effectiveness (Schlexer 2008). At each lured station, 10 ml of coyote urine was applied to cotton balls inside a 12 cm segment of garden hose (to protect the lure from rain), and a similar amount of LDC was applied to a second hose segment. Hoses were staked to the ground in the target detection zone (~3-5m in front of camera) using garden staples (Appendix). Lures were only applied once (no reapplication since ABMI protocols will not easily allow multiple site re-visits).

3.3 Results

3.3.1 Sampling Effort and Logistics

After accounting for periods of camera inactivity or malfunction, total sampling effort within the 116 day survey period was 6,035 camera-days across 87 active stations. This included 3,454 camera-days for 40 Reconyx stations and 2,581 camera-days for 47 Bushnell stations. In general, Bushnell cameras were less reliable, with 5 stations excluded due to malfunction (no active days) and several others with limited periods of activity. Reconyx cameras performed well but one was stolen before final collection (from Ellerslie) and 5 others had reduced active periods due to disturbance by cows, full memory cards (from vegetation triggers), or other deployment problems.

Mean effort per camera station was 69 days (sd = 29, range = 8 - 116, not counting stations with no active days noted above). Effort by sampling area ranged from a minimum of 281 trap-days at Ellerslie to a maximum of 1,494 at Meanook (mean = 670 trap-days per area).

As anticipated, deployment in grassland areas was challenging due to lack of suitable attachment devices. It was often difficult to securely attach cameras to existing features such as fence posts (difficult to drill into), and pounding in new stakes added considerably to field effort. Disturbance by cattle caused problems as they knocked over or moved cameras such that the field of view was changed or lost (and grazing cattle triggered large numbers of consecutive photos). Moving grass also caused many false triggers, resulting in thousands of photos of vegetation at some sites (clearing vegetation throughout the field of view was not feasible). Field staff also found it difficult to set cameras at randomly selected points, gravitating toward subjective “wildlife” features that were often > 100 m from the pre-selected point.

These logistical challenges did not prevent us from collecting useful data in this pilot; however, if they are deemed problematic for the ABMI design, potential considerations include: investing more field effort in deploying secure posts and protective devices (such as camera boxes available from Reconyx); reducing camera sensitivity in grassy areas (provided it does not significantly reduce detections of target animals); reducing the number of photos per trigger and increasing the delay between subsequent triggers to limit consecutive photos of grazing cattle (provided this will not adversely affect detections of target species); or choosing to set cameras at targeted habitat features (e.g. forest patches, wetlands) rather than random points (provided the potential bias is estimated and accounted for through model covariates).

3.3.2 Species Detections

Approximately 270,000 images were captured during the survey period (consuming ~125 GB of disk space), but over half of those resulted from “false triggers” caused by moving vegetation, which was particularly problematic at open grassland sites. Nearly 50,000 images of wild mammal species were obtained, and over 80,000 of domestic animals (Table 2).

A relatively conservative threshold for “independence”¹ of one detection per species per camera-day resulted in 2,369 detection events across the survey period, and a less conservative threshold of one detection per species per camera-hour yielded 3,735 events (Table 2). For this study I use the former as an index of relative abundance, as well as the alternate index “latency

¹ Consecutive photos should not be considered independent detections, given that cameras repeatedly photograph the same individual(s) as long as it stays in the detection zone (and each trigger resulted in 3 photos as per our Reconyx settings). There are many ways in which camera data can be analyzed, and a detailed evaluation of potential response variables from camera trap data is beyond the scope of this report (but is the subject of a separate literature review in prep.; see also Fisher & Burton 2012).

to detection” (LTD), defined as the number of days from station deployment to the first detection of a given species (Long et al. 2008).²

Eighteen mammal species were detected across all sites and stations (not including humans and domestic animals; Table 2, Fig. 4). White-tailed and mule deer can be difficult to distinguish in many images and were grouped together as “deer” for this report. They were by far the most frequently photographed wildlife species with >40,000 images, being detected at all 9 sites and 71 of 87 stations. Coyotes were the next commonly detected species, followed by moose and lagomorphs (primarily snowshoe hare but also white-tailed jackrabbit – the two species were grouped for this summary).

Mean latency to detection (LTD) for species detected at a minimum of four stations ranged from a low of 9.7 days for deer to highs of 67.0 days for red squirrel and 66.3 for porcupine (Table 2). Mean LTD across all species was 23.4 days (sd = 25.2), however it increased to 36.8 days (sd = 30.8) after excluding the three most common species (deer, coyote and moose). Species accumulation over time across stations suggested that, on average, the number of new species detected at a station leveled off after approximately 2-3 months of sampling (Fig 5).

² I do not try to explicitly estimate the probability of detection using an analytical approach such as occupancy modelling (as recommended in Fisher & Burton 2012) due to uncertainties around model assumptions (e.g. site closure; Efford & Dawson 2012). I note that the relative abundance index used here (daily detection rate), while being straightforward, is also subject to untested assumptions, and therefore that further analysis and alternative indices should be considered. Evaluating the reliability of camera trap indices is another component of the camera trap strategy outlined in section 2 above and will be reported on elsewhere.

Table 2. Species detected and indices of relative abundance across all 87 stations and 9 sites sampled during the 2012 pilot surveys (scientific names in Appendix Table 1).

<i>Species</i>	<i>Prop. Sites</i>	<i>Prop. Stations</i>	<i>Detections per 100 trap-days</i>	<i>Mean days to detection (sd)</i>	<i>Total Images</i>
Deer ¹	1.0	0.82	19.74	9.7 (14.8)	41,607
Coyote	1.0	0.45	6.31	20.7 (19.5)	3,328
Moose	0.56	0.36	1.39	34.1 (22.4)	1,196
Lagomorph ²	0.67	0.10	1.2	40.0 (24.2)	690
Elk	0.33	0.07	0.20	23.7 (14.0)	365
Black Bear	0.33	0.15	0.55	22.6 (20.6)	304
Pronghorn	0.11	0.06	0.35	11.8 (15.9)	251
Red Fox	0.11	0.02	0.20	12.5 (13.4)	110
Badger	0.22	0.03	0.18	32.7 (23.8)	63
Porcupine	0.44	0.08	0.15	66.3 (35.8)	57
Striped Skunk	0.22	0.02	0.03	64.0 (42.4)	15
Red Squirrel	0.22	0.05	0.07	67.0 (24.1)	15
Weasel ³	0.11	0.01	0.02	114.0 (-)	12
Lynx	0.11	0.01	0.02	6.0 (-)	9
Ground Squirrel ³	0.11	0.01	0.03	9.0 (-)	4
Raccoon	0.11	0.01	0.02	33.0 (-)	3
Bird ³	0.67	0.21	2.09	-	1,019
Cow	0.44	0.24	2.55	-	78,670
Horse	0.11	0.01	0.25	-	2,858
Human (motorized)	0.89	0.26	2.20	-	1,526
Human (non-motorized)	0.89	0.23	1.01	-	431
Domestic Dog	0.22	0.03	0.22	-	43
Domestic Cat	0.33	0.03	0.17	-	35

¹ Combined white-tailed and mule deer; ² primarily snowshoe hare but also white-tailed jackrabbit; ³ not identified to species for this report.

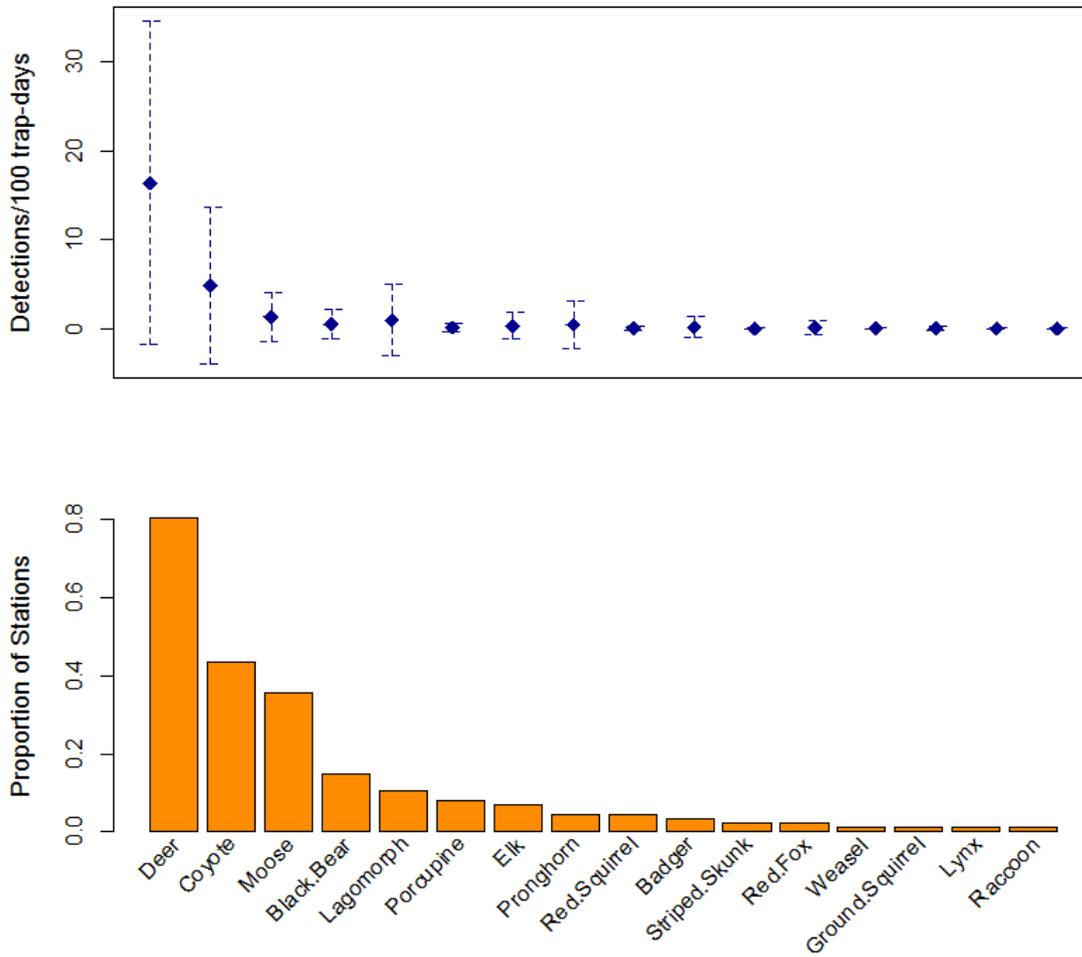


Figure 4. Relative abundance of wild mammal species detected across all 9 sites sampled in 2012. *Bottom*: Proportion of all 87 stations at which species were detected. *Top*: Mean detection rate at a station (detection-days per 100 trap-days), with standard deviation (same species order as in bottom panel).



