ALBERTA WOLVERINE EXPERIMENTAL MONITORING PROJECT

2003-2004 ANNUAL REPORT

Alberta Wolverine Experimental Monitoring Project

2003-2004 Annual Report

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DISCLAIMER

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EXECUTIVE SUMMARY

This report outlines preliminary data obtained in 2003-2004, and provides some discussion and recommendations for wolverine monitoring occurring in the final year of the project. Wolverine were remotely monitored across the Foothills region of Alberta, Canada. Monitoring stations consisted of hair traps for noninvasive genetic tagging. We deployed 95 stations between November 2003 and April 2004, logging over 11,000 trap nights. A subsample of 15 of these hair-trapping stations were fitted with infrared-triggered remote camera systems to assess detection rates of hair stations. Twelve mammal species were detected at monitoring stations, ranging in size from flying squirrels to grizzly bears. Hair traps consistently undersampled species presence; we recommend a detectability correction factor for mid-size and large mammals. Detection rates for wolverine were very low – only one wolverine was detected in 48 baited stations (2.2%). Further data are required to achieve an accurate density estimate, but we believe that our results are indicative of the very low densities at which wolverine exist in the foothills of Alberta – possibly as low as one wolverine per 300 km^2. Monitoring will continue in 2004-2005 with further technical refinements to the traps, and to site selection; more data will improve on assessments of detection rates, and estimates of density. We will use these to provide final recommendations for a wolverine population monitoring program for Alberta.

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CHAPTER 1. BACKGROUND AND RATIONALE

Background

The wolverine (*Gulo gulo*) is a member of the weasel family (Mustelidae). Once having circumboreal distribution, the wolverine has experienced considerable population reduction and range retraction across North America since European occupation. In eastern Canada, the wolverine has declined dramatically, to the point of extirpation from several areas. In 1989, COSEWIC listed the eastern population of wolverine as *Endangered*. The western population has also been substantially reduced, and has been listed as a species of *Special Concern* (COSEWIC 2003). In Alberta, wolverines still inhabit the mountains, foothills, and boreal plain, but numbers are suspected to be low. The Government of Alberta has designated this species *Data Deficient* (Alberta SRD 2000). The *Data Deficient* designation delineates a need for further information, and acknowledges the potentially threatened status of this species. There has never been an inventory of wolverine population size, distribution, demographics, or habitat use in the boreal regions of the Province; very little work has been done in the montane region.

The wolverine's biology makes it susceptible to anthropogenic perturbation. Solitary and wide-ranging, wolverines normally exist at low densities. Estimates of density range from 1 wolverine per 65 km^2 in Montana (Hornocker and Hash 1981) to 1 wolverine per 177 km^2 in the Yukon (Banci and Harestad 1990). No data on wolverine densities in the boreal forest – which represent a sizeable portion of their global range - exist. Wolverines have naturally low reproductive rates and low juvenile survivorship (Banci and Harestad 1988; Petersen 1997), which contribute to their sparse distribution and low population size. Low wolverine density is also due, in part, to the requirement for extremely large home ranges that are highly variable, with habitat selection based on food availability and habitat suitability (Whitman *et al.* 1986; Landa *et al.* 1998; Vangen *et al.* 2001).

The wolverine is a scavenging carnivore. Winter forage consists largely of ungulate carcasses; in other seasons wolverines feed on ungulates, small rodents, and snowshoe hares (Hornocker and Hash 1981; Banci and Harestad 1990). Food availability - most notably the availability of ungulate carcasses in winter - is likely a primary driver of wolverine habitat use, as wolverines are highly susceptible to fluctuations in foraging opportunities (Weaver *et al*. 1996).

Rationale

Wolverines' large home-range requirements, low densities, and low productivity, make them potentially sensitive to overexploitation. They rely on large geographic areas encompassing the full spectrum of seasonal habitat requirements, while providing enough variability in food availability that natural fluctuations are buffered. Therefore, anthropogenic activity that reduces available habitat may have repercussions for already low wolverine mortality and survivorship, and hence impact abundance and distribution. Currently, timber harvesting, oil and gas activity, and a limited wolverine fur harvest all occur in Alberta's boreal forest. However, wolverines' response to forest harvesting and other anthropogenic disturbance in Alberta is completely unknown (Fisher and Wilkinson 2002). In British Columbia, wolverines appear to be vulnerable to human development and are in decline (J. Krebs and E. Lofroth, pers. comm.). In Montana, wolverines occurred most often in mature and old stands, least often in young dense stands, and never in clear-cuts (Hornocker and Hash 1981). Wolverines avoid human settlements and seem to be susceptible to disturbance, particularly during the denning period, as humans cause a significant portion of recorded wolverine mortalities (see review in Weaver *et al.* 1996).

Responsible species and land management is required to mitigate potentially adverse effects of anthropogenic activity on wolverines in Alberta. However, for an appropriate management plan to be created, we require reliable estimates of population size, home range size (for density estimates), immigration and emigration rates, reproductive rates, and recruitment rates. Currently, none of this information has been garnered in Alberta.

Objectives

Our lack of knowledge of Alberta wolverine distribution and abundance is primarily due to the extreme difficulty and large expense associated with obtaining adequate sample sizes from this rare, low-density, highly vagile species - a problem shared with areas home to other northern wolverine populations, such as Scandinavia (Flagstad *et al.* 2004). Noninvasive genetic sampling (Taberlet *et al.* 1999) holds promise as an inexpensive method for obtaining replicated data on wolverine distribution, population size, dispersal distances, and density (Flagstad *et al.* 2004). This technique may also be used over the long-term as a monitoring program, to provide information on wolverine population trends. However, establishing a monitoring protocol for low-density animals is difficult, as the design requirements of new protocols are largely unknown (Kendall *et al.* 1992). As we have no pilot data on Alberta wolverine distribution, density, and coefficients of variation, we have no starting point from which to design a statistically rigorous monitoring program. No reliable and cost-effective methods for tracking wolverine populations in Alberta currently exist. This project attempts to address this need.

The goals of the Alberta wolverine experimental monitoring project are:

1) to assess and calibrate noninvasive genetic tagging as a method for long-term population monitoring, by examining the relative efficacy of hair trapping with remote camera systems to reliably detect wolverines;
2) to examine and assess the experimental design requirements of a wolverine remote monitoring program; and
3) to provide preliminary data on wolverine distribution, density, probabilities of occurrence, coefficients of variation that will pilot the implementation of a larger statistically rigorous Province-wide wolverine monitoring program.

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CHAPTER 2: STUDY AREA AND METHODS

Study Area

Monitoring for wolverine in this year occurred in the Foothills and Montane regions of Alberta (Figure 1). Ninety-five (95) stations were established, generally following the Forestry Trunk Road between the Ram River area (Figure 2) and the Grande Cache area (Figure 3).

