Evaluation of winter tracking protocols as a method for monitoring mammals in the Alberta Biodiversity Monitoring Program

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Disclaimer

1 - Executive Summary

The Alberta Biodiversity Monitoring Program is a tool intended to inform Albertan's on the state of biodiversity in their province. As ABMP is designed to monitor biodiversity rather than individual species per se, protocols are required that are capable of tracking multiple species simultaneously in a cost effective and scientifically rigorous manner. The report provides details on a test of the winter tracking protocol, which was designed to detect changes in the occurrence and abundance of winter active mammals in Alberta. The protocol is a modification of tracking protocol used in the Finnish wildlife triangle program, which has been collecting data on the relative abundance of mammals in that country for the past 15 years.

The protocol relies on snow to accumulate tracks of animals over time. Beginning a recommended 3 days after the last snowfall event, observers move along a 9-km triangular transect. As observers walk along transects the number of tracks of each species intersecting the transect are recorded. Data are collected at varying times since the last snowfall event. Days since last snowfall is always included as a variable in statistical models to correct for differential track accumulation times.

The Integrated Landscape Management group at the University of Alberta did a field test of the snow tracking protocol between 2001-04. A total of 26 mammal species were recorded in the northeastern boreal forest using this approach. This study was able to correlate differences in the abundance of mammals with level of human disturbance and spatial location. Preliminary power analyses suggest that the tracking protocol is sufficiently precise to have the desired statistical power to detect a 3% annual exponential change in abundance using 25-50 ABMP sites for most species.

Winter tracking has several strengths over other methods used to survey mammalian communities: 1) it detects more species than methods such as remote cameras, hair snares, or aerial surveys; 2) it is passive relying on natural animal movements to leave countable tracks; and 3) it does not influence the behavior of the animals, as the visit to count tracks occurs after the animals have left the transect area. Tracking is more expensive than hair snares or cameras, as it

requires a larger number of staff (~22) to track the 382 ABMP sites annually. Part of this cost is caused by staff having to wait for optimal snow conditions. Tracking is significantly cheaper than aerial surveys however, which miss the vast majority of mammal species. Given the demands to survey as many mammal species as possible in the most cost-effective fashion, ***we recommend the winter tracking protocol tested by ILM be used by ABMP with some minor modifications.***

Three ways to reduce the costs of the ABMP winter tracking program and/or increase its precision are suggested. First, the randomized nature of the tracking triangles means that all 9-km triangles have to be walked or skied, this is physically quite demanding and time intensive. A pilot study is being implemented this winter by the ILM group to compare the results from walking transects to those done on randomly selected seismic lines/trails surveyed by snowmobile. If the results from the two approaches are similar then a shift towards trail based monitoring might be desirable. Second, estimates of animal abundance from snow tracking could be made more precise if the number of tracks accumulating each day from initial snowfall were known. We recommend this data be collected in the winter of 2005 by ABMP. Finally, a scoping exercise should be done by ABMP to determine the viability of developing an “on-call” staff of local hunters and trappers to collect the data. Not only would such an approach reduce costs and ensure that the tracking data be collected during optimal snow conditions, but would truly engage Albertan’s in monitoring biodiversity.

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3 – Background

The rapid pace of change in many of Alberta's landscapes means that tools are needed to document the sustainability of human actions if an economic, social, and ecological balance is to be maintained. The Alberta Biodiversity Monitoring Program (hereafter ABMP) is one such tool that will inform industry, government, and the public on the state of biodiversity in Alberta. ABMP is intended to track the occurrence and/or abundance of a wide variety of species using cost-effective and scientifically rigorous means rather than tracking detailed information of individual "indicator" species.

Societal concerns over their welfare, large home range requirements, and a general perception of low ecological resilience to human activities are cited as evidence for the value of large to mid-sized mammals as effective ecological indicators for biodiversity monitoring (Carroll et al. 2001). Thus, ABMP has chosen to include mammals as a key group in their biodiversity monitoring strategy (Moses et al. 2001). Some government and industry programs already exist in Alberta to monitor certain species of large to mid-sized mammals (Moses et al. 2001). However, there is a distinct lack of consistency in the methods used by these different programs, lack of a central repository for the data that is collected, problems with sampling methodologies changing over time, inconsistent sampling effort, and a distinct focus on a few species (i.e. ungulates). The end result is that these data have been difficult to use in assessing trends in mammalian biodiversity over time in the province. The goal of the ABMP mammal sampling protocol is to correct these deficiencies and provide a long-term, consistent sampling method that is capable of tracking the widest array of mammalian species possible in the province of Alberta.

During Phase I of ABMP development, Moses et al. (2001) proposed that winter snow tracking be utilized as the key method for tracking abundance of mammals. The protocol recommended was modeled on the Finnish wildlife triangle program (Linden et al. 1996). This method relies on snow tracking to record the number of mammal tracks left in an area after a snowfall event. The Finnish snow tracking program has been in operation since 1989. Data in Finland are collected by government biologists, volunteers, and hunting groups interested in the conservation of that country's wildlife. Over 1500 triangles are monitored every 3-4 years, much like ABMP. The long-term value of the data collected by the Finnish program is becoming increasingly apparent given the number of published scientific studies that have begun to use the data to test fundamental ecological principles (Kauhala 1996). Data are also used in applied management for setting harvest quotas on animals such as moose (Lehtonen et al. 1998).

3.1 – Goals of report

This report outlines the results from a 4-year pilot study testing a modified version of the Finnish snow tracking protocol in the northeastern boreal forest of Alberta. This test was designed to detect changes in the relative abundance and/or occurrence of winter-active mammals along a gradient of anthropogenic effects. The report provides details on the methods used in the protocol, demonstrates the protocol's ability to identify impacts of human activity on various mammalian species, and highlights the strengths and weaknesses of the protocol in terms of costs, logistics, and data precision. Suggestions on alternative methods that could be tested to reduce the costs and improve the efficiency of the snow tracking approach are also provided.

4 - Description of the Winter Tracking Protocol

4.1 – General design and method of sampling

The winter snow tracking protocol in Finland uses a total transect length for each survey of 12-km. Transects are done as an equilateral triangle (4-km per side). Triangles are walked twice each year. On visit 1 the transect is walked to get a count of tracks. This visit is done at varying times since the last snowfall event. On visit 2 the transect is walked again to determine how many tracks accumulate in a 24-hour period. Triangles are either walked or skied. While traversing the transect, all mammal tracks that intersect the path of the observer are recorded on datasheets (Appendix 1.1). During the first visit, old tracks are erased using a ski pole or conifer bough. Erasing old tracks allows the observer to identify those new tracks that accumulate in a 24-hour period between periods.

Triangles are randomly located relative to the centroid of ABMP sites. The apex of the triangle faces north. To make tracking as efficient and repeatable as possible, waypoints of each 1 km segment are taken from data in a Geographic Information System (GIS). Coordinates are uploaded into a Global Positioning System (GPS) in decimal degrees. Observers traverse transects using their GPS, compass bearings, and flagging their way between waypoints. A sheet outlining the location of each waypoint is provided to ensure that observers go to pre-defined coordinates or if an issue in orientation is encountered (i.e. open water) that the new coordinates are recorded (Appendix 1.2). High-quality winter flagging tape is used to identify waypoints. These can be used in subsequent years to track identical routes. Tracking can be done during any appropriate snow conditions, typically Dec. 15 to Mar. 15. Detailed notes on the route take to a triangle are recorded on datasheets given in Appendix 1.3.

While moving along transects, observers record all tracks crossing transects. Data are recorded per 1 km segment (Appendix 1.1). Collecting data at the 1-km scale is done to make record keeping easier for observers. It also allows the data to be used for analyses at finer spatial scales, which may be important for modeling changes in species with smaller home ranges and identifying fine scale habitat associations. At the beginning of each segment, snow depth and condition (powder, wet, crust, windblown), temperature, and start time are recorded. General tracking data is recorded on a single datasheet for each side of the triangle (three datasheets per triangle).

Only tracks intercepting or crossing the observer's line of travel are counted. The protocol does not try to distinguish whether different individual animals made the tracks. Instead, all tracks that intersect the transect are counted regardless of whether the observer thinks it was the same individual animal moving back and forth across transects. This is done because of the difficulty in standardizing the ability to identify individual animals by different observers (Linden et al. 1996). Aural and visual observations including sightings of live animals, ungulate beds, and squirrel middens are recorded (Table 1). This information is collected even if these types of detections occur off transect. Tracks are tallied for each species and track type in each 1 km segment. Each segment is numbered in consecutive order from 1 to *n*… beginning at the apex and following the triangle in a clock-wise motion (Appendix 1.2).

Table 1 - Observation types for snow-track scoring sheet.

Observation type	Definition	Code
Snow-track	A single track or a number of tracks where individuals can be distinguished.	S
Trail	Any snow-tracks on top of one another where the number of individuals is > than 3.	T
Visual	Identification by sighting an animal from the transect.	V
Aural	Identification by sound	A
Bed	Bed seen from transect, applies to ungulates only.	B
Midden	A squirrel home—pile of cone bracts, with tunnels and trails— area larger than 1 m^2	Mid
Mat	So many tracks over an area that it is impossible to guess as to the numbers, or how many times they passed, or even to count trails. Usually applies to hare, but can also describe ungulate tracks, or canid tracks near a kill.	Mat
Old track	A track scored that occurred before the last obliterating snow (these tracks scored for detection purposes) – (See ABMP modifications to protocol).	OLD

In each segment of the triangle, the species that are observed, the observation type, and a tally of track intersections on the segment for that observation type and species are recorded. Standardized species codes when recording data are used (Table 2). The end-time at the completion of each side of the triangle should then be recorded and a new datasheet for the next side of the triangle started. At the end of each day, technicians **MUST** review their datasheets, ensuring that they are complete, legible, and that there is one datasheet for **EACH SIDE** of the triangle (3 in total per triangle).

Table 2 - Commonly encountered species in boreal forest and standardized species codes.

Species	Code	Species	Code
Coyote	CO	Cougar	CR
Fox	FO	Lynx	LY
Wolf	WO	Red squirrel	SQ
Wolverine	WV	Grouse	GR
Marten	MA	Mouse/vole	MV
Fisher	FI	Snowshoe hare	HA
Weasel	WE	Porcupine	PO
Mink	MI	Deer	DE
Beaver	BE	Moose	MO
Muskrat	MU	Elk	EL
Otter	OT	Caribou	CA
Domestic Cat	DC	Domestic Dog	DD
Horse	DH	Cow	CW
Bison	BI	Domestic Sheep	DS

A sample score sheet (Appendix 1.1) for snow track data is depicted in Table 3. Species are scored separately for each type of detection code or code combination, in each segment of the transect. Scores are totaled at the end of each day. Each time a track intercepts the transect it is scored. This way, an individual animal may wind visibly back and forth across a transect and be scored many times even though it is assumed that there is only one animal.

Table 3 - Example of how data is scored on a snow-track score-sheet.

