Results of Population Census Trial on Northern Wolverine (*Gulo gulo*)

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Abstract

Little is known about the Wolverine (*Gulo gulo*) in British Columbia. In conjunction with the Columbia Mountains Wolverine Project, the Northern Wolverine Project is attempting to develop inventory methodologies for Wolverine. This paper deals with the photographic results of a trial of methods in the winter of 1997. Three sampling sessions were used to photograph animals and collect hair samples near the northwest corner of Williston Reservoir. A Mark-Recapture analysis was performed on the photographic data using the standard Peterson Method as well as a modified Peterson Method for small samples. Standard error, confidence intervals and densities were determined where possible. Reported densities range from 1 Wolverine per 47.62 km^2 to 1 Wolverine per 122.70 km^2. Suggestions are given to improve future sampling.

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1.0 Introduction:

1.1 Introduction to the Project:

Wolverine (*Gulo gulo*) are a poorly understood and understudied animal. The largest member of the Weasel family, they are a true wilderness species occurring at low densities throughout the province. These low densities combined with low reproductive rates contribute to the vulnerability of the species to human activities. They are considered a threatened species and have been placed on the blue-list by the BC Ministry of the Environment. Despite their sensitivity, the information available to wildlife managers about the Wolverine is extremely limited. Existing information consists of harvest data obtained from monitoring harvests of registered trap lines. Consequently, there is a need to determine Wolverine densities, distributions, population dynamics, and habitat ecology to provide sufficient information for the development of management plans that address the needs of Wolverine populations.

The lack of knowledge regarding Wolverines stems from the inherent logistical problems associated with studying a secretive and wide ranging wilderness species that occurs at such low densities. The effort and skill required to obtain information on Wolverines is substantial; hence, studying them is expensive. Despite these problems, two research projects (the Columbia Mountain Wolverine Project and the Northern Wolverine Project) are underway in an attempt to better understand wolverine biology and ecology, as well as to develop the inventory methods required by resource managers.

1.2 Background Literature:

Various inventory methods have been used in attempts to inventory Wolverines. A wide variety of these methods have been summarised by Banci for the United States Forest Service (USDA 1994). These methods include: harvest levels and snow tracking (Quick 1953); logarithmic extrapolation (Whitman and Ballard 1983); telemetry studies and snow tracking (Hornocker and Hash 1981); habitat suitability rating (Banci 1987); habitat suitability rating and telemetry studies (Banci 1987); and aerial estimators (Becker and Gardner 1992). Densities calculated from these inventories range anywhere from 37 km^2/wolverine to 656 km^2/wolverine.

1.3 Objectives of the Paper:

This paper deals specifically with the results from a trial of inventory techniques used by the Northern Wolverine Project between February 1 and April 24, 1997. Hair capture stations equipped with remote cameras were used to collect hair and photograph animals. This data was then used to develop population estimates. Since DNA marking techniques have not yet been developed, the estimates explained in this paper rely solely on the identification of individuals from remote camera photographs. With some individuals this is made easy because a number of individuals in the area have been live captured, radio collared and ear tagged. These animals are identified in the data by their names given them by researchers. Other individuals have been identified with the help of their unique markings, size, coloration, and their location of capture.

2.0 Study Area:

The Northern Wolverine Project's study area is located along the Rocky Mountain Trench on the northwest corner of Williston Reservoir. This area is within the Manson Plateau and Southern Omineca Mountains ecosections and includes Sub-Boreal Spruce, Boreal White and Black Spruce, Englemann Spruce- Subalpine Fir, Spruce Willow Birch and Alpine Tundra biogeoclimatic zones. It is approximately 4000 km^2 (unpub. data Hoodicoff). The uniqueness of this study area is that it can be divided into two adjacent halves with good access to the majority of the study area. The two halves are divided based on the primary resource extraction activity, namely forestry, that has occurred in the two areas.