Site Selection

Within this large study area, monitoring stations were established using a stratified systematic approach. Stations were a minimum of 3 linear km apart to reduce the probability of pseudoreplication (Hurlbert 1984) resulting from one individual being detected at several sites. Stations were a minimum of 50 m from access roads. Within this roughly systematic structure, stations were located at points of high elevation relative to the local landscape, where wolverine were known or suspected to occur and where bait scent dispersion is most effective. Stations were located in all stand types. Areas where access was poor, or where industrial activity was currently occurring, were not sampled.

Wolverine Monitoring

The power of a new monitoring protocol to statistically and accurately detect a change in population size needs to be assessed against other techniques (Kendall *et al.* 1992). Classic mark-recapture experiments use the measure *trappability* to assess the accuracy of population estimates (Krebs and Boonstra 1984); an analog for remote detection methods such as hair trapping, is required. In Fisher (2003), we attempted to assess detection probabilities of three different monitoring techniques – snow tracking, hair trapping, and camera trapping. We found that of the two trapping techniques, hair trapping consistently undersampled animals visiting bait stations, thereby producing a unidirectionally biased abundance estimator. We recommended the use of hair trapping and camera traps together to construct a detectability correction factor.

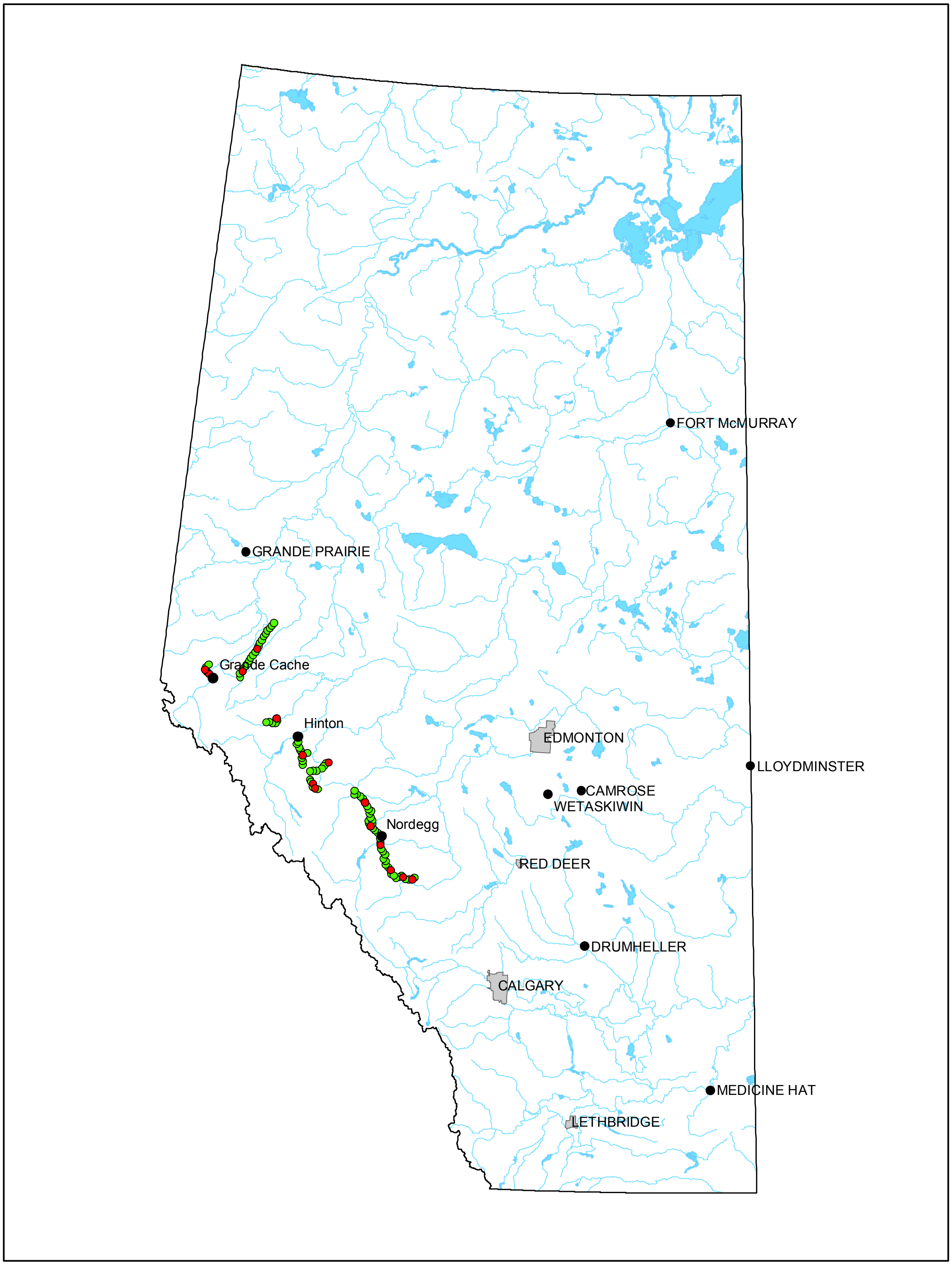

Figure 1 The Province of Alberta. Monitoring stations, indicated as circles, were placed in the montane and foothills regions between Ram River and Grande Cache.