	SEGMENT	SPECIES /GROUP	CODE	SCORE	TOTAL
a.	2	DE	S	IIIII IIIII IIIII II	17
b.	2	DE	B	III	3
d.	2	WO	S	III	3
e.	3	DE	S	I	1
f.	3	WV	S,OLD	/	1

In segment 2, there were 17 snow-track intercepts of the transect by deer
In segment 2, there were 3 deer beds observed from the transect
In segment 2, there were 3 observations of wolf snow-tracks intercepting the transect
In segment 3, there was 1 observation of a deer snow-track intercepting the transect.
In segment 3, there was 1 observation of an old wolverine track intercepting the transect.

4.2 –Track identification

When observers encounter tracks not easily identified, additional information is collected. When sufficient information cannot be gained from the intersecting track, observers backtrack the animal trail to gain more information until precise identification is possible. In particular, observations of track dimensions, gait length, and scat should be made. If an observer still cannot identify the animal, then notes and a rough sketch of the tracks is made (include scale). Track dimensions are particularly important to measure (Figure 1) as well as the depth that the animal sunk into the snow (considering the likely weight of the animal). Most importantly, observers should note what the track is not (i.e. it is too small to be an ungulate, bigger than a squirrel, definitely not a canid). At the end of the day, consultation with crewmates is done to make a definitive ID. All extra notes should be included in the data book. Track-counts from the now identified species should be recorded on the snow-tracking datasheets. Notes in field books need to be directly linked to the data on the applicable datasheet (i.e. date, township, segment, species). We did not collect photographs of questionable tracks during the test phase of the protocol but this would be a useful addition, particularly for rare species. A photographic record of the tracks of rare or endangered species should be considered as historical archive much like the CD recordings from the summer bird survey protocol. In the pilot study conducted in the boreal forest of Alberta there were a total of 26 species detected. Details on how to identify the most difficult tracks are described below.

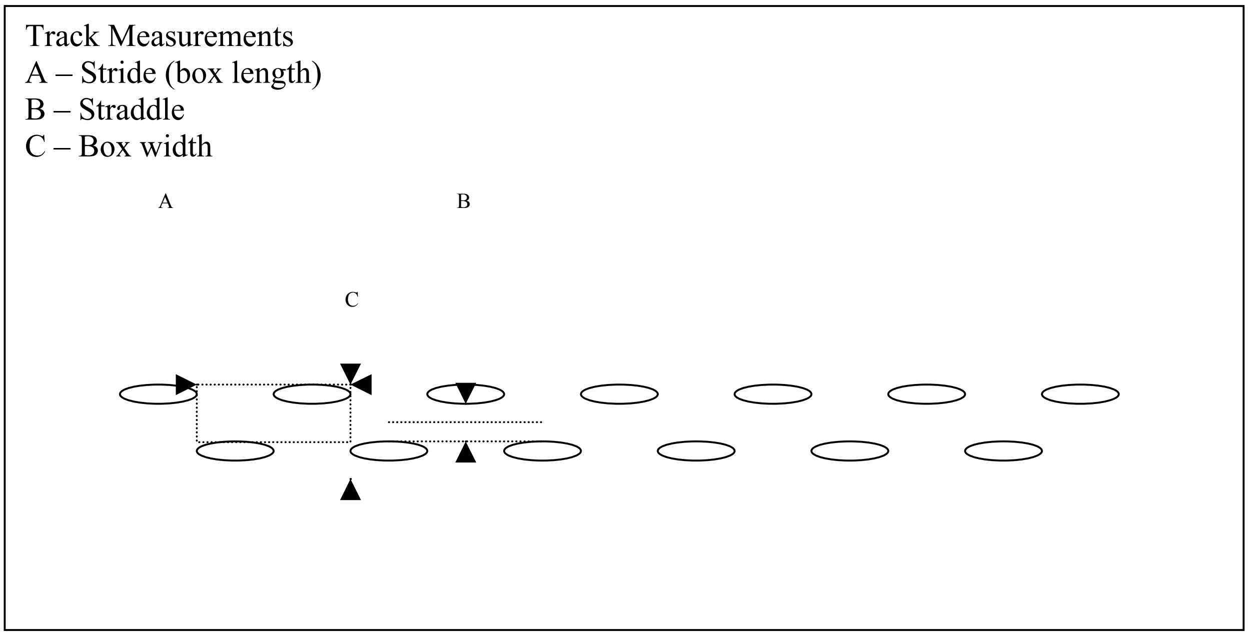


Figure 1 - Snow-track trail measurements illustrated.

Coyote and Fox

Coyote and fox tracks can be difficult to distinguish from one another. Ideally coyote or fox tracks should be followed over a distance to collect at least 3 measurements of trail dimensions (Figure 1). However, there is insufficient time to measure every coyote or fox track encountered. Instead, measurements of the first set of coyote or fox tracks encountered in a segment are taken, recorded in a field book, and a decision made about the species based on these measurements. This decision is then used as a benchmark for assessing any other coyote or fox tracks within a segment. Below is a comparison of coyote and fox measurements (Table 4). Field observers are the experts so any decisions about the species of a track must come from their interpretation in the field.

Table 4 - Body and snow-track trail measurements of coyote and fox.

MEASURE	COYOTE	FOX
Body size (w/o tail)	81-94 cm (32.4-37.6 in.)	56–63 cm (22.4-25.2 in.)
Body weight	9–22 kg (20-50 lb.)	4.5–6.7 kg (10-15 lb.)
Trail stride	30-40 cm (12-16 in.)	30-40 cm (12-16 in.)
Trail straddle	10-15 cm (4-6 in.)	8-10.5 cm (3-4 in.)
Print width	5.0-5.5 cm (2-2.2 in.)	5.0–5.5 cm (2-2.2 in.)
Print length	5.5-6.5 cm (2.2-2.6 in.)	5.0-5.5 cm (2-2.2 in.)

Marten and Fisher

Marten and fisher tracks are also similar in appearance and dimension. Thus, marten and fisher tracks need to be followed to collect more data. At least 3 measurements of trail dimensions (Figure 1) for all marten and fisher tracks should be done. Clear prints should be located and measurements taken. Fisher are generally larger than marten, but there is considerable overlap in size. The most discriminating feature separating marten and fisher is probably weight—the largest marten weighing only 1/3 of the largest fisher (Table 5).

Table 5 - Body and snow-track trail measurements of marten and fisher.

MEASURE	MARTEN	FISHER
Body size (w/o tail)	35 - 43 cm (14–17.2 in.)	51 – 63 cm (20.5–25 in.)
Body weight	681 – 1248 g	1400 – 3200g
Bounding stride (average for large animals)	61 cm (24.4 in.) Range 22-115 cm (9-46 in.)	65 cm (26 in.)
Bounding straddle	9 -12 cm (3.6-4.8 in.)	15-20 cm (6-8 in.)
Print width	4 - 5 cm (1.6-2 in.)	6 - 7 cm (2.4-2.8 in.)
Print length	4 - 5 cm (1.6-2 in.)	6 - 7 cm (2.4-2.8 in.)

Weasels (least, shorttail, longtail)

Weasels leave very subtle tracks. Because they are small and light, their prints are small and shallow and difficult to see. Additionally, they take long leaps and change direction frequently making a trail pattern difficult to see. There are three species of weasel that commonly in Alberta, but they are not distinguished in the protocol.

Wolverine and Cougar

Wolverines and cougars are of special interest because of their rarity. If a wolverine or cougar track is encountered, care should be taken to collect additional information and take a photograph Track measurements should be taken to help confirm, additional sign such as scat and hair sought, a general habitat description should be made (dominant tree type / stand age), and a GPS coordinate recorded.

Snowshoe Hare

The number of hares is highly variable based on where in the population cycle a survey is being done. In some winters hare numbers are so high that counting their tracks becomes difficult and excessively time consuming. To counter this, a system of classifying the degree of trail use on any snow track observation is used (see observation types in Table 1).

Wolf

Wolf tracks are common, and easily identified. It is possible to misidentify wolf tracks if large domestic dogs are present. In deep snow this is a little more difficult depending on the activity of the individual. Scat and other sign should be used to make a definitive identification.

Lynx

Lynx tracks are very obvious in soft snow, but they are often found on snowshoe hare trails and in other animal's tracks. Technicians should take care to examine hare trails and other tracks for lynx prints over top.

Deer (mule and white-tailed)

Generally there is not effort made to distinguish between mule deer and white-tailed deer by snow tracks. If the track is a running track, mule deer tracks are often recognizable, but these are encountered too infrequently to be useful. When observers are sure, they should record the species of deer track—usually they are not.

Moose

Moose tracks are easily identified in most cases. However, moose tracks can be mistaken for a caribou or a small moose might be mistaken for an elk. This is especially likely in deep snow. If trackers are unsure, they should follow the track until they find scat. This should not take long—ungulates defecate frequently.

Caribou

Caribou are large ungulates and their tracks can resemble elk and moose tracks in deep snow. Look for clear tracks or scat and consult a field guide.

Mice and Voles

We do not distinguish between the tracks of mice and voles, having no way effective way to differentiate between species.

Red squirrel

In addition to counting red squirrel tracks, we record any squirrel middens observed from the transect or any calling squirrels (see observation types in Table 1).

Other species

As ABMP is intended to eventually cover the entire province of Alberta, track information for mammals not present in the boreal forest is required (i.e. pronghorn antelope). This was outside the scope of this report.

5 – Test of the winter tracking protocol in Alberta

In the winter of 2001/ 2002, a pilot study of the Finnish tracking protocol was done by the Integrated Landscape Management group at the University of Alberta. A total of 21 sites ranging from heavily disturbed boreal landscape partially converted to agriculture to pristine landscapes north of Fort McMurray were examined.

5.1 – Modifications of Finnish protocol to suit Alberta conditions

After the initial pilot study done in the winter of 2001/02, the ABMP version of the tracking protocol made three distinct modifications to the Finnish scheme. First, two observers are used to walk the transects rather than a lone individual as in Finland. This is done for safety purposes; the second observer can be tasked with other responsibilities including a winter bird survey (see section 7). Second, ABMP triangles were reduced to **9 km in length**. The short duration of an Alberta winter day and difficulties in accessing many sites during daylight hours made the 12-km transect untenable. Crews on 12-km triangles were finishing just before sunset and had to snowmobile out from triangles in the dark, which was deemed unacceptable for safety reasons.

The most significant change made in the ABMP pilot study was to drop the second visit used in the Finnish protocol. The second visit was designed to provide a standardized 24-hour track accumulation period to occur. At the 21 sites sampled in 2001 using the Finnish protocol, the total number of species detected during the first visit was 11.0 ± 1.94. After “wiping” out old tracks, an average of 6.4 ± 1.7 species were detected 24 hours later (Table 6). The number of tracks per species detected during the second visit was also much lower than the first visit (Table 6). This was not surprising as the number of days since last snow and the first visit was often more than 24 hours. However, to determine if the relationship between abundance as estimated by visit 1 was correlated with abundance determine in visit 2, we conducted regression analyses on the number of tracks per species (ln+1 transformed) between visits. This analysis allowed us to determine if areas of high abundance as determined by a short 24-hour sampling period were also areas of high abundance over a longer “unknown” sampling period. Six of nine species showed reasonably strong correlations between their abundance as determined by a 24-hour accumulation rate and their abundance as determined by the first visit (Figure 2).