In Area 1 little or no forestry operations have occurred. The area encompasses the Omineca Valley and the Wolverine Range of the Omineca Mountains. Although currently untouched by forestry operations, the area is surrounded by intensive forestry operations. Area 2 is characterised by this intensive forestry. It sits along the eastern edge of the Wolverine range and continues to the shores of Williston Reservoir.

This paper deals with the inventory trial performed in the southern portion of the study area. The area covers a section south of Conglomerate Mountain and the mouth of the Omineca Arm of Williston Reservoir in the north and continues to Germenson Lake and Mount Bison in the south. A second trial occurred in the fall of 1997 in Area 2 and was completed using the most effective hair collection methods used in the first trial. Results of this second trial will be the subject of a later paper.

3.0 Methods:

3.1 Sampling design:

The entire study area has been divided into grid cells for the purpose of stratified sampling. Grid cells are 100 km^2 (10 km X 10 km) in size and are located using the Universal Transverse Mercator (UTM) grid on National Topographic Service (NTS) 1:250 000 maps. The southern portion of the study was chosen for sampling. This area is covering 2900 km^2. Twenty grid cells were then randomly selected from this area so that sampling of a 2000 km^2 area was performed. Within each grid cell the locations best able to catch a Wolverine were selected based on their ability to intersect Wolverine movements. These sampling sites include areas within remaining timber corridors (in logged areas) and along natural animal travel routes (streams, ridges etc.). Site selection was also affected by site accessibility. In grid cells with roads, easy access to the site contributed to the location of the site. When a suitable area was located, the area was scouted for the availability of a "run pole". Run poles consist of a piece of course woody debris greater than ~20 cm in diameter. They must be elevated at one end; to restrict access to this end by animals. Alternatively, the other end of the run pole must reach near the ground to allow a Wolverine to climb up the pole. The purpose of the run pole is to provide a place to attach the hair collection device while restricting the animal's approach enough to allow the animal to be photographed. Additionally, the pole must be orientated so that the infra camera beam used to trigger the camera and camera itself can be mounted on adjacent trees. Locating suitable run poles can sometimes be a problem (especially in young pine stands); however, a pole can usually be located within the area selected.

3.2 Site set-up:

When a suitable site is located baited, hair collection devices, cameras, and remote sensors were installed. Hair collection devices were mounted far enough up the run pole as to stop animals from disturbing the box from the ground. Each site was baited with salmon, moose or commercial lure. Bait was placed in such a way as to not reward the animal. The hair collection devices were of five types (Appendix II)(unpub. Hoodicoff):

1. Baited A-frame

   A triangular wooden frame attached to the run pole. Two pieces of 2" x 2" Victor glue mouse trap, also known as "stick-um tape", were placed on either side of the entrance to collect hair. Bait was hung inaccessible to the animal on the other side of the hair box. Ideally the animal would travel up the run pole to investigate the bait, breaking the camera beam, climbing through the hair box, and leaving hair on the mouse trap in the process.

2. A-frame with scent

   Similar to the baited A-frame; however, a wire screen was placed over the back of the A-frame. Bait was place inside a perforated ammunition box inside the A-frame. This configuration did not require the animal to climb through the A-fame; it need only place its head and shoulders within the box. Hair was collected in the same manner using Victor, glue mouse traps placed on either side of the entrance to the A-frame. Commercial lure was also used at these sites.

3. Baited short culvert

A 30 cm piece of 10" corrugated plastic culvert was mounted to the run pole. Bait was hung behind the culvert and the mouse trap was attached to the inside of the culvert. This set-up was similar to the Baited A-frame in that the animal would travel up the run pole breaking the camera beam and continue through the culvert to investigate the bait.

4. Long culvert with Scent

A 60 cm piece of 10" corrugated plastic culvert was anchored to the pole. The top end of the culvert was covered with wire mesh and commercial lure was placed within the culvert. As with the A-frame with bait, the animal need only place its head and shoulders within the box to investigate the smell and leave hair on the mouse trap.

5. V-formation with Scent

Four 60 cm long 2"x 4" poles were attached to the run pole. A 2" x 2" piece of stick-um was attached to each 2"x 4". Bait was again placed within a perforated ammunition box located in the centre of the four 2"x 4"s. The animal would travel up the run pole breaking the camera beam. While investigating the bait box, the animal would leave hair on at least one of the four posts surrounding the box.