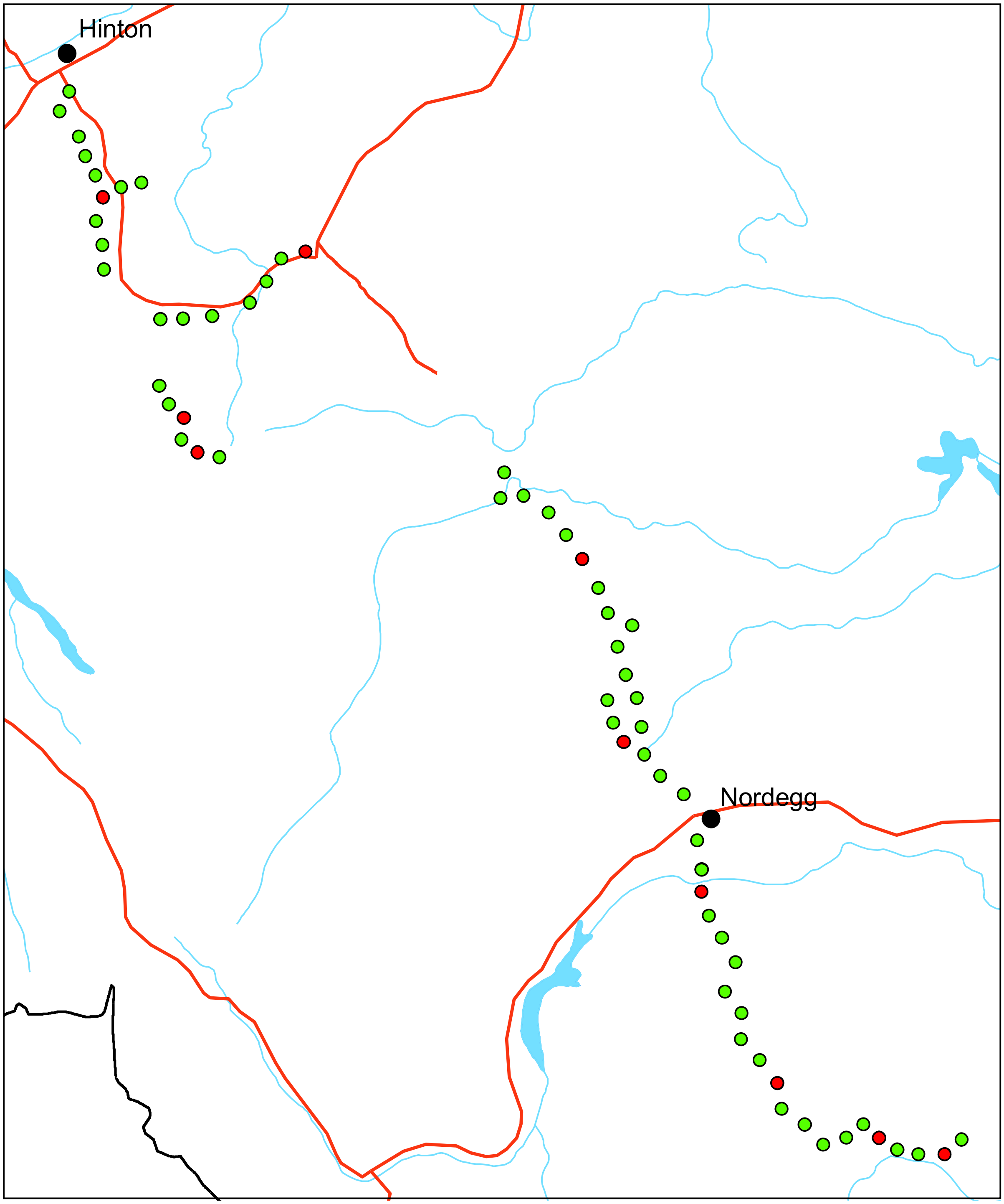

Figure 2 Monitoring stations, indicated as circles, were placed along the Forestry Trunk Road and adjacent access roads between the Ram River area and the Town of Hinton. Five stations were placed around Cadomin and Mountain Park. Red circles indicate camera stations.

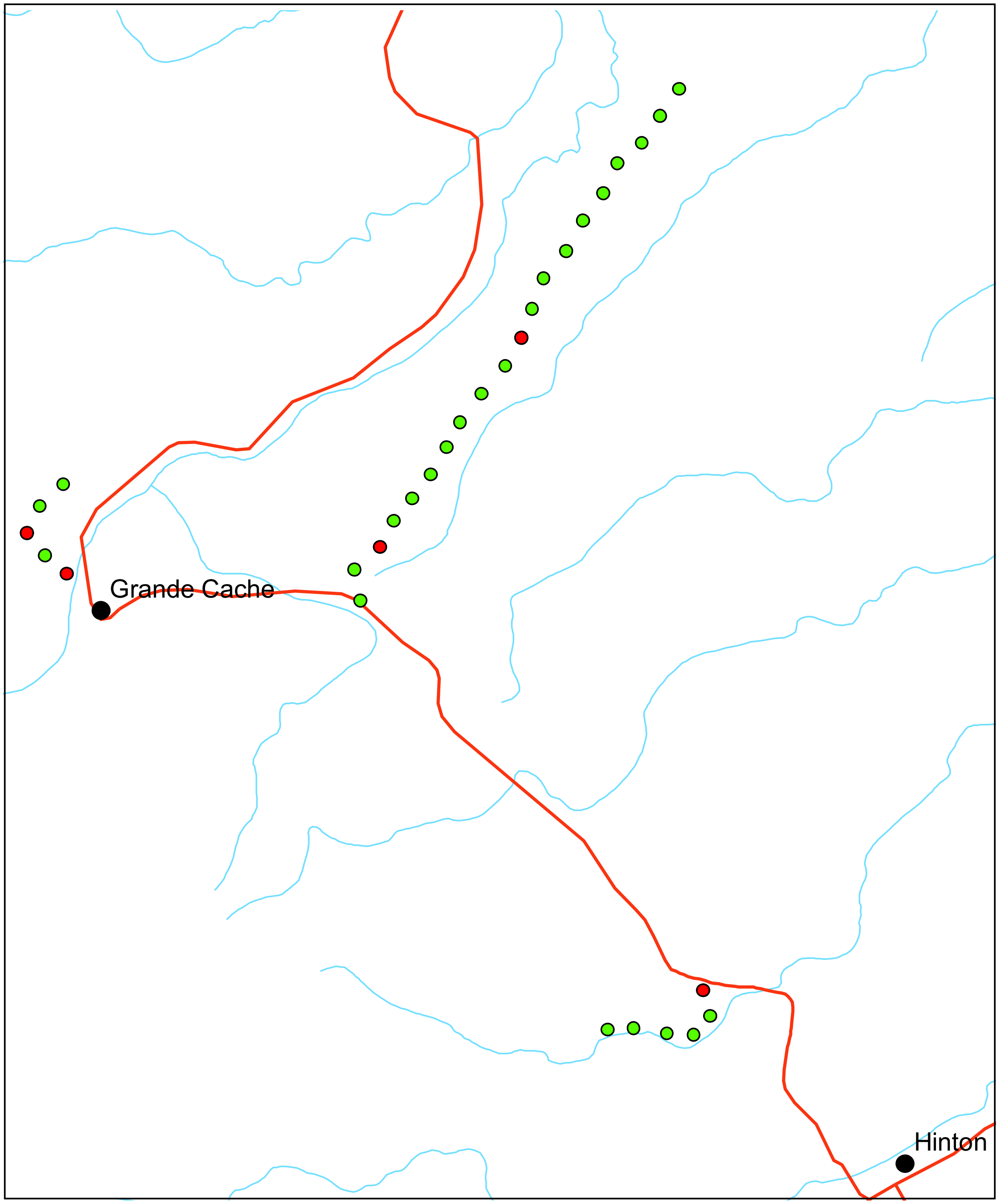

Figure 3 Monitoring stations, indicated as circles, were placed on access roads adjacent to Highway 40 between Hinton and Grande Cache, and along the Forestry Trunk Road northwest of Grande Cache. Five stations were placed on Beaverdam Road and the mine sites west of Grande Cache. Red circles indicate camera stations.