These results suggest that an interval longer than 24-hours is necessary to detect the maximal number of species. Admittedly, more and more species will always be detected with longer exposure time. There was a significant relationship between the abundance of most species between visit 1 and visit 2 however, which suggested that tracks accumulate in a somewhat predictable pattern over time that can be controlled for statistically (see section 6) rather than setting a specific period of time for tracks to accumulate. Combined these results suggested that we could drop the second visit. The second visit doubles the effort and costs of the winter tracking protocol with relatively little gain in information. Thompson et al. (1989) have previously recommended a single tracking visit.

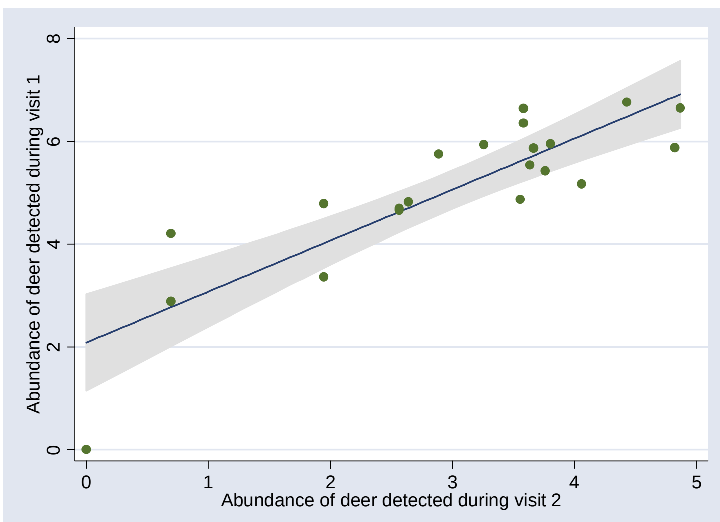


Figure 2 - Scatterplot showing relationship between abundance of deer detected 24 hours after the first visit to a wildlife triangle and abundance of deer on the same triangle detected during the first visit which occurred at various times since the previous snowfall event. Both axes are ln(+1) transformed. Shaded area represents 95% confidence interval for the slope of this relationship.

6 – Testing the modified ABMP tracking protocol

ABMP is intended to track changes in occurrence or abundance of species in time, space and to propose possible mechanisms for such changes. To test the efficacy of the modified ABMP protocol a project was initiated by the Integrated Landscape Management group at the University of Alberta beginning in 2002. Tracking was done along a continuum of human disturbance ranked from low to high. The scale at which human disturbance was ranked was the township (100 km^2). Townships sampled ranged in disturbance from 70% agriculture to pristine forest sites with no measurable human change to the vegetation. Townships sampled were within the Boreal ecozone around the Alberta Pacific Forest Management Area. A total of 164 unique townships were tracked over the period 2002-04. Seven townships were sampled in two consecutive years and an additional three townships were sampled in all years.

Table 6 - Abundance and occurrence of various species of mammals along 21 9-km transects sampled using the Finnish winter tracking protocol. Visit 1 occurred at various times since it last snowed (time since last snow was not recorded). Visit 2 occurred 24 hours after the initial visit and counted the new tracks that had accumulated since the first visit. Beta is the standardized regression coefficient describing relationship between ln(+1) abundance of visit 2 as predicted by ln(+1) abundance at visit 1 (r^2 = is the coefficient of determination for that relationship).

Species	**Abundance Visit 1**	**Abundance Visit 2**	**Occurrence Visit 1**	**Occurrence Visit 2**	**Beta**	**R^2**
Beaver	0.1 ± 0.2	0	0.05	0	.	.
Bison	1.3 ± 6.1	0	0.05	0	.	
Cat	1.8 ± 6.5	0	0.10	0	.	.
Coyote	23.5 ± 24.5	6.1 ± 10.7	0.91	0.62	0.57	0.29
Cow	3.0 ± 11.1	2.4 ± 10.9	0.10	0.05	.	.
Dog	1.5 ± 5.0	0.1 ± 0.4	0.15	0.05	.	.
Deer	291.3 ± 259.0	35.7 ± 36.5	0.95	0.95	0.86	0.73
Elk	4.7 ± 21.4	0	0.05	0	.	.
Fisher	5.3 ± 6.6	0.3 ± 0.6	0.86	0.19	0.11	0.00
Fox	0.6 ± 1.1	0.1 ± 0.5	0.29	0.10	.	.
Hare	714.5 ± 432.4	103.5 ± 119.6	1	0.95	0.56	0.28
Lynx	11.7 ± 13.3	1.9 ± 3.3	0.86	0.48	0.67	0.42
Marten	1 ± 1.4	0	0.43	0	.	.
Mink	10.7 ± 15.2	2.0 ± 2.3	0.86	0.62	0.50	0.20
Mouse	38.3 ± 27.5	3.1 ± 3.9	0.95	0.62	0.29	0.03
Muskrat	0.05 ± 0.2	0	0.05	0	.	.
Otter	0.6 ± 1.0	0	0.38	0	.	.
Porcupine	0.2 ± 1.1	0	0.05	0	.	.
Squirrel	59.9 ± 57.6	11.4 ± 12.1	1	0.9	0.68	0.43
Weasel	12.1 ± 15.3	1.8 ± 3.4	0.95	0.57	-0.08	0.00
Wolf	3.7 ± 4.1	1.0 ± 4.1	0.71	0.14	.	.

6.2.1 – Determining the optimal days since last snowfall to wait before beginning tracking

The tracking approach used in 2002/04 was the same as described in section 4, except that transect length was 9-km and a single visit was made to each site. For analysis of snow track data based on a single visit, it is crucial to know how long transects have accumulated tracks.

This is the window of time over which tracks are sampled and is the snow free period preceding the track observation, hereafter days since last snow (DSS).

A Generalized Additive Model was used to determine how the number of species detected changed with DSS. The number of species detected began to asymptote at 3 – 4 DSS (Figure 3). Between DSS 1 to 4, ~ 0.5 new species were detected per site per day. After 4 DSS, ~ 0.2 new species were detected per day. The exposure period for detecting the most species with the shortest "down time" for tracking crews is about 3 days.

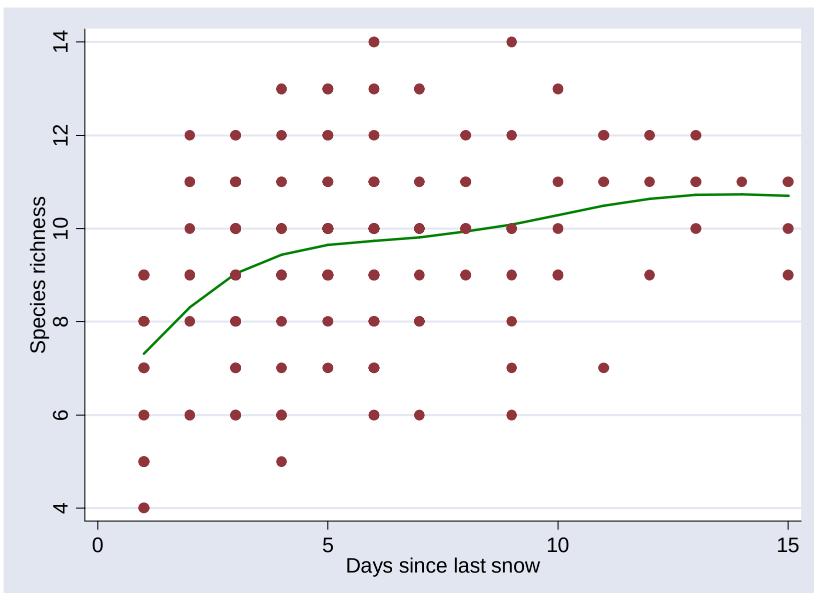


Figure 3– Number of species detected per days since last snow

6.2.2 – Determining days since last snow

Given the limited number of species detected in a 24-hour accumulation period, the aforementioned results suggest it is better to wait at least 3 to 4 days before commencing tracking after the last snowfall. Generally a snowfall event resets the DSS in that area to 0 DSS. However, not all snowfalls are equal—some obliterate tracks completely while others are barely noticeable. This is can complicate the definition of DSS.

An obliterating snowfall (OS) is one that inhibits an observer's ability to detect tracks and to identify species. This is straightforward—any snowfall greater than 10 mm is an obliterating snowfall (OS). Alternatively, a non-obliterating snowfall (NOS) is one that does not inhibit track identification. Light snowfalls less than 10 mm should not deter observers from collecting snow-track data. The tracks of animals as small as weasels can be detected and identified through 10 mm of snow. Two or more NOS snowfalls will deter data collection if the combined accumulation of the two NOS snowfalls is greater than 10mm. Any snowfall greater than 10 mm is considered an obliterating snowfall and will restart the DSS count at "0" DSS. An obliterating snowfall may begin to occur while transects are being surveyed. In most cases, observers should keep tracking, keeping special note of the snowfall and tracking conditions (i.e. snowing heavily, but small tracks still discernable). Make sure that such notes can be linked to the data for which it applies. The decision to abandon transects due to an OS is up to the discretion of each observer.

To monitor DSS, there is a hierarchy of 4 measures:
1) Environment Canada; 2) Remote contacts; 3) Camp weather records; and 4) On-site assessment.

1) Environment Canada
Environment Canada provides web-cast information that can be used to provide a very general view of regional conditions. This is most useful for monitoring major snowfalls and periods of no-snow in regions where you are sampling but are not currently located (i.e. planning field activity using forecast information). Web-cast monitoring is done from the office and the information relayed to crews in the field. See http://weatheroffice.ec.gc.ca.

2) Remote DSS Contacts (Appendix 1.4)
A second level of monitoring DSS comes from regional contacts—local residents, Fish and Wildlife, and Forestry contacts that have been asked to relay snowfall information to technicians who will call them regularly. Reports from these contacts will be recorded and used to determine DSS. Reports from Remote DSS Contacts are to be recorded every 2-3 days using the datasheet in Appendix 1.3. Each remote source will require a separate datasheet. The following

information should be recorded: Year—to which this data applies; Location—to which these local observations apply; Name—of the contact person; Phone number—of the contact person; Date—Month, day—to which observations apply; Time—of the observation—when the contact noted conditions; Observer -who filled out datasheet; Snow—if snowfall was observed; How much--quantity of snowfall that day; General Weather—description of conditions.

3) Camp Weather Records (Appendix 1.5).

Camp weather information is entered into Camp Weather Records daily. These will help to interpret results, assess potentially dangerous weather conditions, and keep track of DSS. The following data will be collected and recorded each day: Year—to which this data applies; Observer—who recorded this information; Location—which camp / region; Temperature—24-hour high and low using max/min thermometer placed in standardized fashion, near camp—preferably read twice daily, morning and evening; Minimum temperature (degrees C); Maximum temperature (degrees C); Snowfall—measured in a standardized location and reported in millimeters.