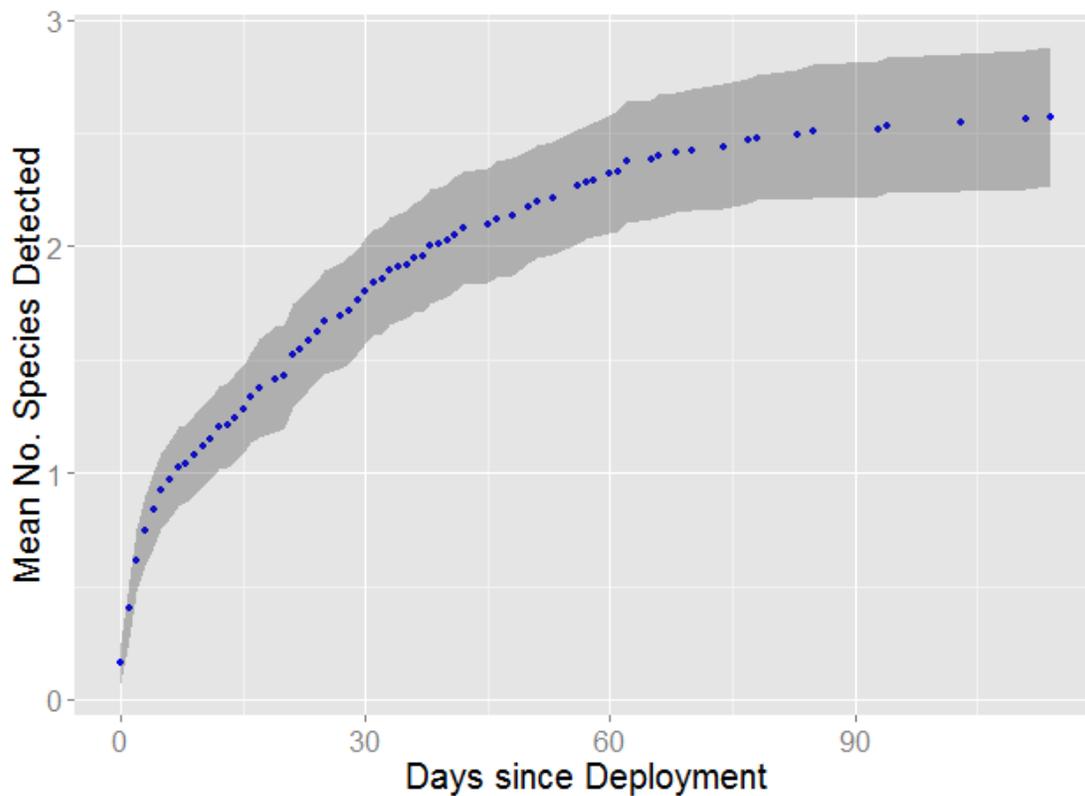


Figure 5. Temporal accumulation of wild mammal species across stations in the 2012 pilot survey, showing mean (and 95% CI) richness per station relative to number of days since camera deployment.

The type of camera trap unit had an important effect on species detections, with the newer high-quality Reconyx cameras detecting more species (and more detections per species) than the older Bushnell cameras (Fig. 6). To avoid confounding variation in detection rates due to camera make with that related to other factors of interest, I restricted some subsequent analyses to only the Reconyx camera stations.

Species detections varied considerably across sites and stations, including both number of species detected and individual species detection rates (Fig. 7, 8). Site-to-site variation could be caused by many factors and is less relevant for this report; spatial variation among stations within a site is examined in more detail below.

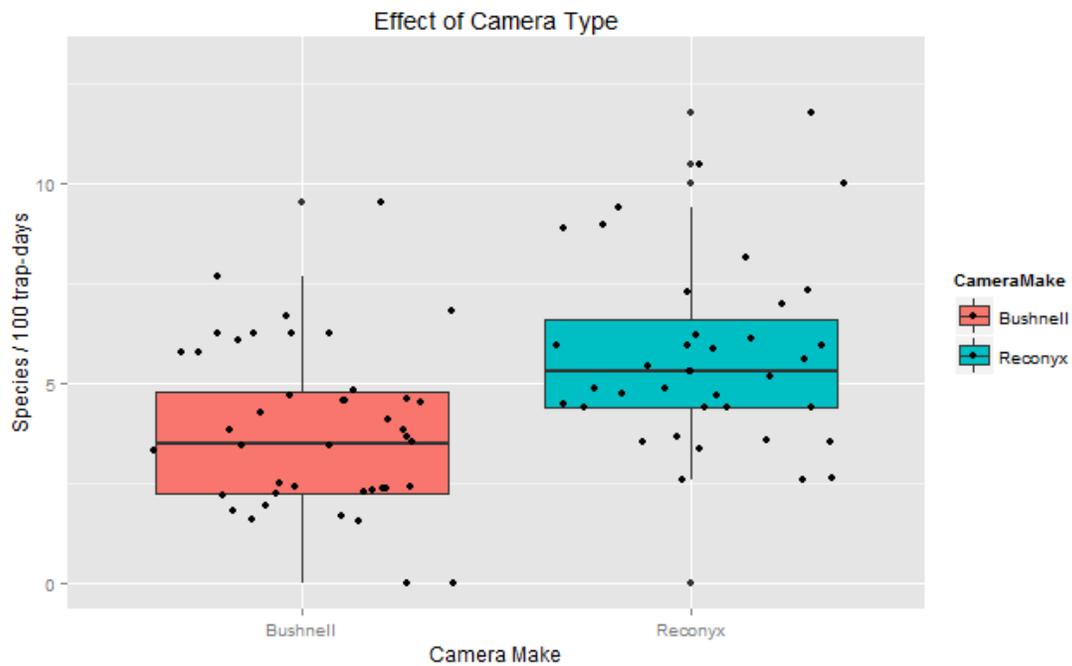


Figure 6. Difference in number of species (or groups) detected (corrected for effort) between the newer Reconyx PC 900 (n = 40) and older Bushnell (n = 47) camera units. Results were similar for detection rates and when considering only wild mammal species.

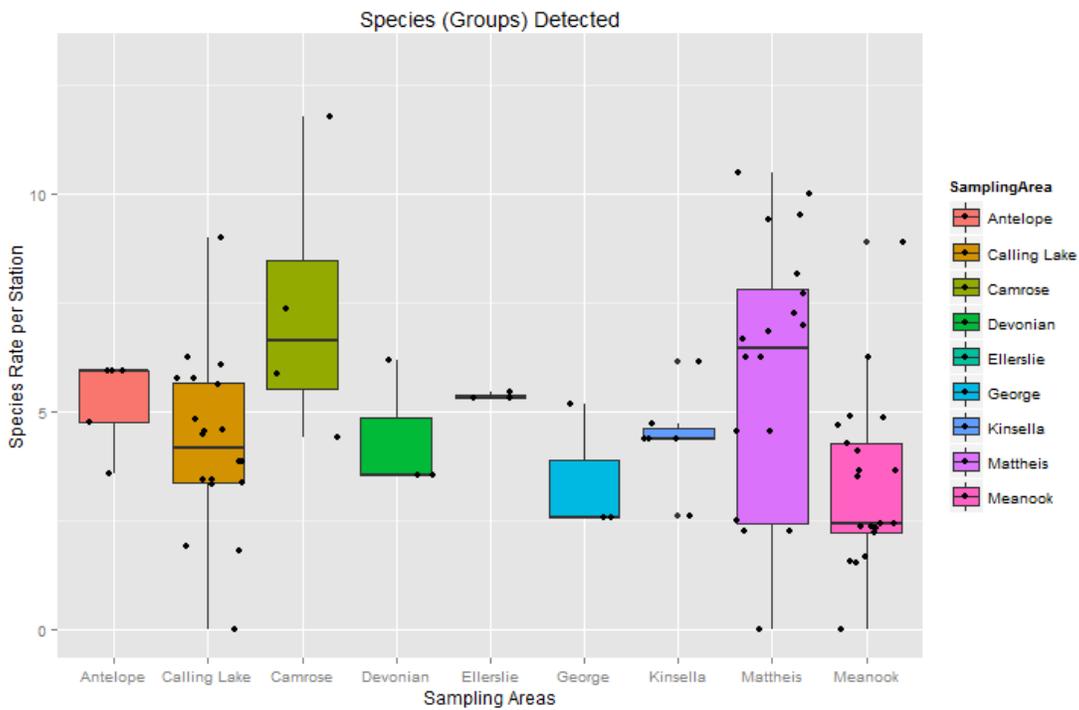


Figure 7. Variation in number of species detected (corrected for sampling effort) across sites, and across stations within sites, during 2012 pilot. Results were similar for detection rates.

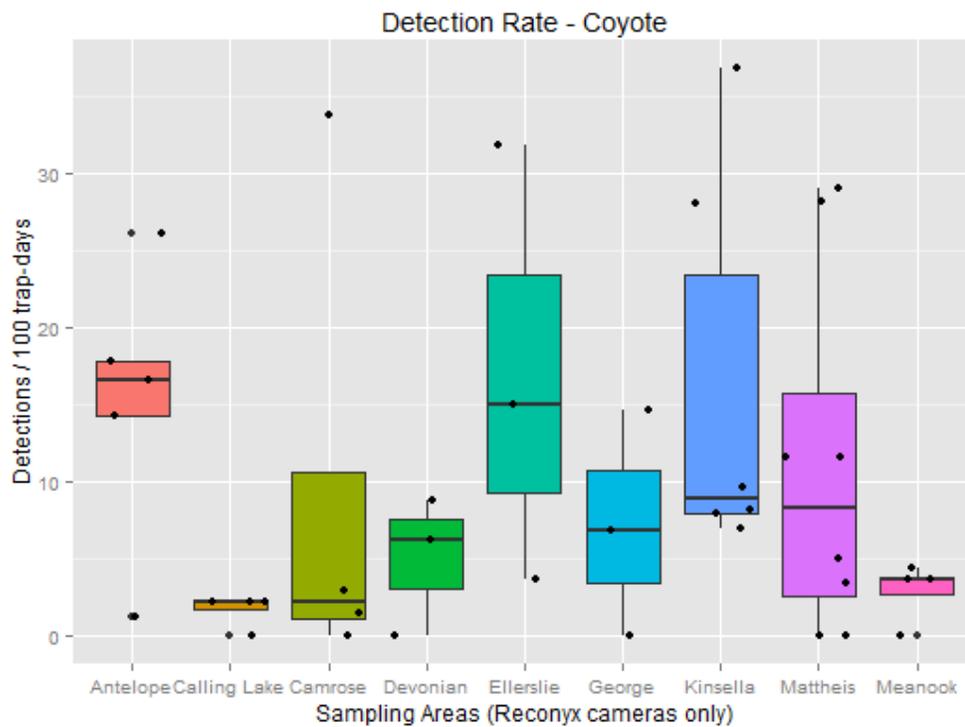


Figure 8. Detection rate of coyote as an example of variation in species detections within and between sites in 2012 pilot.