Noninvasive genetic tagging: Hair capture

Hair samples taken from animals, if the follicle is present, can yield DNA samples. Genetic analysis can identify these hairs to species; if hairs belonged to wolverine, genetic 'fingerprints' can be detected that identify individual wolverine (Mowat *et al.* 1999; Mowat 2001). An Alberta SRD investigation into the feasibility of a hair collection protocol indicated this technique showed promise as a tool for wolverine monitoring (Mowat 2001). Hair trapping can yield low-cost and high-return data on distribution, relative abundance, and home range estimates.

Fisher (2003), modifying Mowat's (2001) protocol, erected beaver-baited hair corrals consisting of high-tensile steel barbed wire, with barbs 5 inches apart, strung between trees to form a roughly square corral ~ 3 m on each side. Barbed wire strands were 15 cm – 25 cm apart, layered 3 strands high. These corrals were baited with beaver (*Castor canadensis*) carcasses. These corrals had some limited success at snagging hair of marten (*Martes americana*) and lynx (*Lynx canadensis*) but did not capture wolverine hair.

In this year of the experimental monitoring project, we adapted a hair snagging technique developed by R. Mulders, RWED, Government NWT (unpubl. data). Mulders wrapped barbed wire 4x4 posts, secured bait at the top, and set these into the snow and ice in the central barrens of the North West Territories. Mulders deployed 48 of these traps and obtained hair at 39 (81%), eventually identifying 20 individual wolverines. We modified this technique for use in forested areas. At each monitoring station we selected a tree 10 cm – 20 cm in diameter, at least 2 m from other trees. We cleared branches from the lower bole of the tree, and wrapped 10 m - 15 m of high-tensile steel barbed wire around the tree, from the base to 2 m up the bole. Immediately above the wire (*ca.* 2.2 m up the bole) we placed either:

1) a partial beaver carcass, wrapped in plastic or aluminum window screen, and *ca.* 10 mL of O'Gorman's LDC Extra scent lure (O'Gorman's Co., Montana, USA).
2) a 10cm x 10 cm aluminum window screen nailed to the bole of the tree, behind which was placed ca. 10 mL of O'Gorman's LDC Extra scent lure.

Monitoring stations with and without bait (termed "lure-only") were staggered with one another along our sampling transect. This was done to assess the efficacy of baited stations *versus* scent stations (see Roughton and Sweeney 1982) for attracting wolverine into a station. As bait can be cumbersome, expensive, and a safety risk when working in bear habitat, being able to achieve the same efficacy using lure-only stations would be a logistical advantage. Of the 95 stations deployed, 47 were lure-only sites, and 48 were baited and lured.

We visited hair-snagging stations every 1–2 months between December 15, 2003 and April 15, 2004. Hair samples were collected using sterile procedures, placed in paper envelopes, and stored at *ca.* 10^{o}C in a standard kitchen refrigerator.

Genetic analysis of hair samples

All hair samples were sent to Wildlife Genetics International (WGI; Nelson, British Columbia, Canada) for genetic analysis. DNA was extracted from hairs using QIAGEN's DNEasy Tissue Kits (D. Paetkau, WGI, pers. comm.). DNA was then analysed for species identification; this involved a sequence-based analysis of the 16S rRNA, mtDNA gene (*sensu* Johnson and O'Brien 1997) that was then compared against a DNA reference library of all known mammal species expected to be found in the foothills and boreal forest. Identification of hair to species provided a presence / absence measure for furbearing species across our sampling transect.

Camera traps

In the same sense as non-detection cannot be construed as an 'absence' in a standard presence / absence survey, neither does a lack of hair indicate that wolverine have not been present at a hair-snagging station. An estimate of hair detection probability is required to assess potential bias in site occupation probability estimators.

To assess this bias for our tree-trunk hair traps, camera traps were installed at fifteen (15) randomly subsampled monitoring stations. Camera traps have been used as a low-cost alternative to livetrapping for a variety of other carnivorous species (*e.g.* Jones and Raphael 1993; Karanth 1995; Kucera *et al.* 1995; York *et al.* 2001). In addition to calibrating wolverine detection rates *via* hair capture, camera trap data can be used as another relative index of wolverine abundance.

Trailmaster™ 1500 and 1550 Active Infra-red Remote Camera Systems (Goodson and Associates Inc., Lenexa, Kansas) were installed at two trees aligned with the hair snag tree. These systems consist of a Canon A1 Sureshot or Olympus camera, loaded with Provia 400F DX-coded 36-exposure 35-mm slide film, wired to an infrared (IR) beam receiver, placed *ca.* 6 m across from an IR transmitter. The IR transmitter and receiver were arranged on aligned trees such that the IR beam was *ca.* 15 cm under the bait. In principle, when an animal climbs the baited tree, it breaks the beam; the IR receiver notes this in a log, and sends a signal to the camera to take a pictures. Trailmaster Receivers were set to record an event if the beam was broken for 5 pulses (0.25 seconds); we set a 5-minute camera delay to extend the sampling period and avoid multiple pictures from non-target animals. Film was checked and changed once a month. Slide pictures were analysed for species present, and compared with hair capture results.

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CHAPTER 3: RESULTS OF REMOTE WOLVERINE MONITORING

Results

Monitoring stations 1-90 were operational from November 13, 2003 to March 11, 2004. Stations 91-95 were installed December 13, 2003 and were collected April 15, 2004. We sampled a linear area in excess of 600 km.

The total area sampled in this study varies as a function of area of influence (AOI) of the monitoring stations (Figure 4). Calculating the AOI - the area within which a randomly located animal will sense the attractant, possess a non-zero probability of moving towards the station, and be detected – is difficult. The AOI depends on the nature of the bait used, ambient temperature, prevailing winds, food availability, the species being attracted, and intra-species variability. Accurate tracking information is required to accurately estimate mean and standard deviation for an AOI; as we lack these data, the AOI can only be postulated. Assuming that the AOI for our monitoring stations is a 1-km radius, we sampled a ~ 300 km^2 area.