4) On-site Assessment

The fourth level of DSS assessment will occur on a site-to-site basis as crews approach and arrive at each triangle. The ability to do so increases with the time spent in a region. For example, fresh snow on a busy road or on a road traveled the previous day will sometimes be obvious, and might be contrary to internet info, our Remote Contacts, and our own observations from Camp. When convenient, time should be taken to stop at sites visited on previous days to observe if snow has accumulated on previous day's tracks. On-site assessments when certain out-weigh other levels of assessment.

6.2.3 - Results from 2002-2004 ABMP winter tracking test

Overall, 26 species of mammals were detected over the 3 year period (Table 7). Approximately ½ of the species detected had rates of occurrence < 20%. This includes species such as caribou and wolverine. For the remaining species, they were detected on > 20% of the triangles suggesting they are detected sufficiently often to monitor not only occurrence but relative abundance as well.

In 2002, it did not snow until mid-January with long-extended periods between snowfall events. We tracked animals between 3 and 15 DSS that year. **We do not recommend tracking past day 10, as the variability in track counts increases substantially past this point** (Figure 5). If new snowfall does not occur before day 10, we recommend observers switch to the Finnish protocol of erasing tracks and then revisiting sites thereafter to determine the tracks that have accumulated.

Table 7 - Minimum detection rate (number of triangles where species was detected), number of tracks not corrected for DSS and number of tracks standardized to a 72-hour sampling period (calculated as (#tracks/DSS)*3). These estimates were created for the 26 mammal species detected using ABMP tracking protocols. The standard deviation and coefficient of variation for each measure is also reported (CV = SD / Mean).

Species	Detection rate	Track count	Std. Dev.	CV Raw	72-hr Count	Std. Dev.	CV 72
Dom. Cat	0.01	0.06	0.62	10.9	0.20	0.21	1.1
Dom. Sheep	0.01	0.15	1.57	10.6	0.13	1.53	11.8
Wolverine	0.01	0.02	0.24	10.5	0.01	0.10	10.0
Beaver	0.02	0.14	1.06	7.4	0.08	0.62	7.8
Caribou	0.02	0.28	2.43	8.6	0.18	1.73	9.6
Elk	0.03	1.02	8.48	8.3	0.29	2.29	7.9
Mink	0.03	0.21	1.44	6.9	0.22	1.63	7.4
Horse	0.05	1.30	11.04	8.5	0.69	3.98	5.8
Porcupine	0.05	0.13	0.78	6.0	0.11	0.73	6.6
Cow	0.06	1.22	8.33	6.9	0.96	6.56	6.8
Dom. Dog	0.11	0.60	2.64	4.4	0.43	2.05	4.8
Fox	0.17	0.86	5.06	5.9	0.64	3.15	4.9
Otter	0.20	0.75	2.61	3.5	0.48	1.48	3.1
Fisher	0.34	2.56	6.47	2.5	1.3	3.2	2.5
Wolf	0.38	1.70	4.87	2.9	0.96	2.24	2.3
Marten	0.52	5.75	12.81	2.2	3.7	8.5	2.3
Lynx	0.67	14.95	25.22	1.7	6.8	11.3	1.7
Coyote	0.85	19.67	28.14	1.4	11.2	18.0	1.6
Weasel	0.88	24.70	35.38	1.4	15.2	21.1	1.4
Moose	0.89	28.08	34.66	1.2	16.9	21.4	1.3
Mouse/ Vole	0.89	21.69	32.02	1.5	12.3	15.7	1.3
Deer	0.91	158.28	205.90	1.3	96.4	112.7	1.2
Hare	0.95	316.90	386.88	1.2	169.5	187.3	1.1
Squirrel	0.98	60.28	96.15	1.6	38.3	85.1	2.2

In 2003 and 2004, snowfall occurred more regularly and reached greater depths. We tracked 3 to 9 DSS during those years. We tracked 33 days in 2002 using 4 teams of 2, 36 days in 2003 using 4 teams of 2, and 17 days in 2004 using 2 teams of 2. The fewer number of days worked in 2004 was partially due to other research activities. In practical terms, approximately 50% of the total days available in Jan.-Feb. were suitable for tracking using this protocol because of having to wait 3 days after each snowfall.

6.2.3.1 – Statistical properties of data

For all species the distribution of the count data were skewed from a normal distribution (Figure 4). The mean was proportional to the variance in almost all cases. In part, this results from increasing variance in the counts with increasing days since last snow (Figure 5). The end result is that track counts cannot be used directly in standard statistical analyses (i.e. linear regression or ANOVA). Instead, data either has to be transformed to reduce heteroscedasticity (i.e. ln-transformation) or more complex statistical models applied such as a Poisson or negative binomial count model applied.

Figure 4– Number of deer tracks detected per standardized 3-day period. The total number of tracks detected was divided by DSS and the quotient multiplied by 3. The assumption of this approach is that there is a constant increase in number of tracks per each increase in DSS (see below).

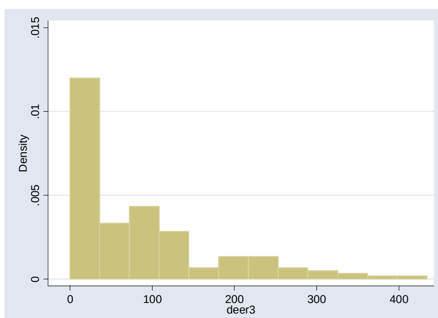
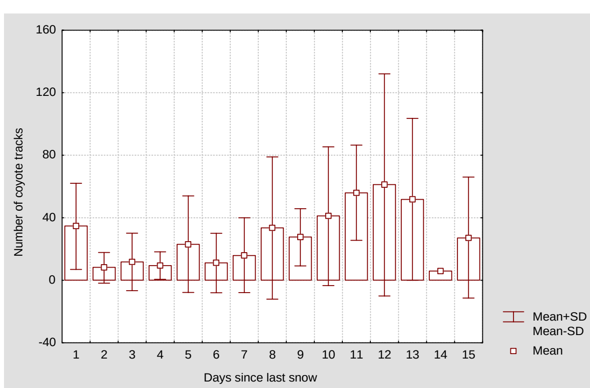


Figure 5– Raw number of coyote tracks (± 1 SD) detected at varying DSS. Note the increasing variance in counts that begins to occur after about 8 DSS.



6.2.3.2 – Methods of correcting for DSS

Many ways of correcting track counts for DSS have been proposed (Halfpenny et al. 1985). Each method has some key assumptions. Many of these assumptions need to be tested further. One approach is to simply divide the number of tracks detected by DSS and multiply the quotient by a constant to get a number of tracks per unit time (i.e. tracks per 3 days). The key assumption of this approach is that the accumulation rate of tracks is constant over time. If this assumption is appropriate then such standardization should result in **NO** relationship using a log-linear model between 72-hour track count and DSS. The vast majority of species violated this assumption. For almost all species (exceptions being hare and lynx), there was a negative relationship between the standardized 72-hour track count and DSS. This result indicates that the number of tracks added per day after initial snowfall decreases with increasing DSS refuting the constant accumulation assumption.

A second way is to correct for DSS in the statistical model directly, by including DSS as an independent term (i.e. simply control for DSS). By inclusion of a linear DSS in the model the assumption is there is an increasing accumulation of tracks but not necessarily with an equal number of tracks added each day from initial snowfall. Non-linear terms for DSS can also be included to test if there is a plateau in the number of tracks that accumulate over time. Alternatively, tracks may start to disappear due to melting or blow-in over time, which could result in a decline in the number of tracks occurring at very long DSS intervals. The weakness of this approach is that the DSS coefficient used in all future statistical models will change slightly over time as more and more data is collected. This is the approach used in this report.

A third way to correct for DSS is to directly estimate track accumulation rates and track survival rates over time. To do this, a limited number of sites must be examined **DAILY** to determine the number of new tracks added each day and recording old tracks that disappear during the same interval. This approach would provide a set model structure by which all track counts from the entire ABMP monitoring program would be corrected. This type of information is **NOT CURRENTLY** available for Alberta and would require further research. Such an approach would not have to be a long-term ABMP commitment per se as once these models were sufficiently robust, further data would not be required. As with all correction factors of this sort, a myriad of environmental factors will influence reliability of such a track survival model meaning that such research would have to consider a wide variety of factors when constructing the model (i.e. snow depth, snow conditions, natural sub-regions, etc.). **We believe this would be the ideal means of correcting the data for DSS.** Once these relationships are understood the track accumulation curve can be added to the statistical models as an *offset*. This will account for the differential exposure period caused by visiting ABMP sites at varying times since last snow (McCullagh and Nelder 1989). The ILM group has collected some data to test this approach but there currently is insufficient data to create a particularly robust model.

6.2.3.3 –Winter tracking & changes in mammal abundance with human disturbance

We developed a Generalized Linear Model using a negative binomial error structure for each species. The dependent variable in these analyses was the number of tracks per species. The independent variables were DSS, year of survey (categorical), northing, road density, % township converted to agriculture, % township harvested, and a log-ratio vector describing the composition of the vegetation in a township (Aebischer et al. 1989). For each of the carnivores, we also included the relative abundance of the preferred prey. These models should be deemed **PRELIMINARY** and have not undergone extensive model testing.

DSS was an important predictor for most species (Table 8). However, the slope of this relationship was variable among species. Some species decreased in abundance with increasing DSS, which was not expected. Two explanations are possible for this pattern: 1) with increasing time tracks of these species were more likely to disappear than others; or 2) the sites sampled where these animals were present were by chance more likely to have been sampled after relatively few days since last snow. Overall, for species showing a positive response to DSS the average increase in number of tracks was ~10% per day.

As shown in Table 8 we were able to detect difference in abundance related to spatial location for 4 species (south-north gradients), cumulative human impacts for 6 species, and year for 10 species. Deer and coyote showed some of the strongest patterns and suggest that human disturbance in the northeast boreal may be creating conditions that are preferred by these species. Fisher showed a strong negative response to roads.

Table 8 - Selected statistical models explaining abundance or occurrence for each species detected using snow tracking. Results are reported as the amount that particular independent variable changes the mean count with a 1-unit increase in a dependent variable. For example, coyote track counts are 1.12X more abundant per DSS, 2.88X per 1 km per km^2 of roads, and 1.12X more abundant per standard deviation increase in small prey abundance. They are also 0.62X less abundant in 2003 than 2002 and 0.78X less abundant per 100 km north you go in our study area. Certainty of human impact reported as raw coefficients and the 95% CI. A value of 1 indicates no change in that species with a change in the dependent variable. NB = negative binomial regression, B = logistic regression.