Overall detection rates did not vary systematically with time over the mid-June to early-October survey period, indicating that there were not strong seasonal effects influencing detection during this period (Fig. 9; this analysis has not been done for individual species).

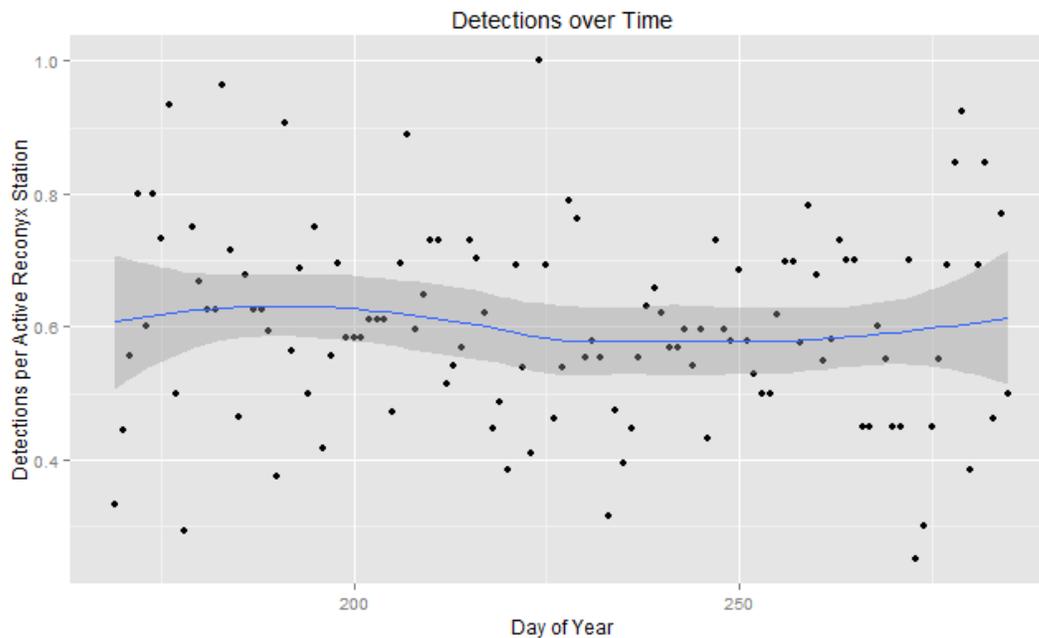


Figure 9. Daily detection rate across all species (at Reconyx stations) over the 2012 pilot survey period (18 June to 12 October).

3.3.3 Effect of Lure

Comparing periods before and after lure deployment ($n = 36$ camera stations), there was no indication that the use of scent lure had a strong effect on the overall mammal detection rate (i.e. daily detections per camera-day summed across all wild mammal species; paired tests $p > 0.2$; Fig. 10A). However, the number of species detected at a station (relative to trapping effort) was significantly higher during the weeks immediately following lure deployment (even though it was marginally lower across the entire post-lure period; paired tests $p < 0.01$; Fig. 10B). This result was driven by higher detection rates for many uncommon species following lure deployment (Fig. 11B). For example, mean detection rate for a group of carnivores (except coyote) and smaller mammals was 4.5 times higher post-lure relative to pre-lure (Fig. 11B), whereas the detection rate for the two most common species (deer and coyote) was higher before lure deployment (Fig. 11A).

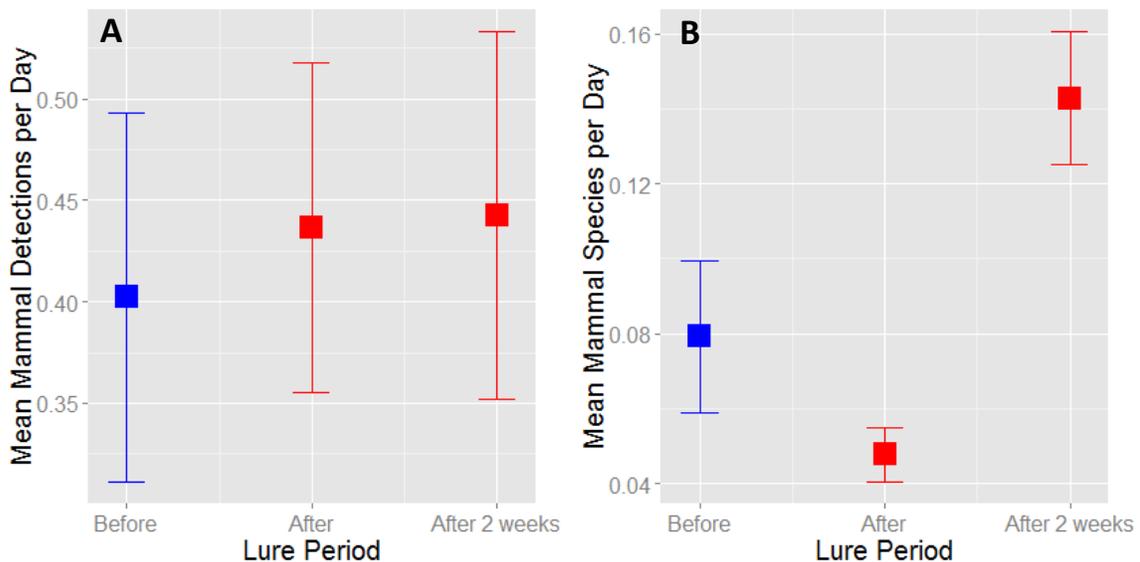


Figure 10. Comparison of mean detection rate for all mammal species (A) and mean number of species detected per trap-day (B) for the periods before and after deployment of scent lure, including only the 2-week period immediately following lure deployment (bars represent 95% CI, $n = 36$ stations. Differences in panel B were significant at $p < 0.01$ in paired tests).

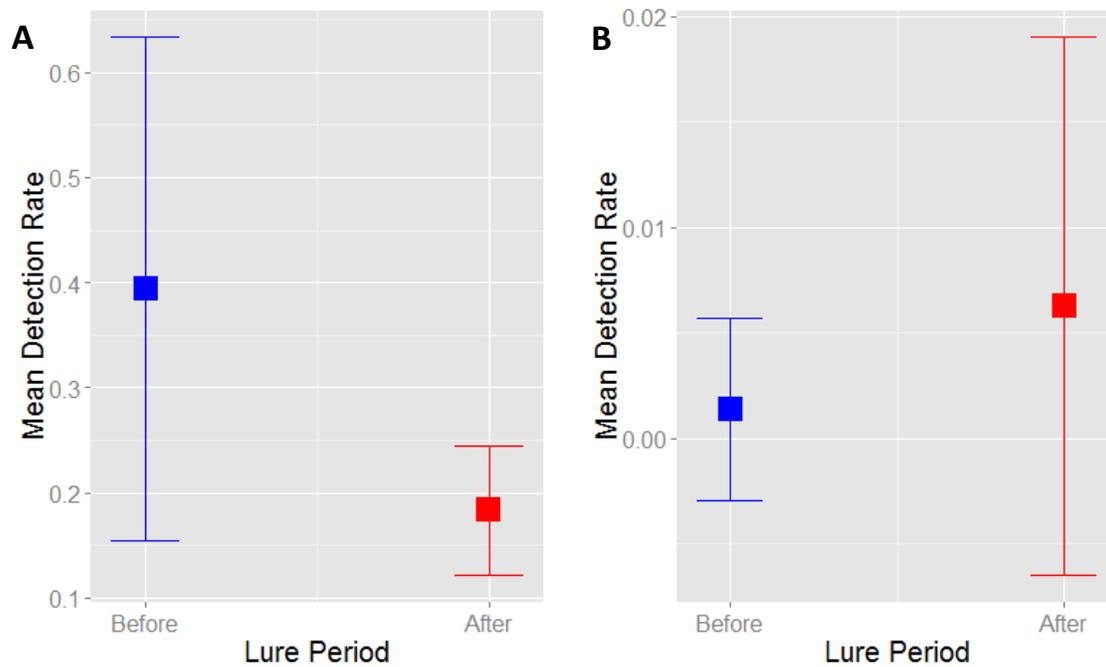


Figure 11. Mean detection rates (and 95% CI) before and after lure deployment (n = 36 stations) for A: the two most common species (deer and coyote), and B: a group of less common species (badger, black bear, ground squirrel, lagomorph, lynx, porcupine, raccoon, red fox, red squirrel, striped skunk, weasel).

Latency to first detection (LTD) did not vary systematically between pre- and post-lure periods across species, suggesting that application of scent lure did not result in a strong or consistent shortening of sampling time required to first detect a species at a station. Mean LTD was shorter post-lure for some species (e.g. badger, red fox), but given the relatively small number of detections for such species it is difficult to reliably estimate the effect.

Similar results were obtained when comparing detection rates between paired stations set within the cluster designs at Calling Lake, Meanook and Mattheis. Twenty-eight camera pairs were set with one of the two cameras receiving lure. There was no significant difference in detection rates across all mammals and for common species like deer and coyote ($p > 0.1$, Fig. 12); however the detection rate for less common species was significantly higher at lured stations ($p < 0.05$; Fig. 12). Mammal richness was also higher at lured stations (Fig. 12), although the effect was not statistically significant ($p = 0.08$), likely due to the fact that several uncommon species were not represented in this sample from the paired stations (e.g., badger, skunk, red fox, raccoon).