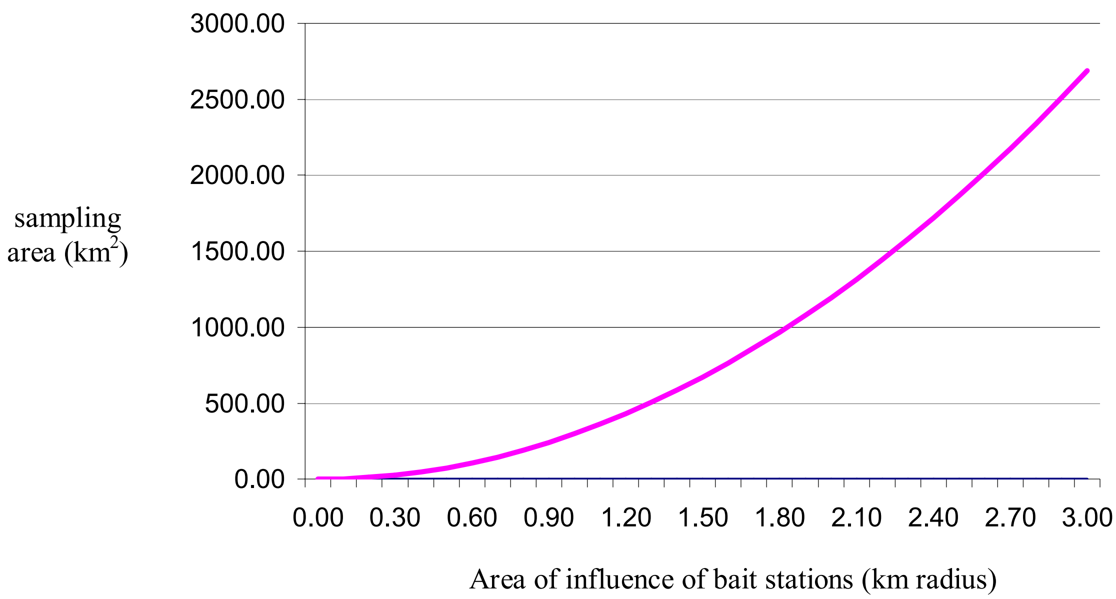

Figure 4 Possible area of influence of baited and scent-lured wolverine monitoring stations, and the accompanying areas potentially sampled in this study.

Hair capture

We logged 11,510 trap nights on the hair capture traps. Hair traps were assumed to be fully functional from the day of deployment to the final collection period. In some cases, trap checks revealed that bait had been missing for an unknown period of time; however, pieces of carcasses, scent lure, and other attractants usually remained at the site to attract animals. Camera data revealed that animals returned to a site even after most of the bait had been removed. Therefore, the assumption was made that functionality of a hair trap was constant throughout the sampling period, for purposes of trap-night calculation.

We collected 54 hair samples in 2003-2004. Of the 54 hair samples collected, 4 did not contain enough material to allow for extraction of DNA. Of the 50 hair samples from which DNA was extracted, 6 failed to produce useful data due to lack of viable material. Three samples were mixed with hair from other species; one species within each of these samples could be identified, while the other species could not be. The identifiable samples (Table 1) were: 15 marten (*Martes americana*), 8 fisher (*M. pennanti*), 3 wolf or dog (*Canis lupus* or *C. familiaris*), 3 red squirrel (*Tamiasciurus hudsonicus*), 2 ermine (*Mustela erminea*), 1 cougar (*Puma concolor*), 1 lynx (*Lynx canadensis*), 1 silver fox (*Vulpes vulpes*), and 1 red fox (*V. vulpes*). The remaining 9 samples were successfully extracted and typed, but their genomes could not be matched to any known reference data from boreal forest mammals, and so remain unidentified (D. Paetkau, WGI, pers. comm.).

Camera traps

We deployed fifteen (15) cameras at fixed stations between November and April 2004. Cameras were active for a gross total of 1,635 trap nights. Camera malfunctions resulted in a net total of 1,026 trap nights. Mechanical malfunctions were a result of damaged Trailmaster™ receiver / camera linkage cables; short circuits causing premature battery drain; and unidentified circuit failure. The latter two items usually occurred in older 1500-model Trailmaster Receivers and cameras. Technical malfunctions were the result of blocked IR beams by slipping bungees or hanging bait; repeated shots in short time frames due to non-target scavengers or sun glare; or large animals knocking down camera systems.

Species identified at monitoring stations using camera data (Table 1) include marten (6 stations), fisher (2), red squirrels (4), flying squirrels (2; *Glaucomys sabrinus*), ermine (2), moose (1; *Alces alces*), grizzly bear (1; *Ursus arctos horribilis*), and 1 wolverine.

Baited stations vs. lure-only stations

Of the 95 stations deployed, 48 stations were baited with beaver carcass and O'Gorman's LDC Xtra scent lure; 47 were scent-lured only. Of the 48 bait sites, 27 (56%) registered detections of a mammal species. Of the 47 lure-only sites, only 1 (2%) registered detection of a mammal species. The bait sites registered significantly more mammal detections than did lure-only sites (X^2 test; $X^2 = 33.46$; $df = 1$; $p < 0.05$). As the different station types were staggered along the transect, clustering of mammals in space would not explain this difference. The data suggest that the O'Gorman's LDC Xtra scent lure alone is not effective at attracting mammals to a station to allow for hair or camera detection, and that bait (beaver carcass in this case) is required. Therefore, all 'lure-only' stations were dropped from subsequent analysis of detection probabilities.

Species detection rates

Twelve mammal species were detected using the combination of hair and camera trapping (Table 2). Detection rates – the percentage of occurrences of a species over the number of (baited) stations – varied considerably. Marten were the most ubiquitous, with a detection rate of 22.9%; red squirrels were also frequently detected (16.7%). Fisher were third-most common, with a detection rate of 8.3%. Cougar, grizzly bear, lynx, moose, and wolverine were only rarely detected (2.1%).

Table 1 Species present at each monitoring station as identified by hair traps and camera traps. Camera sites are noted with a 'C'. Results are an integration of all data gathered between November 2003 – April 2004.

Station	**Species detected by camera**	**Species detected by hair snagging**
2C	marten	unknown sp.
3		unknown sp.
5C	marten	none
9		marten not extracted
11C	marten red squirrel	marten
13		marten
15		silver fox
16		wolf/dog
17		wolf/dog
19C	marten	marten red squirrel failed
25C	red squirrel	marten failed
31		red squirrel
33		unknown species not extracted
35C	grizzly bear	none
37		red fox
39		marten failed test
41C	ermine	ermine not extracted

Station	Species detected by camera	Species detected by hair snagging
43		failed test
47		unknown sp.
49C	none / malfunction	none
51C	flying squirrel red squirrel	unknown sp.
57C	fisher	fisher
59		fisher
65C	malfunction marten	fisher failed test
69		marten
73C	marten	not extracted failed test unknown species
75		marten
79		marten unknown sp. failed test
81C	fisher wolverine	fisher
85		wolf/dog
91C	ermine red squirrel flying squirrel	none
93C	moose	cougar red squirrel unknown sp.
95		ermine lynx unknown sp.

Table 2 Unadjusted detection rates by species. The percent of stations at which species were detected, out of a total of 48 baited monitoring stations. Detections have been integrated across time (November 2003 – March 2004).