Species	Model	North	Year	Human Impact	DSS	Certainty of human impact
Coyote	NB	0.78X	0.69X	2.88 X more abundant per 1 km per km^2 of roads	1.12X	1.06 (0.38: 1.72)
Deer	NB	0.49X	0.82X	2.54 X more abundant per 1000 ha harvested	1.04X	0.933 (0.55: 1.32)
Fisher	B	.	0.46X	0.14X as likely to occur per 1 km per km^2 increase in roads	1.11X	-1.95 (-3.39: -0.51)
Hare	NB	.	0.53X	0.63X as abundant per 1000 ha harvested	1.09X	-0.45 (-0.78: -0.13)
Lynx	NB	1.64X	0.69X	.	1.28X	.
Marten	NB	1.97X	0.79X	.	0.92X	.
Moose	NB	.	.	.	1.10X	.
Mouse	NB	.	1.11X	.	.	.
Squirrel	NB	.	1.06X	.	.	.
Weasel	NB	.	1.53X	0.25X as abundant per 1 km per km^2 of roads	1.07X	-1.37 (-1.99: -0.73)
Wolf*	B	.	0.21X	0.22X as likely to occur per 1 km per km^2 of roads	0.99X	-1.49 (-3.10: 0.12)

6.2.3.4 – Annual variation in counts

The aforementioned analyses demonstrate that the proposed protocols have the ability to detect patterns in mammal abundance in space and changes correlated with human-impacts. As such, we believe the proposed methodology is sufficiently robust to be considered as a cost-effective ABMP tool. The factors causing the observed declines in abundance with year remain unclear. The decrease in abundance observed between years may have been caused by the changing snow conditions we described earlier (i.e. animals may have moved less in 2003/04 due to deeper snow which occurred more often). While this may seem like a limitation of the snow-tracking method, all other winter-based protocols discussed in section 8 would tend to suffer from the same issues (i.e. during aerial surveys animals move less and tend to stay in areas with less snow cover under dense canopies; animals moving less are not likely to intercept cameras or hair snares). Different crewmembers existed on this project between years making it possible that some of the differences were related to observer ability. The crew leader from 2002 trained staff in 2003 however. Alternatively, actual declines in the abundance of species may have occurred. Most species that demonstrated a large temporal change consume snowshoe hare as part of their diet. Snowshoe hare declined considerably over the length of the ILM study, which was expected. This gives support to the idea that these declines have a biological explanation. Many species not typically linked to the snowshoe hare cycle showed no or only slight changes (deer, moose).

A limited number of 11 sites were revisited in different years between 2002/04. A GLM with negative binomial error structure that treated each site as random effect was used to determine if there was significant difference among years for only those sites sampled in more than one year. Controlling for DSS, we found that 5 species out of 10 showed significant differences between years (Table 9). Those species that declined in abundance between 2002 and 2004 included coyote, fisher, snowshoe hare, lynx, and wolf. Marten increased over this same time period.

Table 9– Mean abundance ± 1 SD for 10 common species between the three years of the study. Results are only from those sites resampled in at least two years.

Species	**2002**	**2003**	**2004**	***P***
Coyote	37.5 ± 28.4	1.8 ± 1.7	9.7 ± 6.8	< 0.001
Deer	246 ± 158.6	249 ± 110.6	169.7 ± 221.7	0.14
Fisher	7.3 ± 9.7	0.3 ± 0.5	0.2 ± 0.7	< 0.001
Hare	445.8 ± 281.3	155.5 ± 183.4	92.7 ± 144.5	< 0.001
Lynx	21.1 ± 24.3	3.3 ± 4.0	7.6 ± 19.2	0.04
Marten	0.4 ± 1.0	1.3 ± 1.5	4 ± 3.8	0.01
Moose	28.7 ± 27.8	37.3 ± 57.4	25.0 ± 17.9	0.12
Mouse	21.2 ± 17.8	4.8 ± 5.3	32.4 ± 54.1	0.16
Squirrel	52.9 ± 52.1	18.9 ± 17.1	104.1 ± 168.8	0.35
Weasel	16.3 ± 16.4	40.3 ± 45.9	21.6 ± 10.8	0.13
Wolf	7.5 ± 16.8	0	0.2 ± 0.7	0.03

6.2.4 – Will the winter tracking protocol have the desired statistical power?

ABMP has two goals related to statistical power: 1) to be able to detect with 90% certainty, an exponential change of 3% per year within a region after 15 years of survey (i.e., after 3 visits to all sites); and 2) To have at least a 90% probability ($\beta = 0.1$) of detecting a 2-fold difference between areas. During Phase I, Schieck (2001) presented estimates of the statistical power of the ABMP based on the coefficient of variation (SD / mean). In Schieck's report, it was argued "30-40 sites are needed to detect a 2% exponential decrease, with a 90% statistical power, when coefficients of variation are between 1.0 and 1.5. Less than 40 sites will be needed to detect a 3% exponential decrease, with a 90% statistical power, even when the coefficient of variation is 3.0." Based on these estimates the mammal tracking protocol seems to be sufficiently precise to detect the magnitude of change proposed by ABMP as most of the reasonably common species have CV less than 3 between sites (Table 7). There are some caveats however: 1) the measure of coefficient of variation from our study is based on variation between sites rather than within sites. This means our estimates of CV are likely biased high; and 2) the count data we observed are not normally distributed even after ln-transformation.

With the limited resampling effort within our sites it is difficult to know what level of within site variation is occurring. However, based on the mean and standard deviation from the three sites sampled three years in a row, the average CV ranges from 0.492 for deer to 1.732 for fisher. On average for all species, the mean CV was 1.11. This is a relatively high level of within site variation for mammals (Gibbs 1988). However, it is within the acceptable bounds defined by the ABMP Phase I guidelines and again suggests the proposed protocol should have the power desired by ABMP to track mammal changes over a relatively small number of sites (i.e. Forest Management Area scale). However, the importance of meeting distributional assumptions cannot be stressed enough when estimating power. Further simulation modeling is required to ensure that the power estimates derived from CV based on normal error structures are in fact appropriate for count-based data, particularly when we control for DSS.

Power curves for detecting changes in occurrence based on the winter tracking data were created in PASS (Table 10). Only 7 to 10 sites would need to be sampled to have the power to detect changes in occurrence for the most common species. With rarer species such as fisher, the sample size to detect significant change is about 50 sites. Wolverines were rarely detected by this protocol so the power may be insufficient to track changes even at a provincial scale. However, this may not be true when sites outside of the northeast region are tracked, where presumably this species is more common. Although caribou were rarely detected in our pilot study this is partially due to the fact that we limited most of our survey triangles to upland forest. We suspect that when tracking triangles are placed in optimal caribou habitat that our detection rate will increase substantially.

Table 10 - Number of sites required to detect a 3% exponential decline in occurrence per year over 15 years. N reported is number of sites that would have to be sampled three times to achieve this level of power. Note these estimates are not corrected for any sources of natural variation. These estimates should only be considered as guides to ABMP power as the data collected are specific to the northeast boreal only.

Species	**Minimum detection rate**	**Sample size (Power = 0.8) (Alpha = 0.10**.	**Sample size (Power = 0.9) (Alpha = 0.05)**.
Wolverine	0.01	>3600	>6000
Beaver	0.02	603	1020
Caribou	0.02	603	1020
Elk	0.03	403	670
Mink	0.03	403	670
Porcupine	0.05	233	397
Fox	0.17	63	107
Otter	0.20	53	89
Fisher	0.34	28	47
Wolf	0.38	24	41
Marten	0.52	16	27
Lynx	0.67	11	18
Coyote	0.85	7	12
Weasel	0.88	7	12
Moose	0.89	7	12
Mouse/ Vole	0.89	7	12
Deer	0.91	7	12
Hare	0.95	8	13
Squirrel	0.98	10	17

7 – Winter bird protocol

The requirement for two observers when conducting the proposed snow-tracking protocol is a considerable cost. While safety is paramount, it is important that the second observer also be engaged in collecting data. One activity that has been tested in conjunction with the winter tracking protocol is a winter bird survey. Winter bird surveys are particularly useful for detecting resident species like woodpeckers that are vocally more active during the late winter than they are during the summer when the other ABMP bird surveys are being conducted. While the ILM test of the ABMP protocol included winter birds, data are the proprietary to Dr. Fiona Schmiegelow.

Thus, analyses of the winter bird data are not provided in this report, although they could be included at a future date.

7.1 – Description of winter bird protocol

While the transect approach to sampling was designed for mammals, it is commonly used in assessing the abundance of birds as well. If conducted in a standardized, systematic fashion, transects yield much the same information as point counts. Point counts are being used in the summer ABMP protocol. The advantages of transect surveys for birds in the winter are that transect permit rapid assessment of bird communities over large areas in a relatively short period of time. The ability to move over large areas is important as relatively few bird detections occur at stationary points during the winter.

The basic protocol used in winter bird/ mammal tracking surveys is for the observer tracking birds to break trail through the snow. This is done to avoid bias in sampling as a result of one person breaking trail and differentially disturbing singing birds. Sampling is done by fixed width transects, incorporating 100 m on either side of the transect line (i.e. roughly equivalent to the same sampling radius used for point counts). As with point counts, it is important to avoid double-counting birds, so observers keep a mental map of bird locations as they conduct surveys. Records of birds beyond 100 m are noted, but abundance is not tallied. Locations of birds are related to general habitat categories, as indicated on the data sheets and the forest inventory maps, and are described in the habitat key on datasheets. Estimates of abundance and records of behavior are tallied within habitat categories, but behaviors are recorded in aggregate for a given observer and 1-km segment of the triangle. All individuals seen, heard, etc. (i.e. tally abundance), and their behavior (e.g., observed, calling, foraging) are recorded within habitat types.

While transect sampling is essentially continuous along the route, data are recorded every 25 m (approx.), while flagging the route for the winter tracker. At these intervals, the observer should stop, listen, and record all observations roughly perpendicular to the sampling location. Records of rare species may be noted beyond this sampling range (e.g., if an observer hears a Northern

Pygmy Owl calling up ahead, its presence is noted. The habitat category is then recorded when the observer reaches the estimated location.

Both presence/absence and relative abundance information are of interest, therefore observers should record all species occurrences, whether or not they are within a fixed sampling area, or can be associated with a specific habitat type. In relation to transect surveys, such records should appear as checks in a habitat column, using “Other” where habitat is either not known, or the observation is a flyover of a species not expected to utilize the habitat being sampled at the time (e.g., a Ring-billed Gull flying over old deciduous forest). If an observer is unsure how to register an observation, record the information separately on the sheet, or in a field notebook, for later transcription. This should be noted in the comments section of the data sheet.

Surveys are not conducted at wind speeds above '5' on the Beaufort scale, nor at temperatures below -30^{o} C.

8 – Is the winter tracking protocol the best choice for ABMP?

<u>8.1 – Strengths</u>

The major strength of the tracking protocol is that it provides relative abundance and occurrence estimates for a relatively large number of mammal and winter bird species simultaneously. Other methods of sampling for mammals have been considered and are described in section 8.3. All of these other protocols suffer from the problem that a more limited subset of animals would be sampled; these other protocols also influence the behavior of animals via baiting and are untested in any sort of rigorous fashion at the scales required by ABMP.

Track identification does require training, but is relatively simple given the limited number of species occurring in the boreal forest. The protocol while labor intensive is temporally segregated from other ABMP activities putting no increased pressure on spring/ summer field crews. Data is easy to collect and can be entered by crews while still in the field. This reduces costs relative to other ABMP protocols, which require extensive laboratory work. By adding new data recording protocols using handheld Palm Pilots linked directly to GPS, data could be entered in the field and provide much more detailed information (i.e. locations of tracks could recorded to nearest 10-20 m rather than abundance per km). Such an approach would be extremely useful for research purposes and would allow development of resource selection functions for a variety of species for which there is currently little data.