There was no significant difference in mean LTD between paired lured and unlured stations across all species. The number of detections in both treatments was too small for robust assessment of variation in LTD with lure for most species. Among the most commonly detected species, there was an indication of lower mean LTD with lure for deer and black bear, but not for coyote and moose.

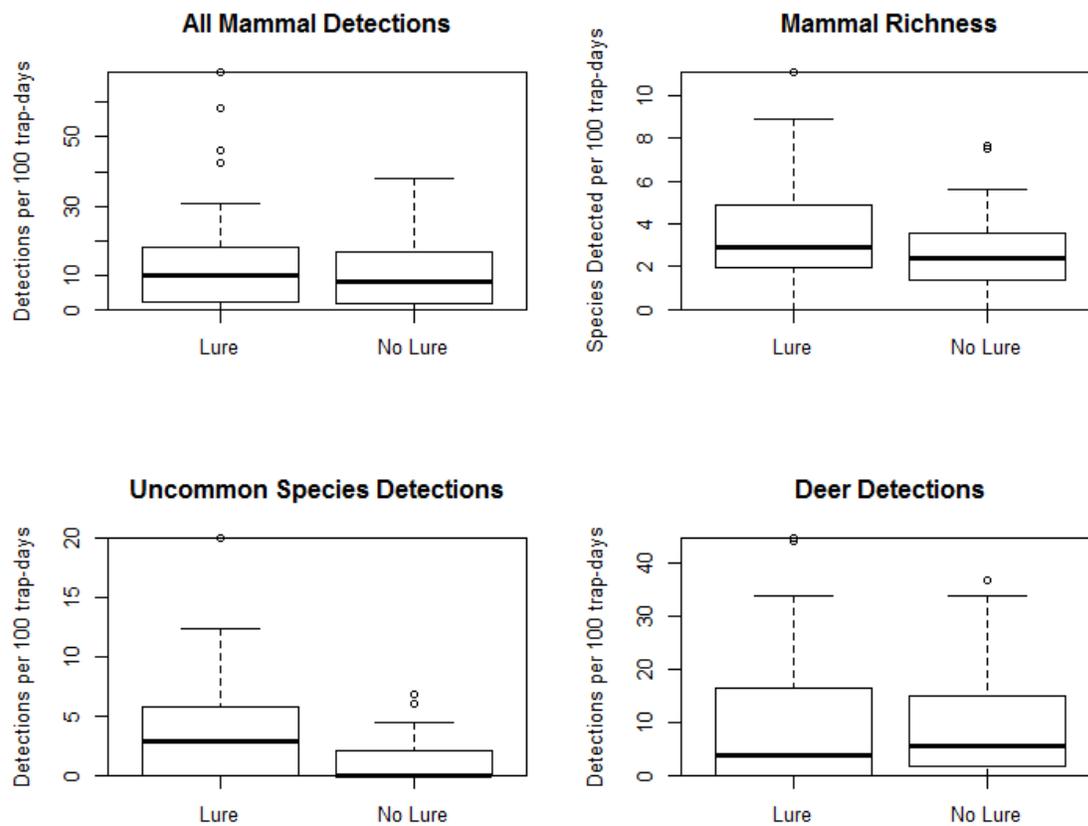


Figure 12. Comparisons between paired lured and unlured stations set in the cluster sampling designs at Calling Lake, Meanook, and Mattheis sites (n = 28 pairs). Lure had minimal effect on overall detections rates or those of common species (e.g. deer and coyote), but increased the number of species detection at a station and the detection rates for uncommon species (i.e. excluding coyote and deer). Boxplots show median (bold line), interquartile range (box), and 1.5 times interquartile range (whiskers).

3.3.4 Effect of Location, Number, and Spacing of Cameras

As noted above, there was considerable variation in detection rates across stations within sampling areas (Fig. 7, 8). This could be related to many factors (including stochastic variation in animal movements relative to cameras) but two key questions are:

- 1) Was the variation related to sampling factors such as camera location?
- 2) How many cameras should be deployed to get a representative sample of the species using the sampling area (and how far apart should they be)?

The mammal detection rate (across all species) was significantly higher at camera stations that targeted a particular feature than at stations set at more random locations ($p < 0.01$; Fig. 13). The effect appeared to be more pronounced for stations targeting substantial trails and specific habitats (wetland, forest patch), and less so for fence lines, seismic lines, and forest edges (Fig. 13; although sampling was not balanced across types). The general effect of targeting camera location was not significant with respect to the number of mammal species detected at a station, although there was a significant increase in richness at stations set along game trails ($p = 0.04$, Fig. 14). The attractive effect of trails was seen across both common and uncommon species (Fig. 15).

It should be noted that our sampling design as implemented did not provide a strong test of the effect of camera location (i.e. location “treatments” were not always well-balanced or consistent in the field), and also that other factors were not controlled in these preliminary comparisons (such as lure). Across the reduced set of paired camera stations set within the cluster design (i.e. matched by on vs. off a feature; $n = 28$ pairs), the differences between detection rates at targeted vs. “random” stations were not significant (not shown).

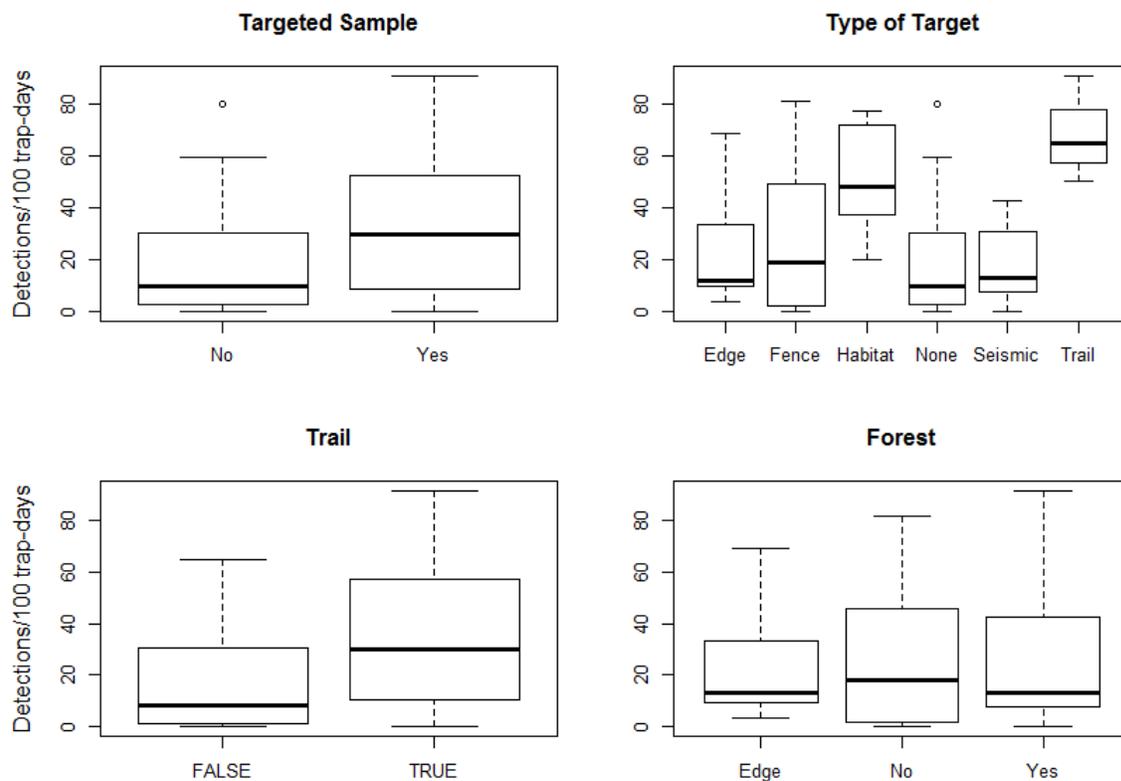


Figure 13. Effects of camera location on detection rate across all wild mammal species ($n = 87$ stations in total), showing: stations targeting particular features (“Yes”) vs. those set close to random locations (“No”, top left); stations set at particular types of features (top right); stations set at significant game trails (“TRUE”, bottom left); and stations set in forest patches (“Yes”) or at forest edge (bottom right).

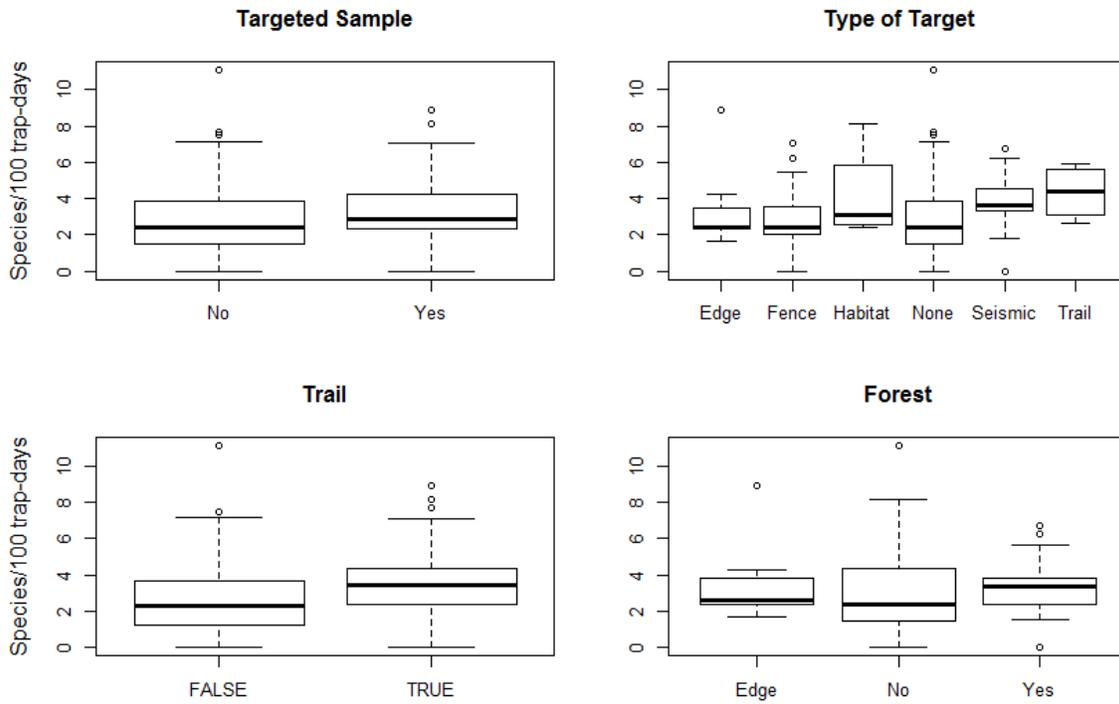


Figure 14. Effects of camera location on the number of mammal species detected (per 100 trap-days; n = 87 stations in total). Panels are the same as for Fig. 13.