Species	Number of detections	Detection rate (%)
cougar	1	2.1
ermine	3	6.2
fisher	4	8.3
flying squirrel	2	4.2
fox	2	4.2
grizzly bear	1	2.1
lynx	1	2.1
marten	11	22.9
moose	1	2.1
red squirrel	8	16.7
wolf/dog	3	6.2
wolverine	1	2.1

Detectability correction factor

At monitoring stations fitted with Trailmaster™ cameras, hair trapping was not as effective as camera trapping at detecting the presence of an occurring species. We dropped flying squirrels and red squirrels from the dataset, as neither cameras nor hair traps were designed to reliably capture these species. Of the 18 remaining instances where species were detected at camera stations (15 stations with 3 stations exhibiting > 1 species), both the hair traps and camera traps detected the same species in only 7 instances. Cameras detected a species when hair trapping did not, in 8 cases; the reverse occurred in 3 cases.

A sign test (Zar 1996) suggested that cameras were not significantly better at detecting the presence of a mammal species at a station than were hair traps (n = 11; $X \leq 3$, $X \geq 8$; $p = 0.227$). However, sample size was small and this analysis was strongly influenced by the few instances where cameras failed to detect a species. In this year of study, one failed camera detection was due to mechanical malfunction. In the second detection failure the species detected by hair (cougar) likely stayed low to the ground under the beam. In only one case was a target species – a tree-climbing mustelid - missed by the camera but detected by hair snagging. When we excluded the first two cases, a sign test suggests that functional cameras are significantly better at detecting tree-climbing mustelids than are hair traps ($n = 9$; $X \leq 1$, $X \geq 8$; $p = 0.039$).

Our results suggest that hair traps are undersampling mid-size and large furbearer species occurring at monitoring stations 8 out of 18 times (44.4% of the time). If this is the case, then a detectability correction factor of ***2.25*** should be applied to hair-capture detection rates to provide more reliable estimates of occurrence. More data are required to obtain a more precise estimate of this correction factor, but at this point it appears hair snagging is detecting furbearer species actually present at a station about half the time.

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CHAPTER 4: PRELIMINARY WOLVERINE MONITORING RECOMMENDATIONS

Discussion

This pilot-phase implementation of the wolverine monitoring protocol provided training data that will serve to guide future iterations of a wolverine monitoring program. Technical recommendations were generated that will help refine field monitoring; these are minor in nature and are presented in Appendix 1. Training data on wolverine density, and resultant implications for the statistical requirements of a wolverine monitoring program, demand considerably more discussion.

Pilot data: Estimated wolverine density

The wolverine detection rate in this pilot project was extremely low. Wolverines were detected only once, at 2.2% of all baited monitoring stations. (This number stems from camera data, not hair trap data, so the detectability correction factor was not applied to this detection rate.) If we assume that the probability of wolverine detection at our stations was 1.0, then wolverine density varies with the area of influence of the baited stations (Figure 5). If we assume, as we did previously, that the AOI of baited stations was 1 km, then our estimated wolverine density for this year was 1 wolverine per 300 km^2.

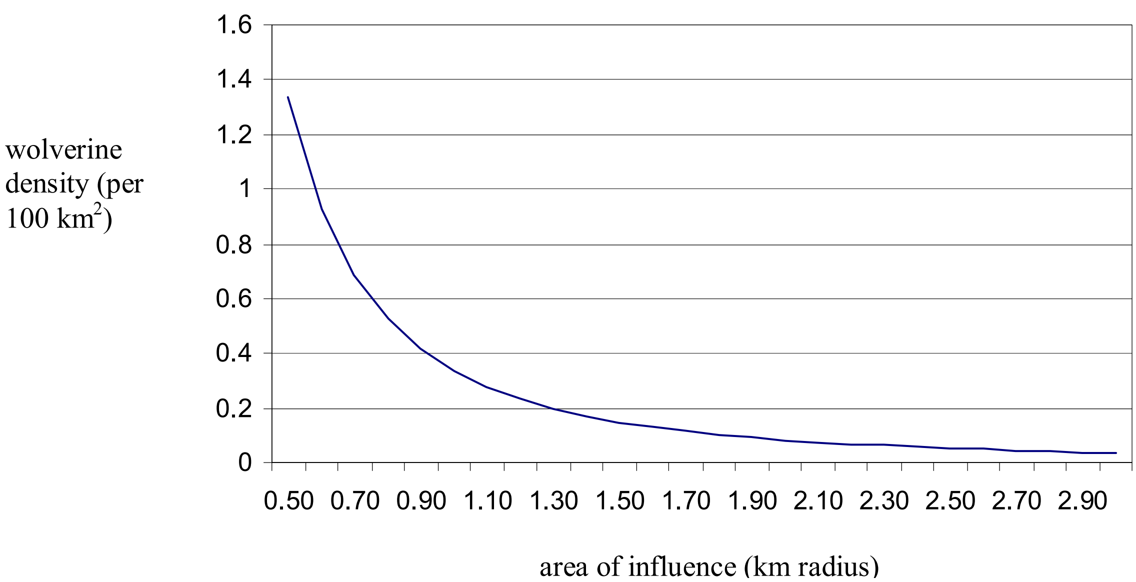

Figure 5 Estimated wolverine density from pilot data in relation to area of influence of the baited monitoring stations.

This estimate is larger than estimates of 1 wolverine per 65 km^2 in Montana (Hornocker and Hash 1981) or 1 wolverine per 177 km^2 in the Yukon (Banci and Harestad 1990). A concurrent study of wolverine home ranges in Glacier National Park, Montana, produced a preliminary home range size estimate of 132 km^2 (Copeland *et al.* 2003). It is possible that wolverines in Alberta occur in lower densities than in other areas, but more data are required before this can be reliably assessed. It is notable, however, that the wolverine detection rate was the same as the detection rate for grizzly bears, during the latter species' hibernation period (December - March). This low detection rate tends to emphasis the rarity of the wolverine in Alberta's foothills.

This preliminary density estimate is in no way reliable; it is based on a single wolverine detection, and includes a number of untested (and some untestable) assumptions. However, this estimate does represent some pilot data that we can use to guide the creation of a statistically sound wolverine monitoring program; to assess requirements for sampling size, experimental design; and determine the potential power of this wolverine monitoring program to detect changes in population size.

Statistical requirements of a wolverine monitoring program

The primary purpose of a wolverine monitoring program is to detect population changes, to provide wildlife biologists and land managers with long-term trend information that will guide active adaptive management efforts. A wolverine monitoring program must be statistically rigorous enough to distinguish real change from random variation, while being sensitive enough to detect change when it actually occurs (Gibbs *et al.* 1998). These demands are further complicated when the subject of the monitoring program is a rare, elusive, vagile species (Green and Young 1993); pilot data suggest this is indeed the case for wolverines.