While more information is needed on exactly how tracks accumulate with increasing DSS, the general statistical properties of the track counts seem to be appropriate for analysis with traditional count based statistical analyses such as Poisson or Negative Binomial regression. Power analyses based on Monte Carlo simulation need to be further examined to assess the true power of the tracking design once DSS is corrected for.

8.2 - Limitations

Every year ABMP will have to visit 382 sites (332 sites will be visited to collect data) while 50 sites will be resurveyed to assess accuracy. If we assume an average of 35 “good” tracking days between mid-December to mid-March then 11 teams of 2 (~ 22 people) will be needed to complete the project annually. This assumes people must work in pairs. The large labor requirements in this protocol mean it is relatively expensive (Table 11). However, the costs of the protocol are significantly lower than what is spent currently by the Alberta Government to conduct aerial surveys of deer and moose. If estimates of moose and deer abundance derived from the ABMP tracking protocol were deemed sufficiently precise, it is possible that the aerial survey protocol may become redundant. This would require a **DIRECT** comparison of the two methods however before such a recommendation could be made.

The cost estimates of the winter tracking protocol assume that days not surveying are the days crews take off. If regularly scheduled periods of on vs. off are desired for field crews, then additional support will be needed to fill in gaps. The large number of days when crews are “not working” is a concern. Consideration of whether employees could be sorting plant or insect samples from other ABMP protocols during this “down-time” is recommended. This would help to minimize the costs of the overall ABMP program. An alternative that would reduce staff “down-time” but increase data variance would be to accept the reduced number of species detected and begin surveying one to two days post snowfall.

As snow conditions deteriorate over time, track ID can become a problem. With wind, tracks get blown in to some degree, while warm weather/ sun can deform tracks making ID more difficult. This issue could become increasingly problematic with global warming as snow conditions may become decreasingly appropriate with changing climate. As a worst case-scenario, entire regions or years may not be able to be sampled using this protocol when there is little snow. How likely a scenario of "no snow" is based on historical records and global climate change projections should be considered further.

Table 11– Estimated annual snow tracking budget.

	Total (2 mo.)	**Notes**
Salary		
22 people at $3K per month	**$132K - $198K**	There will need to be some flex here related to timing. In some years, it may take a different amount of time (2 to 3 months) to get good snow
Vehicles		
8 trucks at	$40K - $60K	
8 SMB rental	$20K - $30K	
Food	$10 - 15K	
Accommodation	Depends	ILM has used forestry cabins almost exclusively. These have been provided at no cost to program. ABMP should seek same arrangement.
Phone Charges	$1K	
Total	~$200 - $300K	
Periodic purchases		
GPS	$5500	$250 each
Survival kit	$2200	$100 each
Snowshoes	$4400	$200 each
Stationary	$100	
Cell / Sat Phones	Variable	
Flagging tape	$500 per year	

The winter tracking protocol should be effective in all regions of Alberta. Winter tracking protocols have been employed by other agencies in montane regions (www.northwestconnections.org/ecologic.htm). To the best of our knowledge, there has been no testing of winter tracking protocols in grassland environments. In open prairie, it is possible that higher windspeeds across open terrain may result in tracks being more prone to "blow in". As a result, tracks may disappear faster in this habitat than in more enclosed areas (i.e. forest environment). To assess the importance of "blow in", more research should be done to estimate the frequency with which tracks disappear between snowfall events in different habitats.

In areas with severe terrain, it is possible that observers will not be able to traverse an entire 9-km transect in a triangular fashion due to safety reasons (i.e. canyons, open water, etc). In such situations, it is likely best if the triangle is moved or broken up into unconnected segments of shorter distances. If triangles have to be broken up, the total length of transect surveyed per ABMP site **MUST** sum to the same 9-km transect length to make results comparable.

8.3 – Other options and rationale for not recommending them

As part of Moses et al. (2001) original proposal, it was recommended that hair snares also be included at ABMP sites. During this protocol test we did not collect this information so we are unable to compare the efficacy of hair snares to snow tracking. Instead, we report on recent efforts by other researchers in Alberta to assess the abundance of mammals using hair snares and cameras outside our study region. This list is by no means exhaustive. In addition, because of proprietary rights of the data collected by these individuals we are unable to provide detailed analyses at this time. Specifically, we provide information on detection rates of various mammal species as determined by hair snares, remote-cameras, and aerial surveys.

8.3.1 – Cameras

Baited or non-baited camera stations have become a popular way of determining the occurrence of animals in different locations. A set number of cameras in some spatial configuration around an ABMP point could be used to detect the occurrence of a species in an area. Like the winter tracking protocol, non-baited cameras, sufficiently camouflaged are unlikely to affect the animal's behavior directly. Thus, cameras should be a representative sample of what crosses any given random point. The randomized nature of camera distribution and subsequent sampling would make for robust statistical analysis. In addition, cameras have the added benefit that photographs can be brought back to the lab for identification. A permanent record of detections is also available reducing concerns about observer misidentification.

Issues related to snow conditions become less of a concern although deep snow may still limit movement of animals and thus influence the likelihood of detection. The protocol could also be applied in the summer resulting in a greater number of species being detected (i.e. grizzly and black bear). If individuals can be identified based on markings, such a protocol also has the advantage of allowing mark-recapture protocols be used to develop estimates of density (Trole and Kerry 2003).

As part of a protocol-testing program for monitoring wolverine by the Alberta Research Council, Jason Fisher tested the efficacy of remote cameras in relation to hair snares in the Rocky Mountain House area (Fisher 2004). This test was done between November and March. A total of 1,026 camera exposure nights were completed. All sites were located next to the Forestry Trunk Road in the foothills region of Alberta.

A total of 8 species were detected by cameras: marten (6), fisher (2), red squirrel (4), flying squirrel (2), ermine (2), moose (1), grizzly bear (1), and wolverine (1). All of the sites where photographs were obtained occurred at sites where the camera was baited with a dead beaver. Sites where O'Gorman's scent lure was used to attract animals received one detection of any mammal species. Cameras without bait are completely ineffective according to Fisher and he argued they should not be considered as part of any monitoring program. An alternative might be to place non-baited cameras in areas of high animal activity (i.e. game trails, edges of water bodies, etc.) to increase detection rates. This type of stratification would have to be adopted for all ABMP points and would rely on judgment calls by field personnel and would stray from the randomized structure currently used by ABMP. Given the difficulty in making such decisions in a consistent manner it is recommended that such an approach not be utilized.

Baiting animals into cameras or hair snares with a beaver carcass increased detection rate in Fisher's study (Table 12). Of the 48 baited sites, one or more mammal species were detected at 56% of sites. However, the vast majority of species were detected at 2-5% of sites. To have the statistical power to detect a 3% annual change in occurrence with in 15 years for individual species, any sampling strategy using baited cameras would have to either: 1) rely on a very large sampling area (~500 sites to get sufficient power for rare species) reducing the efficacy of the

ABMP program for industrial partners; or 2) increase the number of cameras placed per ABMP site. If we assume a species detection rate of 5% per camera unit, then 10 camera units per site would be required over 50 ABMP sites to reach the stated statistical power goals of ABMP. The optimal spatial pattern of a 10-camera layout at an ABMP site is unknown and would have to be tested. This would require a very large amount of bait that may not be easily obtained (see 8.3.2).

Baited cameras are inherently targeted at carnivores. Information on herbivores like deer and moose will be virtually non-existent using such a protocol in isolation. In addition, there may be a differential effect on some carnivores. Wolves for example may be more wary of cameras than coyotes. The winter tracking protocol does not suffer from this bias as the animals move through the triangle before the observer visits the site.

A camera protocol requires sites be visited twice, carrying loads of bait. With cameras there are high initial startup costs. Camera units cost between $300-700 each. Life span of camera units is variable so replacement costs over time need to be considered. The effectiveness of cameras in winter situations is also questionable as batteries get cold and fail, cameras are not always effective in the dark, and how cameras should be mounted and hidden in open habitats. Jason Fisher lost approximately ~38% of his "trap-nights" during his winter test of cameras due to equipment malfunction.

While detection rates using a baited camera approach are lower than winter tracking they require less effort. Using ground-based vehicles, we estimate that approximately 2-3 ABMP sites with 10 cameras each could be set up per day per team of two. With 382 sites to sample each year and **assuming** a two-week exposure period would be optimal, a total of 53,480 camera nights are required each year to complete such a protocol. If we also assume a 4-month winter interval would be the correct season to place cameras (because baiting is more effective in winter when natural food sources are lower), then approximately 50 ABMP sites would have to be sampled every two weeks. At 10 sites per camera by 50 sites, an initial capital expenditure of about $250,000 at $500 per camera unit would be required. To place and move these cameras would take 3 crews of two people. The 10 cameras per site is considerably more than the number of snares originally recommended by Moses et al. (2001) who suggested an array of three cameras/ snares per ABMP site would be sufficient.

8.3.2 – Barbwire hair snares with bait

Stations using barbed wire have been used to get samples of hair from carnivores and can also be used to develop probability of occurrence models much like cameras. Dave Latham has been examining the spatial distribution of predators within the Wabasca peatland using such an approach. He has used baited barbs in both summer and winter to determine the occurrence frequency of predators in this area. In general, this baiting protocol results in a lower frequency of detection than winter tracking (Table 12). Like cameras, bait stations represent a single point. Exactly how large an area is sampled by a single point is unknown and likely depends on type of lure, species you wish to track, and habitat.

A strength of the hair snare method is that DNA can be extracted from the hairs to get an estimate of the number of individuals present through capture-recapture methods. However, more than one hair snare would have to occur per ABMP site to make this type of data analysis practical. The frequency of multiple snares of hair of the same individual at one trap per ABMP sites would be extremely low. Thus, the data would simply be presence/ absence unless more than one snare per ABMP site was set up. Latham had much higher detection rates for most species than the snares put out by Fisher. Based on Fisher's estimates of species occurrence at least 10 snares per ABMP site would have to be set up. Based on Latham's estimates this number could be reduced to about 5 snares per site.

Barbed snares are a controversial method for tracking carnivores. First, snares require a considerable amount of bait to attract wolves and to a lesser extent coyotes. Latham placed approximately ½ a deer per site as only a large amount of meat seemed able to attract wolves into the snare. Using beaver carcasses, Fisher only attracted wolves to 6.2% of sites. Finding this amount of deer road-kill carrion is difficult, messy, and requires extensive planning. Alternatives such as scent lures have been shown by Fisher to be extremely ineffective (56% detection of mammals at sites vs. 2% at scent lure sites). Alberta Fish and Wildlife have disallowed baits such as chicken or cow, due to concerns about disease transmission.