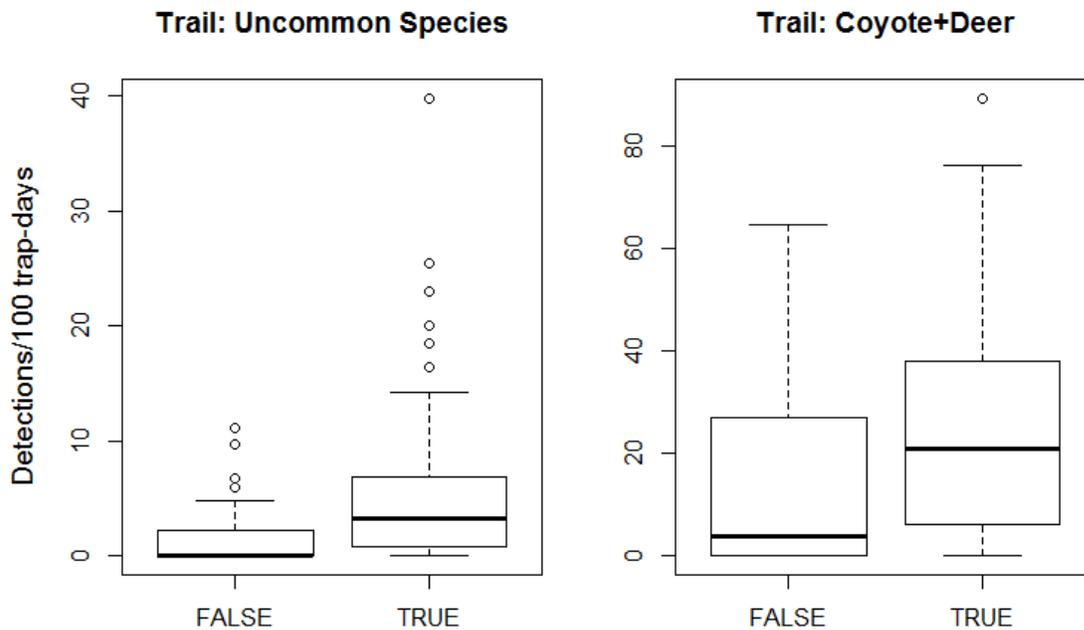


Figure 15. Camera stations set at game trails (= “TRUE”) had higher detection rates for common species like coyote and deer (right) as well as less commonly detected species (e.g. other carnivores, smaller mammals; left; $p < 0.05$ in both cases).

With respect to the number of cameras, accumulation of species across camera stations within sites supports a design with multiple cameras at site. The number of species detected in a sampling area increased with the number of stations, levelling off at 3-4 stations for some sites but continuing to increase with 5-6 stations for other sites (Fig. 16). Only Reconyx stations were included in this analysis (implemented in R package *vegan*) because of the lower detectability with Bushnell stations (leading to slower species accumulation), and it should be noted that the distance between stations varied across sites (see below).

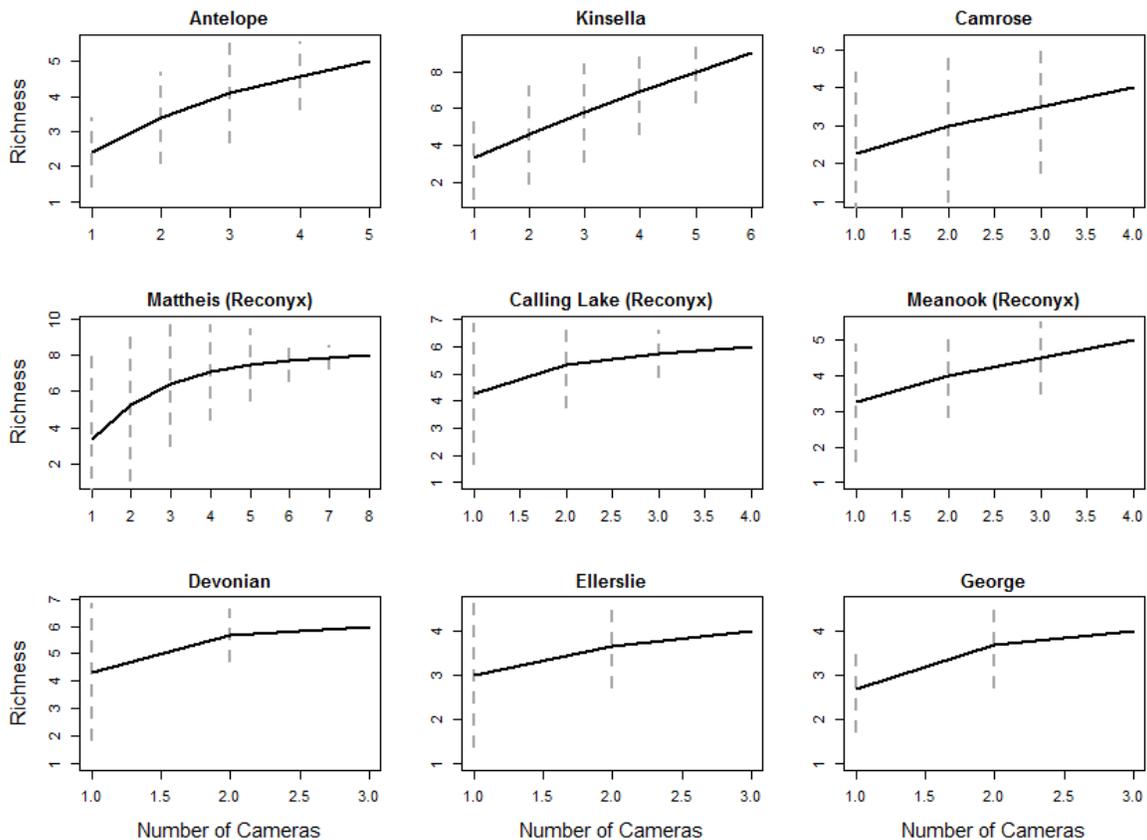


Figure 16. Species accumulation curves showing the number of wild mammal species detected relative to the number of camera stations within a sampling area (confidence intervals calculated across stations using the “exact” method in R package *vegan*).

Mean distance between camera stations within a site was 2.7 km but ranged from a minimum of 130 m to a maximum of 8.3 km. As a preliminary assessment of the relationship between spacing and mammal detections among stations, I compared the dissimilarity in detections between stations with their Euclidean distance. Community dissimilarity was calculated as the Bray-Curtis index in R package *vegan*, based on the community matrix at each site (i.e. species detection rates across stations), and a Mantel test was used to test the correlation between dissimilarity and distance. There were no significant correlations between community dissimilarity and distance across all nine sites, suggesting that mammal detections were not more similar between nearby stations than between more distant stations. Further assessment

of variation in mammal detection rates with distance is beyond the scope of this report; future work may consider analysis of spatial autocorrelation to further investigate spatial (in)dependence among stations at a site.

3.4 Discussion and Recommendations

Among mammal species that have been detected in ABMI snow track surveys (Appendix) and whose ranges overlap substantially with the surveyed areas in south-central Alberta, only three wetland species were not detected in this pilot study (mink, muskrat, and beaver). Weasels and other small mammals were detected less frequently by cameras than in snow track surveys. These results are expected given the relatively small number of sites surveyed in this pilot and the fact that wetland habitats were minimally targeted and that cameras are likely to be less sensitive for detecting small mammals (unless specifically targeted). This camera pilot detected three mammal species not detected in snow track surveys (black bear, raccoon, and ground squirrel). While a detailed comparison of camera trapping and snow tracking is beyond the scope of this report, the indication from this pilot is that **camera surveys will be an adequate replacement for snow tracking in terms of the species detected in this region.**

Species accumulation curves from this study suggest that **4-6 cameras (or more) should be deployed at a site for at least 2-3 months** to increase the probability of detecting less common species that may be using the site. There was no indication that mammal detections were strongly correlated with the distance between camera stations within a site, suggesting that relatively close **spacing such as the 600 m proposed for ABMI sites should achieve some sampling independence** (although more detailed evaluation is warranted).

Scent lure did not have a strong effect on detection rates of common species but did appear to increase the detectability of less common species such as smaller carnivores. Given that these species form an important part of multispecies monitoring, **the use of scent lure is recommended based on these results** (specifically O’Gorman’s Long Distance Call). Further work should test the effect of lure in other areas (e.g. see Kananaskis study below), and may consider testing other types of lure. More analysis is also warranted to better estimate effect sizes across species and the corresponding significance for statistical power in trend monitoring.

There was an indication that natural attractants such as game trails and wetlands increased species detection rates in this study (although other hypothesized attractants like fence lines and seismic lines did not have a strong effect). It may be effective to target such features within a site, particularly given that deploying cameras at randomly selected locations entailed some problems (e.g. uncertainty from field teams, greater field effort such as for post-pounding, and more disturbance from cows and vegetation). However, our sampling design did not provide a strong test of natural attractants, and these also were found to vary considerably with location. I therefore suggest that **scent lure is a more effective attractant, and that use of natural attractants be further evaluated (including recording covariates at stations to be included in subsequent models of variation in detection rates).**

4. Monitoring Centre On-Grid Pilot 2013

A pilot study was undertaken by the ABMI Monitoring Centre (MC) to evaluate the operational considerations of deploying camera traps and autonomous recording units (ARUs) at ABMI grid sites. Thirty cameras were deployed at five ABMI sites in north-central Alberta (High Prairie-Peace River area, Fig. 17) between May and September 2013. Deployment followed a



sampling protocol entailing four cameras at point count stations and two cameras at a wetland near the site (Appendix). Stephanie Luider of the MC is managing this pilot and has prepared a report summarizing results from an operational perspective (Appendix). We trained MC staff in our data entry protocol (Appendix) and Stephanie is implementing a QA/QC process to ensure reliable image classifications. Data from the pilot were not available in time to be included in this report, but they should be available early in 2014. A preliminary tally of species captured in ~ 2/3rds of the dataset (~ 20,000 of > 36,000 total images) was prepared by Stephanie and is shown in Fig. 18, indicating that deer are again the most frequently detected species.