Gibbs (1995) suggests that the power of a monitoring program to detect population change is dictated by 1) sample size of sites monitored; 2) count variation; 3) number of counts per plot; 4) plot weighting; 5) duration of monitoring; 6) interval of monitoring; 7) significance level assigned; and 8) the magnitude and direction of population trends. Although a full analysis of these requirements as they pertain to a Provincial-level wolverine monitoring program is reserved for the final phase of this project in 2004-2005, it is worth providing some preliminary discussion of a few of these parameters.

Sampling regime

Presence/absence studies often have low power to detect changes in species abundance. Strayer (1999) modelled the statistical power of presence-absence surveys to detect a change in animal abundance, using encounter rates as a proxy for population density, over a range of sampling regimes. It was found that spatially heterogeneous changes to populations were more reliably detected than uniformly distributed changes. More notably, Strayer (1999) found that, all else being equal, power to detect population changes increased dramatically with number of points surveyed. This was especially true when encounter rates were low (as they are for wolverine). Based on his models, and our results obtained thus far, sample sizes, session lengths, and number of sessions need to be substantial to detect wolverine population change. When we acquire final data next year, we will use the program *Monitor* (Gibbs 1995) to delineate the sample sizes required to detect changes in wolverine populations.

Count variation

Most of the monitoring program parameters listed previously can be manipulated, with the exception of count variation. This parameter is measured as the coefficient of variation (CV):

$$CV = \frac{\text{mean (standard deviation)}}{\text{mean (mean density)}}$$

The density estimates (or average abundance, or equivalent value) and associated standard deviations taken from several different studies, or from pilot data, yield the coefficient of variation (Gibbs *et. al* 1998). Unfortunately, this pilot did not yield enough occurrences of detection to provide for a mean and standard deviation of a density estimate, so the CV for wolverine remains unknown. Further data from 2004-2005 will be used to augment this year's data and will be used to calculate the CV of wolverine density.

Although the CV is inherent in the species or system being monitored, it is influenced by species- or system-specific characteristics with associated variance structures that may be minimised through experimental design. Minimising the unexplained component of the variance structure will increase statistical power of a test. This may be done spatially and temporally (Schieck 2002).

Spatial variability can be minimised through *a priori* stratification of the landscape, and restriction of sampling effort to sites with similar habitat, topography, and disturbance types. Variability can also be minimised via *post hoc* blocking of the sites into some ‘treatment’ effects, such as ecoregion or habitat. We attempted to do this by deploying sites within a single ecoregion (the Foothills) and by restricting sampling effort to upland forests in areas of high topography relative to the adjacent landscape. Within this stratification, there still existed considerable variability in topography and habitat, especially when quantifying the surrounding area at landscape scales.

The temporal component of variability is much more difficult to minimise, or compensate for, especially for vagile organisms. If there is a wolverine in a given area, what is the probability we will detect it? The answer is based on:

1. Probability of encounter, p(enc): the probability that an animal will occur at the monitoring site within the sample period.
2. Probability of detection, p(det): the probability that given that an animal is present, that presence will be recorded.

To calculate our preliminary wolverine density estimate, we integrated temporal variability across an entire season, and assumed that the resultant probabilities of encounter and detection were equal to 1.0. This is almost certainly an erroneous assumption, although an unavoidable one in the face of a paucity of data. The calculation (or estimation) of these probabilities is critical to the assessment of statistical power of a monitoring program; there are a number of ways this can be accomplished for wolverines.

Probability of detection

In a presence / absence experiment, non-detection of a species does not necessarily imply that the animal is absent. However, a fundamental assumption of such an experiment, including monitoring programs, is that non-detections indicate an absence, and there is a zero probability of committing a Type II error by recording an animal as absent that is actually present. However, for vagile wide-ranging animals with large home ranges, this assumption is rarely fulfilled. Detection rates are often less than 1, and 'absences' can thus be mistranslated.

This year's study as well as the first pilot year (Fisher 2003), suggest that hair trapping undersamples species occurring at a site, thus providing a probability of detection that is consistently less than 1.0. Remote camera systems appear to be effective at detecting tree-climbing mustelids in Alberta, as they have in a variety of other species-studies and ecosystems (Carter and Slater 1991; Kucera and Barrett 1993; Mace *et al.* 1994; Wilton *et al.* 1994; Karanth 1995; Hernandez *et al.* 1997). With the implementation of a detectability correction factor, such as the one we recommend in this pilot, and refinements in technical design requirements (Appendix 1), we propose that the probability of detection of wolverine can approach 1.0. Further camera data will be acquired in 2004-2005, to refine the detectability correction factor applied to hair trapping.

Probability of encounter

Mackenzie *et al.* (2002) provided equations for an estimation function for site occupancy rates when detection probabilities are less than 1. This maximum likelihood estimation function is based on probability of encounter, probability of presence, the aforementioned sampling parameters, and can include environmental or temporal covariates (Mackenzie *et. al* 2002). Although useful in providing rigorous estimates of site occupancy, this equation still requires values for probability of encounter. As such values can rarely be accurately measured, an estimate of p(enc) is required – thus leading to an estimate based on another estimate.

To estimate the probability of encounter, it may be advisable to adopt a simplistic approach based on random movement models. For a vagile organism, the probability that any particular point in space is occupied at any given point in time (in this case, day) is defined as:

$$\text{p(occupation)} = \frac{\text{mean movement rate (km}^2\text{/ day)}}{\text{home range size (km}^2\text{)}}$$

By way of simple example, if a wolverine's home range is 100 km^2, and the mean movement rate is 1 km^2 / day, then the p(occupation) for any point within that home range on any given day is 0.01. The probability of encounter at a monitoring station is then a function of p(occupation), sampling period, and sampling replication within a target animal's home range:

$$\text{p(encounter)} \sim \text{p(occupation) x sampling period x replication within home range}$$

Continuing our example, if the probability of occupation for our species is 0.01, and we sample once within an individual's home range for 100 days, then our estimate of the probability of encounter approaches 1.

It thus becomes clear that to sufficiently minimise temporal variability in a long-term population trend monitoring program, there is a requirement for some basic GPS-collar study data on wolverines in Alberta: mean home range size, mean daily movement rates, and distribution (density) of home ranges. Without these data, our estimates of density, population size, and population trend, will be based on untested assumptions.