Cameras and infra red monitors were placed surrounding the run pole as to place the infra red beam across the run pole and the camera so that a picture was taken of the animal breaking the beam. Olympus AF-1 mini cameras were attached to Trailmaster TM 1000/TM 1500 infra red monitors. In addition to transmitting the beam and triggering the camera, the Trailmaster receivers also maintained a log of all events (breaking of the infra red beam) that occurred at the site. Receivers were set to trigger the camera at events no closer than one minute apart and their sensitivity was adjusted to reduce the number of false events. Colour print film with 200 ASA and 36 exposures was used with either a single lithium battery or two AA batteries to power the camera. Four C-cell batteries were used to power both the receiver and transmitter of the infra red beam.

3.3 Site monitoring:

Sites were monitored each week from January 29 to April 24, 1997. Each week event data was recorded; film and batteries changed, if necessary; stick-um replaced, if necessary; and bait and lure freshened. The sites were not pre-baited.

3.4 Data Analysis:

Population estimates were developed from the photograph recapture data using two methods. The Peterson method (Schenmitz 1980) and a modified Peterson method (Krebs 1989), used to reduce biases with small sample sizes, were used. Where possible, standard error and confidence intervals were also determined for each estimate. From these estimates, densities of wolverine were then calculated to provide estimates of the number of square kilometres per wolverine.

The sampling period was divided into three, 20 day sessions. This was done, presumably, to provide a comparison of sampling success at different time periods throughout the winter. As the Peterson Method provides estimates for populations that have undergone only a single marking, 3 individual estimates can be obtained from this division of the data. These estimates use the number of radio collared individuals that were present in the area during the sampling period as the marked individuals. The three, 20 day sessions were then used as the recapture session.

4.0 Results:

4.1 Photographic Recapture

Wolverines were photographed at 8 different camera sites (grid cells 2, 4, 11, 20, 21, 22, 24, and 28) between January 29 and April 24, 1997. Twenty photographs of 15 individual Wolverines were taken during this time period. Other animals photographed at the camera sites included Marten (*Martes americana*), Fisher (*Martes pennanti*), Gray Jays (*Perisoreus canadensis*) and Lynx (*Lynx lynx*). Unidentified Weasels (*Mustela sp.*) were also photographed.

Due to the failure of camera batteries in cold weather, camera operation was not always reliable. Attempts were made to select session dates in which all cameras were operational throughout the entire session. This was not possible so sessions were selected in which the majority of cameras were operational. Additionally, equal length sessions were spaced over the sampling period to provide somewhat representative samples from each time period. The three, 20 day sessions ran from February 4 - February 23, March 4 - March 23, and April 4 - April 23, 1997.

In total, 12 photographs of Wolverine were recorded during the three sessions. Of the 12 captured 4 were marked. Only a single photograph of an unmarked individual was taken in session 1. In session 2, 3 photographs of Wolverine were taken; 2 of these animals were marked. Session 3 proved more productive. Photographs were taken of 8 individuals of which 2 were marked.

The original Peterson estimator gave one undefined estimate, an estimate of 18 and 42 individuals for Sessions 2 and 3 respectably. The undefined estimate in Session 1 stemmed from the absence of any marked individuals within that sample. Calculations are given in Appendix II. The standard error was calculated and used to create 95 per cent confidence intervals for the estimates. These results are given in Table 1.

Table 1: Results of Original Estimator

	Population Estimate	Standard Error	Confidence Interval
Session 1	undefined	undefined	undefined
Session 2	18	12.72	5.27 - 30.72
Session 3	42	19.79	2.40 - 81.60

The small sample estimator used to develop the second estimates gave three estimates more closely grouped. Results are given in Table 2 and calculations in Appendix II.