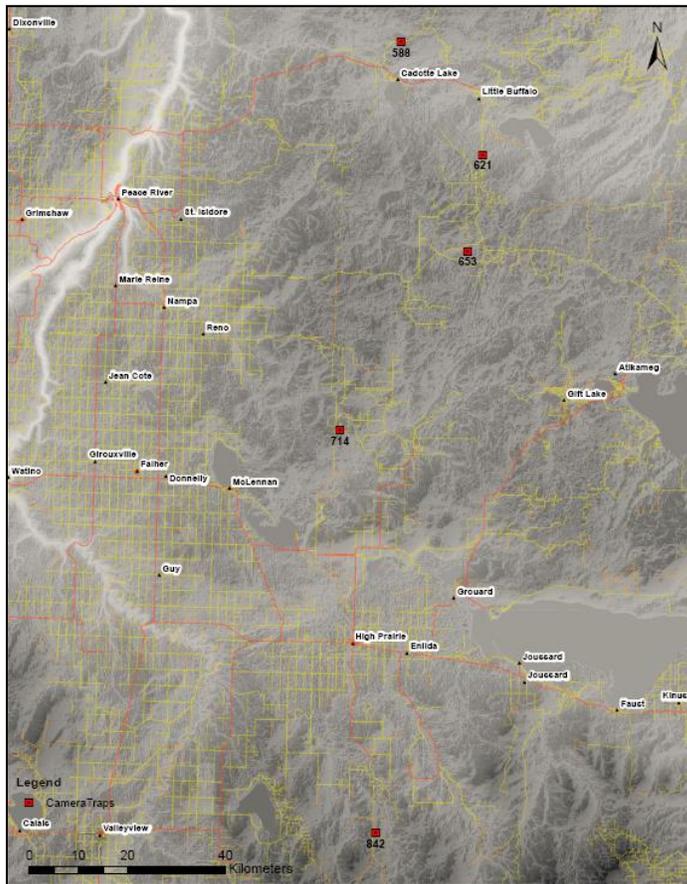


Figure 17. Location of 5 ABMI sites where 30 camera stations (6 per site) were deployed between May and September 2013 for the Monitoring Centre pilot (map by S. Luider).

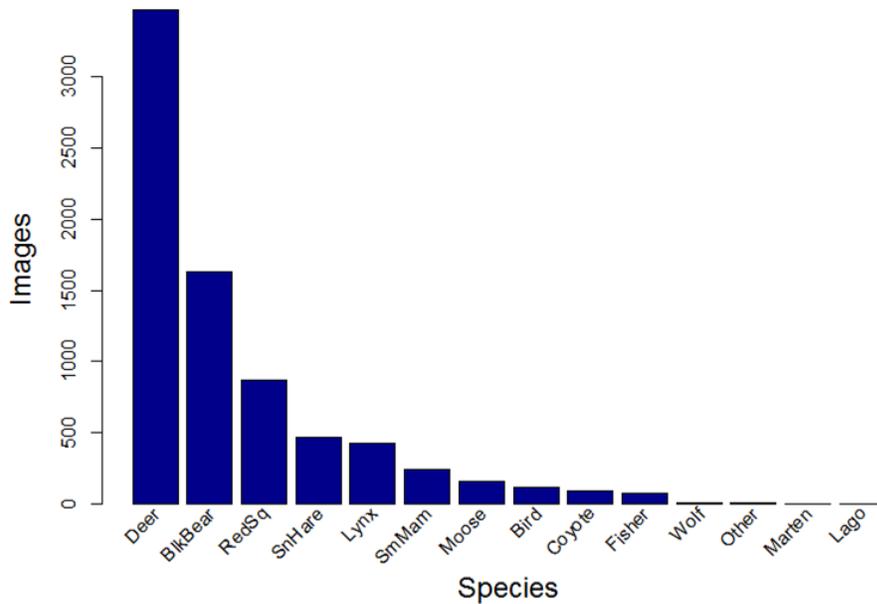


Figure 18. Preliminary tally of species images captured during the 2013 Monitoring Centre pilot, based on processing of ~2/3rds of the total images.

5. Kananaskis Pilot 2013

5.1 Objectives

The primary objectives of this pilot project were to a) assess camera-trap detection rates across mammal species in a different region from other ABMI pilot projects, and b) provide another test of the effect of scent lure on detection rates. This project was done in collaboration with Alberta Tourism, Parks and Recreation; Alberta Environment and Sustainable Resource Development, and Alberta Innovates – Technology Futures (a data sharing agreement is being arranged with John Paczkowski, ATPR).



5.2 Methods

Twenty-two ABMI camera stations (Reconyx PC900) were deployed between 23 July and 26 November 2013 in and around Kananaskis Country in southwestern Alberta (Fig. 19). Stations were deployed within existing 10 x 10 km grid cells established by study collaborators as part of the East Slope Predators Project (Fisher & Heim 2013). Each ABMI station was left unlured and matched to an existing lured station in the same grid cell operated by the partners. Lured stations consisted of Reconyx cameras (PC900, RM30 or PM30) with LDC scent lure applied approximately monthly on a tree in the field of view. Unlured stations were set within ~ 1km of their lured pair within similar habitat conditions. Camera protocols were similar to those described for the 2012 pilot study (Appendix; see also Fisher & Heim 2013). Date entry was completed by Sandra Code following a protocol used by Alberta Parks and Parks Canada, with a minimum of 10 minutes separating independent detection events for a given species and station (Heuer & Whittington 2011).

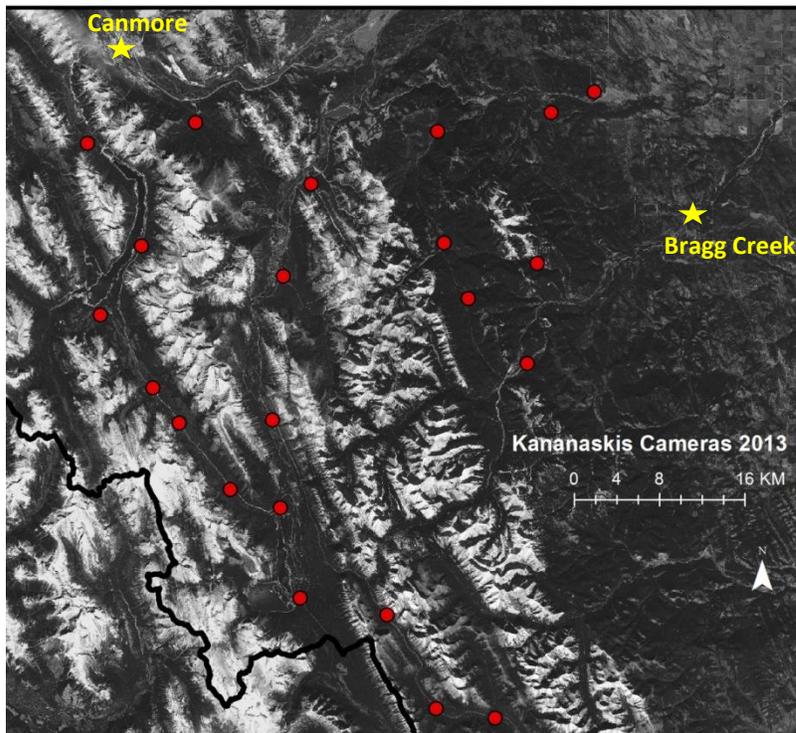


Figure 19. Locations of ABMI camera stations (red circles) deployed in and around Kananaskis Country during the 2013 pilot project (paired camera stations not shown but were within ~1 km of matched ABMI stations).

5.3 Results

Sampling effort for this project was 4773 camera-days across the 44 stations (mean = 108.5 days per station). Effort was well matched between treatments, with a total of 2435 camera-days across the 22 unlured stations and 2338 across their matched lured stations (the discrepancy was due to a few lured stations with malfunctions over part of the total sampling period).

Seventeen wild mammal species were captured across all camera stations (Table 2), along with humans, cattle, horse, dog, and three bird species (raven, flicker, owl). Similar to the 2012 pilot survey, deer and coyote were the most frequently detected species. Median richness per camera station was 5 species (mean = 5.1, sd = 2.0).

Table 3. Detections of wild mammal species in the Kananaskis pilot study.

<i>Species</i>	<i>Detections (per 100 trapdays)</i>	<i>% Stations</i>	<i>Detections at lured stations</i>	<i>Detections at unlured stations</i>
White-tailed Deer	344 (7.21)	75.0	91	253
Coyote	143 (3.00)	59.1	93	50
Mule Deer	68 (1.42)	36.4	32	36
Moose	60 (1.26)	47.7	27	33
Black Bear	48 (1.01)	45.5	32	16
Grizzly Bear	39 (0.82)	27.3	32	7
Red Squirrel	37 (0.78)	56.8	24	13
Snowshoe Hare	36 (0.75)	50.0	24	12
Marten	36 (0.75)	22.7	33	3
Elk	34 (0.71)	29.5	16	18
Red Fox	9 (0.19)	11.4	4	5
Cougar	9 (0.19)	15.9	8	1
Bobcat	7 (0.15)	6.8	6	1
Lynx	5 (0.10)	11.4	2	3
Flying Squirrel	4 (0.08)	4.5	4	0
Wolf	4 (0.08)	9.1	3	1
Bighorn Sheep	2 (0.04)	4.5	1	1

Note: scientific names are given in Appendix. Not included in table are detections of humans, birds, and domestic animals.

There was no effect of scent lure on overall mammal detection rates at a station ($p = 0.96$; Fig. 20). However, this coarse-level result masked differential responses among species groups: there were significantly more carnivore detections ($p < 0.01$) and fewer ungulate detections ($p = 0.05$) at lured stations relative to their unlured pairs (Fig. 20). The effects were most pronounced for white-tailed deer (negative association with lure) and rare carnivores like marten, grizzly

bear, and cougar (positive association with lure; Table 3). Contrary to the result from the 2012 pilot, the detection rate of the most common carnivore (coyote) was also higher at lured stations (Table 3). Due to the greater detection rates for rare species, the number of mammal species detected was greater at lured stations, although not significantly so ($p = 0.17$; Fig. 20).