Snares are good in summer for detecting black bears however. Latham's snares had a black bear detection rate of 53%. Given that approximately ½ of these sites were well into non-preferred black bear habitat (core of Wabasca peatland), this method would likely be quite effective in monitoring black bear occurrence during the summer months. Second, snares are undoubtedly the most biased sampling method as they only attract a very limited number of species. In particular, they virtually never sample herbivores and in fact may repel them, requiring another method of sampling for these species either via aerial survey, pellet counts, or track counts. Third, the ability to differentiate hair of coyotes, dogs, and wolves can be extremely difficult and in most cases requires genetic analyses to be confident in identification. Costs of genetic analyses would be considerable ($10 per sample). Fourth, of all the methods proposed snares have the greatest impact on the animals and can have a large effect on their behavior. Snares can also cause conflicts with local people, particularly trappers and other recreational users. Snares create hazards for forestry operators if left in place.

Table 12 - Minimum rates of detection for other methods of mammal surveys.

Species	Tracking (Winter)	Snares - (Summer)	Snares – (Winter)	Snares - Cameras (Winter)	Aerial Surveys (Winter)
Black Bear	.	0.53	.	.	.
Beaver	0.02	.	.	.	.
Caribou	0.02	.	.	.	0.04
Coyote	0.85	0.25?	0.55?	.	0.22
Deer	0.91	.	.	.	0.45
Fisher	0.34	.	0.14	0.08	.
Fox	0.17	.	.	0.04	.
Grizzly Bear	.	.	.	0.02	.
Hare	0.95	.	.	.	.
Lynx	0.67	0.01	0.18	0.02	.
Marten	0.52	.	0.58*	0.23	.
Mink	0.03	.	.	.	.
Moose	0.89	.	.	0.02	0.63
Mouse	0.89	.	.	.	.
Otter	0.20	.	.	.	.
Porcupine	0.05	.	.	.	.
Squirrel	0.98	.	.	0.17	.
Weasel	0.88	.	0.42*	0.04	.
Wolf	0.38	0.23?	0.27?	0.06	0.04
Wolverine	0.01	.	.	0.02	.
Scale	9-km	Single point	Single point	Single point	Township
Scheduling	1 visit	Min. 2 visits	Min. 2 visits	Min. 2 visits	Single visit

- Mustelids determined mainly by tracks in snow around bait rather than hair being snared. Jake Fisher did get reasonable hair snaring of marten and fisher at individual points (maximum frequency of 22%) ? - Hair not analyzed genetically so uncertain identification

8.3.3 - Aerial surveys

Probably one of the most common ways of monitoring large mammals in Canada is by aerial survey. Alberta is no exception and Sustainable Resource Development (SRD) has flown aerial surveys for moose and deer for over thirty years. During these flights, other animals such as coyotes, wolves, and caribou are recorded sporadically. Aerial surveys have been done from November through April during the leaf-off phase. Many methods of survey have been used over the past thirty years, which has made analysis of changing patterns of abundance and occurrence difficult. Kerri Charest has collated all of the aerial surveys done in the northeastern portion of the province since 1969. Major changes in aerial survey methods have taken place over time, including the type of aircraft used (helicopter versus plane) and the actual type of survey method employed. Survey methods used by SRD have included the Gassoway polygon method, quadrats, linear transects, and following riparian corridors. The currently accepted protocol is the Gassoway polygon method. With this method, fixed-winged aircraft are sent over a Wildlife Management Unit to get an initial estimate of animal abundance. Based on these preliminary surveys, the WMU is then stratified into Low, Medium, and High density areas for moose and deer. A random sample of each strata is then surveyed via helicopter in a completely systematic coverage within that strata. Flight lines via helicopter are 400 m apart (200 m observing width) whereby all animals detected are recorded. Carnivores are recorded to varying degrees but there is no *apriori* stratification for these animals based on the preliminary survey.

While budgets for wildlife surveys are declining in the province, the integration of the established system with ABMP could create a powerful link between the two programs. Money used to fund current surveys done by the government could be integrated into the overall ABMP strategy. Aerial survey methods and appropriate statistical techniques for estimating density are well established. The biggest weakness of aerial surveys is that it has traditionally only sampled large ungulates. Information on large carnivores such as wolves and coyotes has been collected sporadically as well, but detection rates have been very low (4X lower than snow-tracking). The costs for aerial surveys are significantly more than any of the other protocols. In addition, the current aerial survey protocol is stratified based on animal abundance, which is not consistent with the systematic nature of the ABMP sampling sites. Species smaller than coyotes are not typically recorded because they cannot be consistently seen from the helicopter.

The ability of the current system to track changes of mammals over time is limited because as new techniques emerge SRD has radically changed protocols making any temporal comparison confounded with method. To make an aerial survey method work, a commitment to a single method for long-term use is necessary.

8.4 - Recommended Protocol

We recommend that ABMP adopt the modified snow tracking protocol tested by the Integrated Landscape Management group. While the protocol is relatively expensive, it represents a balance between precise estimates of mammal abundance and the ability to track more than a few species. Other sampling methods described in section 7 may be more effective for particular mammal species and at slightly lower costs, but none have the capability to track as many species simultaneously. An ideal solution might be to combine baited cameras with snow tracking but this would further inflate costs. There are several ways of improving the winter tracking protocol and reducing its costs however that could be considered.

8.3.1 - How could the costs of the tracking protocol be reduced

The tracking protocol is economically expensive because of the large number of people required to conduct the surveys in a short period of time and the extreme physical demands of the work. The “down-time” waiting for 3 days to elapse since a new snowfall is also a problem. ABMP should consider utilization of experienced trappers and hunters to help in the fieldwork and collecting data. In Finland, over 1500 triangles are surveyed regularly by over 6000 volunteers and constitute the framework whereby wildlife management decisions are made. While volunteers maybe problematic given the relatively low number of people living in the forested areas of Alberta, we believe a system of “on-call” employees paid a stipend per triangle to collect the data ABMP would be effective. Such an approach would avoid the need to amass an army of seasonal employees that will often not be working due to poor snow conditions.

Preliminary discussions with the Alberta Trapper's Association (ATA) suggest that members of this group would look upon an "on-call" staff approach favorably. We recommend scoping out the possibility of setting up a liaison officer between ABMP and the ATA. This person would be in charge of setting up and organizing local people to conduct the tracking surveys. There are approximately 2300 trappers in the province of Alberta. Of these, about 1600 conduct their trapping on 1700 registered fur management areas (RFMA). Methods of organizing such an arrangement should be discussed with Glen Semenchuk of the Alberta Bird Atlas Project who has created such an arrangement in certain areas for gathering of bird data.

The benefits of engaging local people to help in the protocol are many. First, members of groups like the ATA are undoubtedly some of the best "trackers" in Alberta, so issues related to track identification would be of little concern (training costs will also be reduced as new people would not have to be trained as often). Second, these people live in the areas where tracking is to take place and will know the best access routes into area. Third, from a public relations perspective this would be invaluable, as it would truly engage Albertan's in the process of monitoring biodiversity. This would give the program greater profile in local communities and help in raising awareness at many social and political levels. Fourth, it could be considerably cheaper. If we were to provide a stipend to each tracker of $250 per triangle, this would come in ~$1000 cheaper than ILM has been able to do each triangle. This large difference is due to the high cost of travel between sites, accommodation, food, use of vehicles etc. Finally, by living in an area, trackers have the ability to get to their sites during times of optimal snow quality, reducing the variance in counts caused by variation in days since last snow. Further work is required to determine what the optimal period should be but somewhere between 3 to 10 days is our current recommendation.

The winter tracking protocol is physically very demanding. Whether "on-call" employees would be willing to walk 9-km along randomly selected transects is currently unknown. The only way to determine the efficacy of such an approach is to engage local people to participate and see what type of response is observed. This could be developed slowly as ABMP evolves. While many would verbally agree they could survey the triangles, once the true demands of the protocol were exposed there might be potential for people to quit or even worse, make up data. For such a protocol to work there has to be strong monitoring of data quality at the outset and strict criteria used to select those given these "on-call" positions. Training and monitoring of "on-call" employees would likely require a full time technician to be in charge of this protocol and to act as a quality-control officer. At the same time, there are many locations in the ABMP that are not accessible to volunteers. A limited number of seasonal staff would be needed to access and survey remote locations would be required.

The use of local people to conduct tracking triangles is not unprecedented. Several initiatives in the United States (http://www.keepingtrackinc.org/) and Europe (http://www.abdn.ac.uk/mammal/current_surveys.shtml; Battersby and Greenwood 2004) have organized large groups of people (1000's of volunteers) to participate in winter tracking protocols. In both of these programs, volunteers are required to undergo an extensive training program to ensure they have the skills required to complete the job effectively. This includes a classroom and field training portion done for groups of 15 or more people. By having a single ABMP staff member whose job is to go out and train local people the same rigor could be applied to having a full-time "on call" contingent of people.

We propose that an effort be put forth to determine the level of interest from trappers and the community at large in participating in winter tracking. This will require a full-time technician to begin discussions with the Alberta Trappers Association and other similar organizations. The goal of such an exercise would be to introduce the ABMP to these groups via a telephone or mail-out survey. Information on interest, availability, ability, and remuneration expectations should be collected. Presentations on ABMP could then be given to interested parties, with a specific focus on the mammal protocol. The deliverables from such a project would be a preliminary list of interested parties and a series of meetings with local trapper associations and hunting groups. If there was deemed sufficient interest from the scoping exercise, this liaison officer would then need to: 1) develop a quality control system for checking on data quality collected from the "on-call employees"; 2) develop a contact framework to inform the "on-call" employees about when triangles are to be done, data delivered etc; and 3) develop a training program for the "on-call" employees. This could lead to a pilot study conducted in winter 2006 to test the efficacy of an "on-call" employee approach. This would entail paying a limited number of qualified trappers to conduct the surveys and test the aforementioned protocols. These surveys would then be spot-checked by the ABMP liaison officer to ensure the protocols are being followed and data delivered in the proper format. The deliverable from this work would be a final report that outlines the findings of the tracking protocol done by "on-call employees" and an assessment of whether the "on-call" model would be effective. The approximate cost breakdown for a test of the "on-call" employee approach is given in Table 13.

Table 13 - Proposed cost breakdown for pilot study to test efficacy of "on-call" employee approach.

Timing	Task	Costs
Sept. – Dec. 2005	Trapper Scoping Exercise	1 Tech. Coord. - $12K 1 vehicle - $7K Food & accom. - $3K **Total: $22K**
Jan – Mar. 2006	Trapper Field Pilot	Trapper stipends - $10K 1 Tech. Coord. - $12K Food & accom. - $3K **Total: $25K**
Proposed budget		**Total: $47K**

<u>8.3.1.1. – Consideration of trail-based survey by snowmobile</u>

Another option to reduce the costs of a tracking program would be to determine how a non-random sampling design might influence the results. Throughout much of Alberta, seismic lines and trails exist that are used to access remote areas. If trackers could simply record the number of tracks that they detect while driving along linear features, the speed of the tracking protocol could be increased dramatically. Snowmobile sampling would likely allow a single observer to conduct track surveys at more than one ABMP site per day. It would also be easier to visit ABMP points after a specific DSS since last snow has elapsed.