Krebs (1989) suggests the use of binomial distribution for the development of confidence intervals in samples when the proportion of recaptured animals to total captures is greater than 0.10 (R/C > 0.10). The table provided by Krebs (1989) for the development of these intervals will only give intervals for session 3 of this trial (Appendix II). With such small samples sizes as those obtained within this trial it is possible to develop an interval for session 2; however, tables and formulas were not provided by Krebs (1989) to do this. For session 1, even the simple proportion could not be developed with the lack of any recaptures. It is unknown whether the estimate obtained with Kerbs method is even valid for session 1 due to the lack of recaptures. The structure of the formula allows an estimate to be calculated; however, the question remains, is 0 photographs a small sample or no sample?

Table 2: Results of Small Sample Estimator

	Population Estimate	Confidence Interval
Session 1	21	undefined
Session 2	16.3	undefined
Session 3	36.5	13.15 - 233.33

Densities were also developed using the original estimator and the small sample estimator. A comparison of estimated densities is given in Table 3.

Table 3: Estimated Densities

	Densities with Original Estimator	Densities with Small Samples
Session 1	undefined	1 / 95.24 km^2
Session 2	1 / 111.11 km^2	1 / 122.70 km^2
Session 3	1 / 47.62 km^2	1 / 54.80 km^2

4.2 Hair recapture

The collection of hair was successful at 12 of the 20 sampling locations with 22 of the 187 weeks of sampling recording hair collected. Some of this hair is undoubtedly from wolverines; however, the source species the hair was collected from, and determination of which individual wolverine the hair came from, has not as yet been determined. Some subjective analysis of which hair collection method is most successful has been performed and two modified methods have been used in a subsequent trial. The rational behind this decision and the results of the second trial will be the subject of a future paper. Results of which sites collected hair on which dates is given in Appendix II.

5.0 Discussion:

The methods used to develop population estimates make five important assumptions (Krebs 1989):

1. The population is closed or constant during the sampling period.
2. There is equal catchability between individuals (i.e. Each animal has the same chance of being caught).
3. Marking animals does not effect catchability.
4. Animals do not lose marks.
5. All animals marked are identified as such on recapture.

Meeting all of these assumptions is required for accurate estimates. However, during this sampling period several of the assumptions were broken. This raises concerns about the estimates obtained.

Assumption 1, the population is closed or constant during the sampling period. This assumption is probably the most difficult of all to satisfy. As with all wide ranging species, it is extremely difficult, if not impossible, to achieve a closed population during a sampling session. Problems associated with the births of new animals can be avoided by sampling during periods when no births occur. The effects of individual mortalities are seen as negligible if the mortality of marked and unmarked individuals are equal (Krebs 1989). However, the real problem lies with immigration and emigration of individuals from the study area. Attempts have been made when sampling Bear with similar methods to account for this by choosing geographically restricted populations and placing sampling stations at all entry or exit locations (pers. comm. D. Wellwood). This assumes that all individuals entering or leaving the sampling area will be captured with the sampling method and accounted for within the population estimate. Although this method may be successful in accounting for all the immigration and emigration, it is highly unlikely that it would be possible to apply this technique in a wide variety of locations. There is no technique that would satisfy this assumption besides enclosing the population to be sampled. With Wolverine, it would be nearly impossible and extremely expensive to enclose a population while still maintaining numbers large enough to provide valuable estimates. Therefore, although not scientifically or statistically sound, the violation of this assumption may have to be accepted. This would then require a final methodology that is robust enough to provide estimates suitable for wildlife management.

Assumption 2, equal catchability between individual animals has also been violated in this sampling session. With reliance on cameras to obtain recapture data it is required that all cameras are operational during the sessions to ensure that an animal is captured if present. With winter sampling this would require a system of monitoring or a type of camera battery that would assure that cameras were reliable. However, an alternate method used in Mark-Recapture inventory is the DNA identification of individuals. This would negate the reliance on such a technical piece of equipment as cameras and would also assure final identification of animals would be correct. There have been some concerns raised in the original description of this sampling session that the effectiveness of the Victor glue mouse traps is affected by cold and/or wetness (unpub. Horticoff). It may be possible to avoid the failure of the mouse traps to collect hair by changing the traps during each visit to the sampling station.