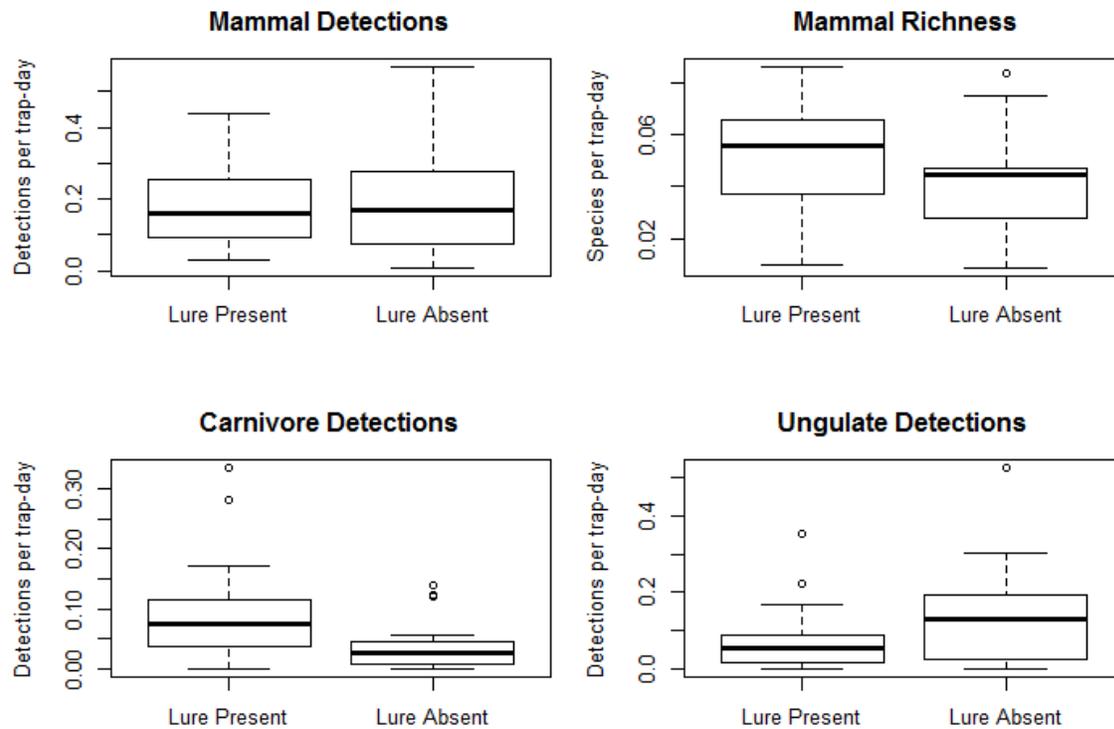


Figure 20. Detection rates between paired lured and unlured stations in Kananaskis across all mammals (top left), for number of mammal species (richness, top right), all carnivore species (bottom left), and all ungulates (bottom right). Boxplots show medians (bold line), interquartile range (box), and 1.5 times interquartile range (whiskers).

Mean latency to detection varied from lows of 10.2 days for white-tailed deer ($sd = 15.1$, $n = 33$ stations) and 11.7 for mule deer ($sd = 11.7$, $n = 16$), to highs of 67.2 for wolf ($sd = 46.8$, $n = 4$), 70.4 for cougar ($sd = 18.9$, $n = 7$), and 72.5 for bighorn sheep ($sd = 13.4$, $n = 2$). There did not appear to be a consistent shortening of LTD with the application of scent lure (mean LTD in absence of lure = 31.2 days, mean LTD with lure = 36.7 days).

5.4 Conclusions and Recommendations

Results from this study support conclusions from the 2012 pilot study (section 3.4 above). This survey in southwestern Alberta detected a broad range of mammal species, indicating cameras will be a suitable method to replace snow tracking in terms of coverage of medium- and large-bodied mammals. Smaller mammals are not well represented and would need to be specifically targeted if there was a desire to monitor them with camera surveys (e.g. camera low to the ground with small mammal bait). Scent lure had a significant positive effect on detection rates of carnivore species, and its use is thus recommended to increase statistical power for monitoring these species, and to provide more reliable comprehensive sampling of the medium and large-bodied mammal community. A minimum sampling period of 2-3 months is recommended to increase the probability of detecting rare species at a site.



6. Athabasca (WHEC) Pilot 2013

6.1 Objective and Methods

The purpose of this sub-project was to obtain a sample of mammal detections across paired lured and unlured camera stations in the Athabasca oil sands region of northeastern Alberta (Fig. 21). The work was done in collaboration with Holger Bohm and the University of Alberta's Wildlife Habitat Effectiveness and Connectivity (WHEC) project.



Nine ABMI cameras were set without lure and paired with 9 WHEC cameras lured with a mix of canned sardines and dog food (all cameras were Reconyx PC900). The original sampling plan was to deploy 30 paired stations during the summer, but logistical challenges associated with flooding limited the sample to 9 pairs (H. Bohm pers. comm.). The 18 cameras were set by the WHEC team following their protocol, with stations set within 50 m of pre-determined random locations, and paired stations matched by coarse habitat characteristics and separated by ~ 500 m (further details available from H. Bohm, holgers@ualberta.ca). Data were obtained from 17 stations (9 lured, 8 unlured), which were active for 286 trap-days between 17 May and 4 July 2013 (mean days per station = 16.8, range = 13-28).



Figure 21. General location of Athabasca (WHEC) camera pilot deployments in northeastern Alberta.

6.2 Results and Discussion

Five of the stations did not capture any wildlife images, and 1253 images of 3 species were captured across the other 12 stations: black bear (216 images), moose (466) and deer (571; note that the latter could include both white-tailed and mule deer but image processing did not distinguish between the two possible deer species). Accounting for non-independence by counting only 1 image per hour for a given species and station, there were only 60 detection events captured over the sampling period (10 bear, 14 moose, and 36 deer).

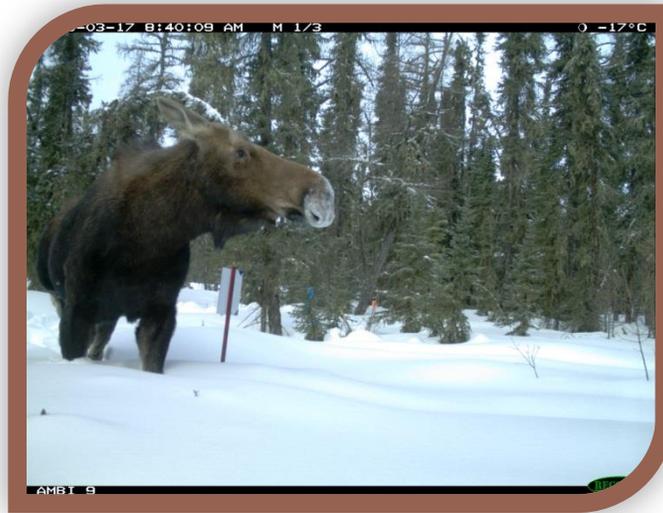
There were no significant differences in detections between the paired lured and unlured stations (whether for individual species or all together, all $p > 0.1$), suggesting the sardine/dog food lure did not have a strong attractive effect. However, the small number of detections and species limits the utility of this dataset for evaluating the effectiveness of lure, particularly for the less common species for which lure effects were found to be more pronounced in the other pilot projects (see above).

It is unclear why detection rates were low in this sample, given that a wide range of species have been detected at other WHEC camera stations (E. Neilson and H. Bohm, pers. comm. Note that the full WHEC dataset could be used for a more comprehensive evaluation of detection rates using the sardine/dog food lure). It is possible that the stations were not set very well, given the randomly selected targets and logistical challenges associated with flooding in the sampling area in 2013 (H. Bohm, pers. comm.), and it is also possible that detection rates could be lower in spring or early summer than late summer or fall (we have not explicitly tested this). However, the ca. 2 week sampling period is likely too short, particularly given the randomly targeted stations, and it is recommended that ABMI adopt a longer sampling duration to maximize the probability of detecting less common species. Nevertheless, given results of the 2012 pilot study, it is recommended that the O’Gorman’s Long Distance Call scent lure be prioritized over the sardine/dog food bait.

7. Cold Lake Winter Pilot 2013

7.1 Objectives and Methods

The primary objective of this sub-project was to obtain a sample of mammal detection rates from camera traps deployed during winter. It was an opportunistic sample capitalizing on collaboration between Erin Bayne (U. Alberta) and Woodlands North consulting firm. Geoff Sherman (Woodlands) was deploying camera traps as part of monitoring seismic line restoration treatments in the Cold Lake region (Cenovus' LiDEA pilot project at Foster Creek).



Sixteen ABMI Reconyx PC900 cameras were loaned to Sherman and deployed on- and off-treated seismic lines (without lure) between late January and early May 2013 (Fig. 21). Cameras were set in a relatively small area within the Cenovus Foster Creek lease, with a mean distance between camera stations of 521 m (range = 13 – 1070 m). Further details on the sampling can be obtained from G. Sherman (geoff@woodlandsnorth.co).

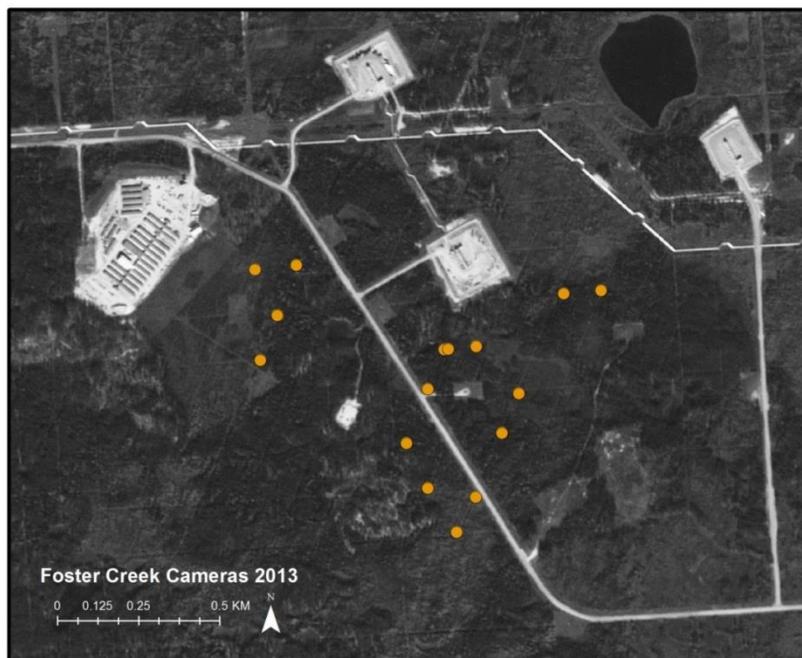


Figure 21. Location of camera traps deployed January-May 2013 in the Cenovus Foster Creek lease near Cold Lake, northeastern Alberta.