If snowmobiles were to be used it would be ideal to have a systematic sampling trail network around each ABMP point. However, to have a fully systematic sample across the province would require cutting trail in many areas. This is **NOT** possible as the costs of using low-impact mulching technology (least environmental impact at lowest cost) are cost-prohibitive ($1000 per km minimum, ~ $10 million just to do the forested sites once). It also would not be desirable in national parks. Thus, snowmobile based surveys would have to be done along **EXISTING** trails or seismic lines. An assessment of whether these trails are random with respect to habitat would have to be done prior to this type of protocol being recommended.

Due to issues involved in snowmobiles sinking in deep snow, observers would likely have to traverse the entire transect ahead of time to set a "working snowmobile" track. The observer would then have to retrace his/her route and count those tracks observed off the snowmobile trail. Trails would have to be selected randomly rather than using established snowmobile routes. Many animals avoid high snowmobile-use areas (i.e. caribou). More worrisome is the possibility that species will actually follow snowmobile trails (packed snow) making an assessment of the number of tracks non-random (i.e. wolves and coyotes). Most protocols that use a trail or road-based survey design simply record occurrence per unit length surveyed rather than number of tracks. Such approaches have been recommended in BC and Wisconsin (http://dnr.wi.gov/org/land/er/mammals/volunteer/guidelines.htm)

An alternative approach used in Prince Albert National Park – Saskatchewan, is to erase all animal tracks on trails by dragging a customized brush behind the snowmobile. This approach removes the track of the snowmobile (albeit with extensive snow packing) and erases all animal tracks. Wardens in the park then revisit the trail 24 hours later and record all animal tracks that have accumulated along the path in the 24-hour period. No statistical analyses of the efficacy of this protocol have been done to date.

Regardless of the type of snowmobile technique employed, smaller mammals such as hares, squirrels, and mice would be missed using a snowmobile, as it is hard to see small tracks regardless of snowmobile speed. One way to correct this limitation would be for observers to walk shorter segments of their snowmobile route (i.e. a 1 km segment) on foot.

The only way to know whether our suggestions will "improve" the tracking protocol as described in section 4, is to compare the suggested snowmobile technique to the protocol that we have already tested. If a comparison of walking transects as outlined in section 4 demonstrates no significant differences relative to animal numbers on snowmobile trails as outlined in section 8 – then a snowmobile based sampling protocol should be strongly considered to minimize costs.

However, safety issues for people working alone on snowmobiles should also be considered before adopting a trail-based protocol. ***In conjunction with partners on other research programs, ILM will be conducting such a comparison in the winter of 2005.***

8.3.2 - How the precision of the suggested tracking protocols could be improved

The snow tracking protocol as proposed is heavily influenced by DSS. The current correction for DSS used in the ILM research program is robust but is influenced by other factors (time, cumulative effects, space, etc.). More effort has to be put to understanding exactly how DSS influences counts in particular habitats and sites. To do so, a series of repeat visits to the same sites over the length of a season are necessary. ***We recommend that the ABMP test daily track accumulation rate. This should be done in the winter of 2005***. By visiting the same triangles at DSS 1, 3, 5, 7, 9 we would be able to develop a track accumulation curve that could be used to correct for DSS more effectively. Repeat visits would also us to record when specific tracks were initiated and when they disappear. Such research has been initiated by ILM but currently there is insufficient data to be confident in the results.

During the same pilot in 2005, the same triangles should be visited between snowfall events in the same year. This would provide information on the repeatability of track count estimates within a site. These two estimates provide the information for within-site variation caused by sampling error and animals moving in and out of a study area. This type of information is crucial for separating sampling variance from temporal variance. Obtaining such estimates would be particularly useful in developing efficient statistical power estimates. Ultimately, repeat sampling within years should be adopted in all protocol tests for ABMP**,** particularly those that measure mobile organisms (birds, insects, mammals). This will allow us to understand the level of variation attributable to sampling error versus temporal/ spatial variation. Current repeat sampling done between years confounds **REAL** annual changes in abundance with variance caused by imperfect detectabilty of species caused by their movements and survey error. Recognizing the wide variety of protocols being tested by ABMP, this may not be possible right away for all protocols but should be given strong consideration.

The current design of ABMP envisions sampling points every 5 years. This means that sampling points within years will be 100 km apart. We believe a modeling exercise is needed to determine if this is the optimal strategy. By clustering ABMP sites into groups of 4 or 9, significant cost-savings related to moving between sites could be obtained. Simultaneously, such an approach might increase the frequency of detection of species with very large home ranges such as wolves, caribou, and wolverines. The very large home ranges of these animals means that during a single tracking visit to one site it is highly plausible to miss these species despite their presence in that ABMP region. Clustering sites may increase the chance that species with very large home ranges are detected in particular regions because more effort is focused within the home range of these large-ranging animals. Sites spread 100 km apart are outside of the typical home range of even wide ranging species meaning that the chance of a triangle intersecting their tracks is relatively low. One way to determine the effectiveness of such an approach would be to develop individual-based movement models created from published radio-tracking data. Using these movement paths it could then be determined the frequency with which different species might be expected to be cross a winter-tracking triangle segment. By applying the movement rules in a GIS framework it should be possible to determine whether sampling clusters of 4 to 9 triangles in any given year would be more effective in tracking the species with the largest home ranges than spreading the triangles out.

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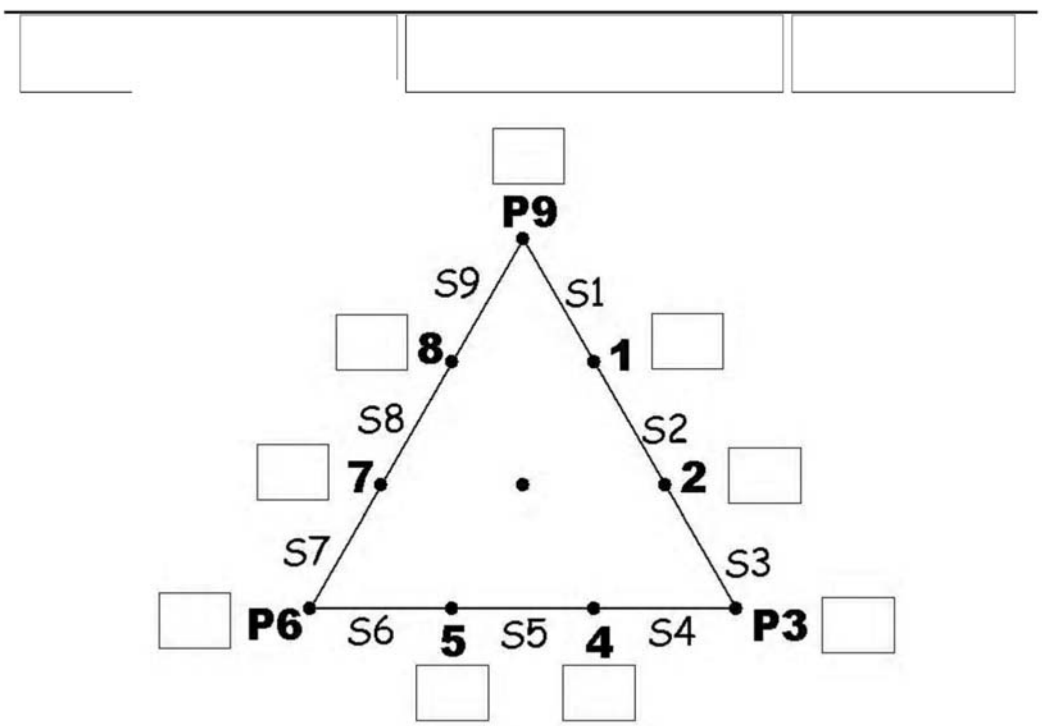
10 - Appendix 1 - Datasheets used in winter tracking protocol

<u>Appendix 1.1 – Track detection sheet</u>

	Date (yyyy/mm/dd)			**Snow-tracking Score-sheet**				Notes:		
	DSS	Start time	End time	Observer	Township	Side #	Temp (^{o}C)	Snow Depth (cm)		
ref.	Segment	Species/ Group	Code	Score	**Total**	Segment	Species/Group	Code	Score	**Total**

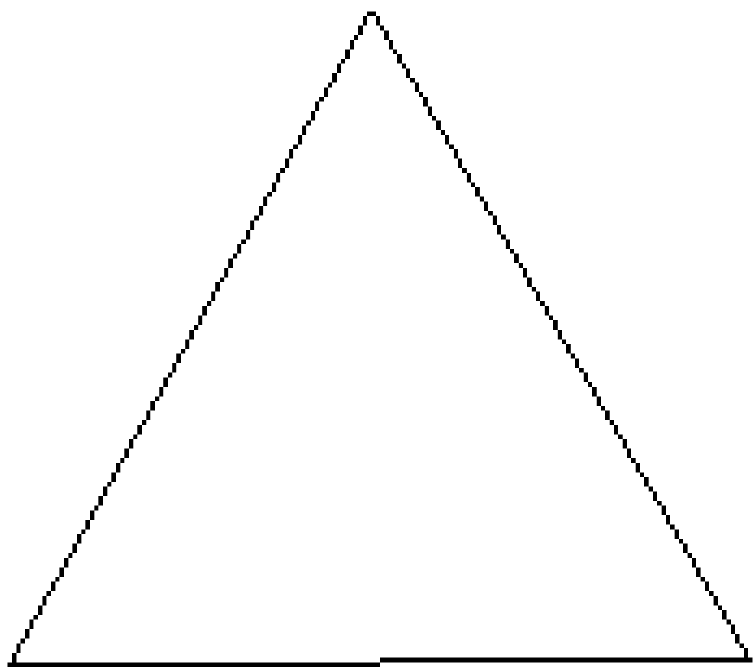
Appendix 1.2 - Triangle coordinate sheet used by ILM group to confirm visitation to all triangle segments. Coordinates are derived ahead of time by a GIS system. Methods have been derived in ArcView GIS to calculate where the triangles should be for all townships in Alberta with an appropriate rotation to accommodate for curvature of the earth. This approach resulted in a considerable time saving as crews did not have to derive coordinates from paper maps in the field.



GPS ID	Pnt	Datum	UTM	Easting	Northing	Longitude	Latitude	NewE	NewN

Appendix 1.3 - Triangle access summary describing route followed to access triangle. To ensure that technicians have important information in subsequent years, it is crucial that Access Summaries be completed for each triangle surveyed or attempted. Important access information should be recorded on access summary datasheets before entering the field. This will include the site location (Twp., Rge., Mer.), and road directions, including distances, road numbers, and helpful hints).

Township		Treatment	
RFMA		Other	
Region			



Appendix 1.4. - Remote Contacts DSS Datasheet

Remote Contacts DSS (Days Since Snow) Datasheet

YEAR:

Remote Source Location:	
Name of Contact:	
Phone Number:	

DSS	Month	Date	Time	Obs (tech)	Snow?	How much?	General weather

Appendix 1.5. - Camp Weather Records Datasheet

Camp Weather Records

YEAR:	

Temperatures should be observed each morning to get Min temp for the previous night and each evening to get Max temp for each day.

Month:

Date	Obs	Location	Min Temp (night before)	Max Temp	Snowfall
1					
2					
3					