Equal catchability may be violated by another factor. The use of the same sampling sites within the grid cells during each session without changing bait may affect trappability of individuals (pers. comm. D. Wellwood). This difference in catchability may have serious effects on estimates. Trap avoidance or "trap happiness" is not likely to occur if new sites or baits are used during each session.

The use of various hair collection techniques also violates Assumption 2 if DNA identification techniques are used. The development of a successful collection method over time will allow for only one method of hair collection and thereby meeting the assumption.

Assumptions 3 and 4, the effect of marking and the loss of marks are fairly easy assumptions to satisfy. Although radio collared animals are used as marked animals, individuals are being recaptured using a new and less intrusive technique. It is therefore unlikely that marked individuals and unmarked individuals will react significantly differently to the recapture sites. Additionally, the use of previously tagged individuals are unlikely to lose their ear tags and provided easy identification from photographs thus meeting assumption 4.

Assumption 5, that all animals are identified on recapture, may have also been violated during the sampling session. The failure of cameras may have allowed individual animals to visit a sampling location and not have been recaptured. The reduced reliance on the cameras and the assurance that hair collection will collect hair when an animal visits the site will allow this assumption to be met in later sampling sessions.

The accuracy of the population estimates is also brought into question because of the small sample sizes achieved during this trial. With the original estimator, there is a 95 percent probability that the population is between 5.27 and 30.72 during session 2 and between 2.40 and 81.60 during session 3. Although the population estimates fall within these confidence intervals it is unlikely that any estimate would fall outside such large intervals. The large size of these intervals suggests that the error for this method is at unacceptable levels. Additionally, Krebs (1989) states that this method "produces a biased estimator of population size, tending to overestimate the actual population" and that "This bias can be large for small samples". Hence, estimates achieved using this method are not only but have large confidence intervals but are optimistic of the number of Wolverines inhabiting the area.

Likewise, the second method of estimation for small sample sizes also produced a large confidence interval (13.15 - 233.33 for session 3); again questioning the validity of the estimate. Krebs (1989) also provided a measure for this second method with which to determine the bias of the estimate. He states that the method "is unbiased if (M + C) > N" and "nearly unbiased if there are at least seven recaptures of each marked animal". For all sessions, neither of these conditions is met and it can be assumed that the second estimates are again biased. Krebs (1989) also states that ecological estimates should never be reported without some measure of their possible error. This statement seems to render the results obtained in sessions 1 and 2 invalid. However, the development of estimates using the small sample estimator was no in vain. It is unlikely that sample sizes in Wolverine inventories will ever be large enough to be unbiased in the original Peterson formula. Therefore, the requirements and limitations observed by using the small sample estimator have been identified in this trial and attempts should be made to meet these requirements in future sampling sessions.

Despite all of these problems the density of Wolverines calculated do fall within the reported densities of Wolverine determine by other methods (USDA 1994). This suggests that although confidence intervals are high and estimates biased the population estimates may be acceptable. However, with such a wide range of reported densities it would be easy to fall within this range. Problems inherent within Wolverine sampling may provide answers. With such low densities over such large areas, multiplication factors needed to convert low estimates into measures of density may induce large error into the estimates (pers. Comm. D. Blundon). This may have also allowed the various reported densities to coincide. Perhaps an examination of the original papers summarised by Banci would reveal that confidence intervals developed using all inventory methods coincide with this papers reported estimates. If so, more confidence could be placed in estimates derived using Mark-Recapture methods.

A subjective look at the data raises other questions regarding the sampling of Wolverine. Captures of Wolverine increased in later sampling sessions. This may result from two factors. First, with Wolverine it may take a long period of time to attract an animal to the bait station. These animals may be travelling from the far reaches of the grid cells to reach the site or may be travelling from adjacent grid cell. This suggests the attraction of animals, and hence the productivity of trapping may be affected by the continual use of one site and one type of bait. Secondly, and perhaps more importantly, the amount of animal movements may have changed during the sampling session. With temperatures and food availability changing as the winter progresses, animals may be more likely to visit baited stations at the latter dates. More information is needed on wolverines seasonal movements before this question can be answered.