7.2 Results and Discussion

Eighty-eight detection events of twelve species were recorded during the ca. three month sampling period (Fig. 21), with substantial variation in detection rates across stations (Fig. 22).

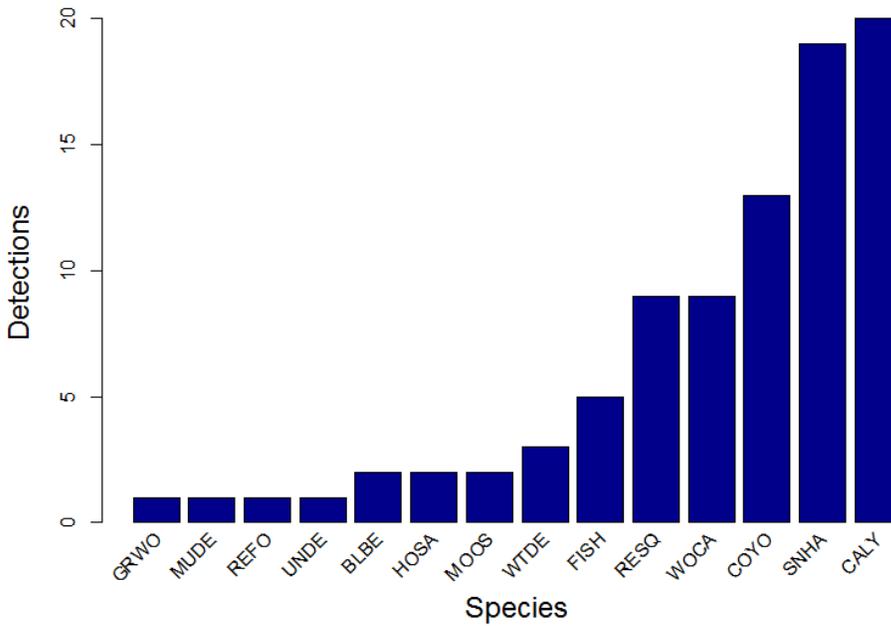


Figure 21. Species detected during the January-May 2013 winter survey at Foster Creek (full names: grey wolf, mule deer, red fox, unidentified deer, black bear, human, moose, white-tailed deer, fisher, red squirrel, woodland caribou, coyote, snowshoe hare, lynx).

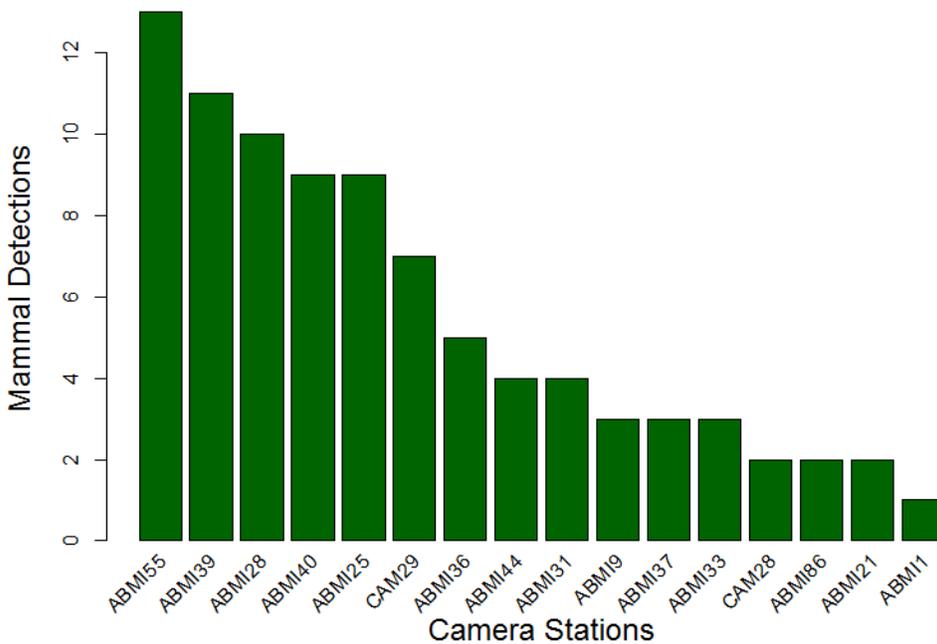


Figure 22. Variation in number of detections across camera stations deployed January – May 2013 at Foster Creek.

Detailed analysis of this dataset has not been undertaken for this report (some details of sampling effort and data processing have not been provided). Species expected for the area were detected by cameras during this winter sample, although detection rates appear to be fairly low (however, there was a relatively high number of detections of species of management interest such as woodland caribou and lynx; Fig. 21). Factors underlying observed variation in detection rates across stations have not been evaluated, but the general result supports the recommendation to deploy multiple cameras in a site to increase the probability of obtaining a representative sample. A direct comparison between detection rates obtained during this winter sample and those from other seasons in the same area would be useful for assessing seasonal variation, particularly with respect to calibrating camera results with those from ABMI snow track surveys (and in the event that ABMI considers the possibility of winter camera sampling).

8. Data Entry and Database Development

During the course of these pilot projects, we assessed several approaches to processing camera trap data. TimeLapse Image Analyser software program is used by several camera trap programs in Alberta (e.g., Alberta Parks, Parks Canada, AITF; see Heuer & Whittington 2011), and is developed by Saul Greenberg at the University of Calgary (<http://saul.cpsc.ucalgary.ca/timelapse>). While it has some advantages, it does not currently capitalize on all metadata contained within Reconyx images (e.g. temperature, moon phase). For this reason, we developed a data entry protocol using the Reconyx software MapView (provided with Reconyx Professional series cameras). This protocol (Appendix) is currently being used by Monitoring Centre staff (under Stephanie Luider's direction) but also has drawbacks, including the need to install and set up MapView specifications on each user's computer (increasing the chance of inconsistencies in data entry). Processing time varied considerably depending on image content (e.g. repeat photos of vegetation or cows vs. photos with hard to identify species), and also on the degree of detail required (e.g. distinguishing all photos by species, sex, age class). We did not track processing time thoroughly, but for a subset of data processed from the 2012 grassland/parkland pilot study, we estimated an average rate of ~ 1000 photos per hour (range 150-4000).

We have been working with Turar Sandybayev from the ABMI Information Centre to develop a new online database for camera trap data that has all of our desired features for effective data processing. Turar has developed a prototype at <http://cameras.abmi.ca/> which we plan to test more extensively in the coming year.

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11. Appendices

Appendix Table 1. Summary of species detected and their relative abundances for 660 winter snow-track transect surveys conducted between 2001 and 2011 across Alberta as part of the ABMI mammal monitoring program (including pilot work done as part of the Integrated Landscape Management project).

Scientific name	Common name	Prop. transects with detection	Mean 1-km segment detections/transect
<i>Canis latrans</i>	Coyote	0.74	4.26
<i>Alces alces</i>	Moose	0.70	2.90
<i>Odocoileus spp</i> ^b	Deer ^b	0.69	4.17
<i>Martes americana</i>	Marten	0.55	2.22
<i>Lynx canadensis</i>	Lynx	0.52	1.95
<i>Canis lupus</i>	Grey wolf	0.31	0.82
<i>Martes pennanti</i>	Fisher	0.30	0.68
<i>Vulpes vulpes</i>	Red fox	0.19	0.47
<i>Lepus americanus</i> ^c	Snowshoe hare ^c	0.93	6.39
<i>Mustela vison</i>	Mink	0.10	0.16
<i>Lontra canadensis</i>	River otter	0.10	0.14
<i>Cervus elaphus</i>	Elk	0.06	0.15
<i>Rangifer tarandus</i>	Caribou	0.06	0.14
<i>Erethizon dorsatum</i>	Porcupine	0.05	0.06
<i>Bison bison</i>	Bison	0.02	0.05
<i>Gulo gulo</i>	Wolverine	0.02	0.04
<i>Ondatra zibethicus</i>	Muskrat	0.02	0.03
<i>Castor canadensis</i>	Beaver	0.02	0.02
<i>Puma concolor</i>	Cougar	0.01	0.02
<i>Taxidea taxus</i>	Badger	0.01	0.02
<i>Antilocapra americana</i>	Pronghorn	0.01	0.01
<i>Mephitis mephitis</i>	Striped skunk	0.01	0.01
<i>Mustela spp</i> ^a	Weasel ^a	0.87	4.29
<i>Tamiasciurus hudsonicus</i> ^d	Red squirrel ^d	0.80	4.73
<i>Sylvilagus nuttallii</i>	Mountain cottontail	<0.01	<0.01
(various species) ^e	Mouse/Vole ^e	0.89	4.36
(various species) ^f	Ground birds ^f	0.63	2.25

^a Weasel could include short-tailed (*Mustela ermina*), long-tailed (*M. frenata*), or least (*M. nivalis*).

^b Includes both mule deer (*Odocoileus hemionus*) and white-tailed deer (*O. virginianus*).

^c In southern parts of province, hare data could include tracks of white-tailed jackrabbit (*Lepus townsendii*).

^d Squirrel data could include some tracks of the northern flying squirrel (*Glaucomys sabrinus*).

^e "Mouse/vole" includes various species such as *Peromyscus maniculatus*, *Microtus spp.*, etc.

^f Ground birds include grouse and ptarmigan (Family Phasianidae).

Scientific names for species not included in the above table but detected during the pilot camera surveys in this report are:

Ursus americanus (black bear), *Ursus arctos* (grizzly bear), *Lynx rufus* (bobcat), *Procyon lotor* (raccoon), *Ovis canadensis* (bighorn sheep), *Glaucomys sabrinus* (flying squirrel), *Spermophilus spp.* (ground squirrel).

The following Supplementary Materials associated with this report can be requested from Cole Burton (acburton@ualberta.ca) or the ABMI (www.abmi.ca):

- ABMI Camera Transition Strategy (draft of May 2013).
- Field protocols and datasheets for pilot surveys.
- Summary of operational issues for 2013 Monitoring Centre pilot survey.
- Data entry protocol (MapView) and associated notes on camera data management.
- Datasets and images from surveys described in this report (subject to conditions of any data sharing agreements with partner organizations).