Estimating power to detect wolverine population trends

The ultimate objective of a monitoring program is to determine trends in population size. Strayer (1999) found that the statistical power of presence-absence surveys to detect population declines of <20% - 50% was very low. Strayer (1999) used encounter rate as a surrogate for population density, and found that power decreased as encounter rate logarithmically decreased; thus detecting changes in populations of sparse, rare species is more difficult than in more ubiquitous species. Power increased with sample size, but then reached a plateau. Power was greater if population distribution was not spatially variable; in general, surveys had more power to detect population declines when they occurred heterogeneously across the sampling area (*i.e.*, as local extinctions), rather than uniformly. However, this power dropped disproportionately faster than in uniform population declines, when species were rare and spatially variable, encounter rates were low, and sample sizes were small (Strayer 1999).

Thus, for wolverine - which are rare, have low expected encounter rates, have highly variable distribution in space and time, and are vagile enough to limit local extinctions - the construction of a statistically powerful monitoring program poses an extremely daunting challenge. Success will require very large sample sizes, which are costly to implement and logistically difficult. The minimisation of variability through sampling design is also essential; this pilot monitoring project will provide information to minimise some variability, but GPD/radiocollaring tracking data is required. Even with large sample sizes and a rigorous design based on sound estimates of monitoring parameters, it may be possible to reliably detect only very large population declines – not a desirable objective for a population already occurring in low densities, and with low recruitment rates.

In 2004-2005, we are continuing with the final-phase implementation of noninvasive wolverine monitoring in the Foothills of Alberta. We are altering our design requirements as per Appendix I; we are also increasing sample sizes, and expanding into different areas to attempt to increase our sample size of wolverines. Final recommendations for a Provincial wolverine monitoring protocol will follow the final year's results. If the final analysis from this project suggests that monitoring remote monitoring for population trend is not feasible, there are equally valuable alternative uses for remote detection data that will help fill gaps in our knowledge of wolverines in Alberta.

Alternative uses for noninvasive genetic tagging data

Although noninvasive genetic tagging has some potential pitfalls, controlled methods for analysis and appropriate interpretation of results can overcome them to provide useful information (Taberlet *et al.* 1999; Mills *et al.* 2000; Waits and Leberg 2000). The use of genetic information for landscape-level analysis of population connectivity and gene flow – a field known as 'landscape genetics' (Manel *et al.* 2003) - is gaining widespread acceptance. Noninvasive genetic data can ascertain the identity of species and individuals, allowing for estimates of population size (Foran *et al.* 1997; Woods *et al.* 1999; Mowat and Strobeck 2000; Popplewell *et al.* 2003; but see Boulanger and McLellan 2001). When presence or abundance data are combined with habitat and landscape data, resource selection functions (*cf.* Boyce *et al.* 2002) or other analyses can be calculated to determine habitat selection. Landscape analysis can be used to determine relationships between anthropogenic alteration of habitat and wolverine site occupancy. This information can in turn be used to create landscape models to aid in management, as has been done for wolverines in the northwestern United States (Rowland *et al.* 2003). The wide variety of uses for noninvasive genetic tagging information for wolverines, beyond population monitoring, suggest that this is a worthwhile endeavour worth continuing, in light of our lack of information on wolverines and the expense associated with obtaining information. These avenues of study will be further explored in 2004-2005.

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APPENDIX 1: RECOMMENDED REVISIONS TO TECHNICAL DESIGN REQUIREMENTS FOR WOLVERINE MONITORING

The purpose of a pilot project such as this is to ascertain whether design requirements created are sufficient to achieve the task at hand. In our case, we compiled information from several previous hair-snagging and camera-trapping studies on large predators efforts internationally, created a set of protocols, and tested their efficacy for monitoring wolverine. These techniques were found to require modification; we believe that implementing these changes will increase the effectiveness of a remote monitoring program.

We implemented an experimental design that staggered lure-only and bait-plus-lure sites across the landscape to determine whether carcass bait could be replaced with commercially available scent lure. This would allow greater replication per dollar and per unit effort in the field, and overcome logistical issues associated with obtaining sufficient quantities of bait, and deploying it in remote areas. The results of this year's pilot demonstrate quite clearly that scent lure is not effective; bait is required to draw in animals. Only one of 47 lure-only sites recorded an animal, and this was a wolf or dog, a non-target species. We therefore recommend that all monitoring stations be baited to be effective.

We used frozen beaver carcasses as bait. Some of these were skinned and others unskinned; we recommend the use of skinned (hide removed) beavers, as these were less likely to contaminate hair samples with beaver fur, and appeared to produce a greater degree of scent (and thus have a greater area of influence). These beaver carcasses were covered with black aluminum window mesh to prevent non-target scavengers (such as grey jays, chickadees) from removing parts of the carcass or setting off the camera trap. We found that the mesh did not achieve this objective, and may in fact have served as a deterrent to wolverines. In some instances, tracks tentatively identified as wolverine were noted near the monitoring station, but did not climb the hair trap to reach the bait. Thus, we also recommend that mesh not be used to envelope the bait.

In Chapter 2 we outlined technical guidelines for programming of Trailmaster™ camera systems, as the programming of these systems can dramatically influence results of camera trapping. We found that the pulse rate (5 pulses, or 0.25 seconds) was satisfactory. We also implemented a 5-minute camera delay to avoid multiple pictures recorded by non-target avian species. However, we believe that this reduced the detectability of furbearer species, possibly including wolverine species. In some cases a single picture was taken but the animal could not be identified; in the following frames (>5 minutes later) the bait was well chewed or missing, suggesting an animal had spent some time at the bait, and this was not recorded by the camera. This would also explain a few instances of species being recorded by the hair traps, and not the camera traps (Table 1). Therefore, we recommend that control of avian non-targets would better be accomplished by placement of the bait further away from the point where the IR beam is broken. We also recommend a camera delay of 1 minute, rather than 5 minutes.

Finally, our original methods required that 10-15 m of barbed wire be wrapped around a tree to create the hair capture trap. Observations from the field suggest that this length of wire is potentially undersampling hair; therefore we recommend that a minimum of 20 m of barbed wire be deployed in hair traps, using the methods previously described; it is believed this will increase the probability of obtaining a hair sample when a furbearer is occupying a station.

APPENDIX 2: PHOTOGRAPHS FROM TRAILMASTER™ CAMERA TRAPS.

Plate 1. Ermine (*Mustela erminea*), Highway 40 southwest of Coalspur.

Plate 2. Two marten (*Martes americana*) sharing bait, Forestry Trunk Road northeast of Grande Cache.

Plate 3. Grizzly bear (*Ursus arctos horribilis*) head, near the Brown Creek Viewpoint, Forestry Trunk Road.

Plate 4. Large fisher (*M. Pennanti)*, Gregg River Road, south of Hinton.

Plate 5. Wolverine (*Gulo gulo)* off the Forestry Trunk Road, northeast of Grande Cache. The face is out of focus, as it is turning quickly in response to noise from the camera.