With all of the discrepancies identified so far with this trial it may seem that little was achieved with this sampling session. This is not the case. As stated earlier this is a preliminary trial in the development of inventory methods and the difficulties in performing reliable and cost effective inventory of a species such as the Wolverine are immense. Much was learned during this trial. Methods for the collection of hair and set up of sites were tested; logistical and technical problems were identified; and sampling intensities require to give appropriate sample sizes determined. Although not quantifiable, the importance of this information cannot be underestimated. Further revisions of the study design and sampling methods are needed; however, with the knowledge gained in this and other trails, a viable inventory method for Wolverines is sure to develop.

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Appendix I

Calculations

Standard Peterson Method for estimating population size, as described by Schemnitz (1980). This requires data are recorded on: the number or individuals marked (M); the total number of individuals captured (C); and the number of marked individuals captured (R). These will provide an estimate of population size (N). This method provides estimates of:

$$N = MC / R$$

for Session 1:

$$N = 10(1) / 0; \; N = \text{undefined}$$

for Session 2:

$$N = 12(3) / 2; \; N = 18$$

for Session 3:

$$N = 14(9) / 3; \; N = 42$$

The standard errors as calculated with methods again described by Schemnitz are:

$$S.E. = M^2C(C - R) / R^3$$

for Session 1:

$$S.E. = 10^2(1)(1 - 0) / 0^3; \; S.E. = \text{undefined}$$

for Session 2:

$$S.E. = 12^2(3)(3 - 0) / 2^3; \; S.E. = 12.72$$

for Session 3:

$$S.E. = 14^2(9)(9 - 3) / 3^3; \; S.E. = 19.97$$

These are multiplied by 2 to provide 95% confidence intervals for the three sessions:

$$C.I. = S.E.(2) - N + S.E.(2)$$

for Session 1:

$$C.I. = \text{undefined}$$

for Session 2:

$$C.I. = 18 +/- (2)12.72;\ C.I. = \{5.27, 30.72\}$$

for Session 3:

$$C.I. = 42 +/- (2)19.97;\ C.I. = \{2.40, 81.60\}$$

Density estimates were created by dividing the estimated number of wolverines into the sampling area.

for Session 1:

undefined due to no captures

for Session 2:

$$D = 2000\ km^2 / 18\ wolverine;\ D = 111.11\ km^2 / wolverine$$

for Session 3:

$$D = 2000\ km^2 / 42\ wolverine;\ D = 47.62\ km^2 / wolverine$$

Krebs method for small sample sizes provides estimates of:

$$N = [(M + 1)(C + 1) / (R + 1)] - 1$$

1. Session 1:

$$N = [(10 + 1)(1 + 1) / (0 + 1)] - 1;\ N = 21$$

2. Session 2:

$$N = [(13 + 1)(3 + 1) / (2 + 1)] - 1;\ N = 16.3$$

3. Session 3:

$$N = [(14 + 1)(9 + 1) / (3 + 1)] - 1;\ N = 36.5$$

Krebs provides methods for calculating confidence intervals and suggests the use of the binomial distribution for samples with R/C values above 0.10. Using this method the estimates are :

Session 1:

undefined due to no recaptures

Session 2:

undefined due to failure of Krebs' table

Session 3:

R/C values determined Figure 2.2 (Krebs 1989)

upper C.I. = 0.06

lower C.I. = 0.72

Substituting into the calculation for population estimates:

$$N = (C / R)(M)$$

the confidence intervals are:

upper limit = (1 / 0.06)(14); upper limit = 233.33

lower limit = (1 / 0.72)(14); lower limit = 13.15

Densities were again developed by dividing the population estimates into the sampling area.

for Session 1:

D = 2000 km^2 / 21 wolverine; D = 95.24 km^2 / wolverine

for Session 2:

D = 2000 km^2 / 16.3 wolverine; D = 122.70 km^2 / wolverine

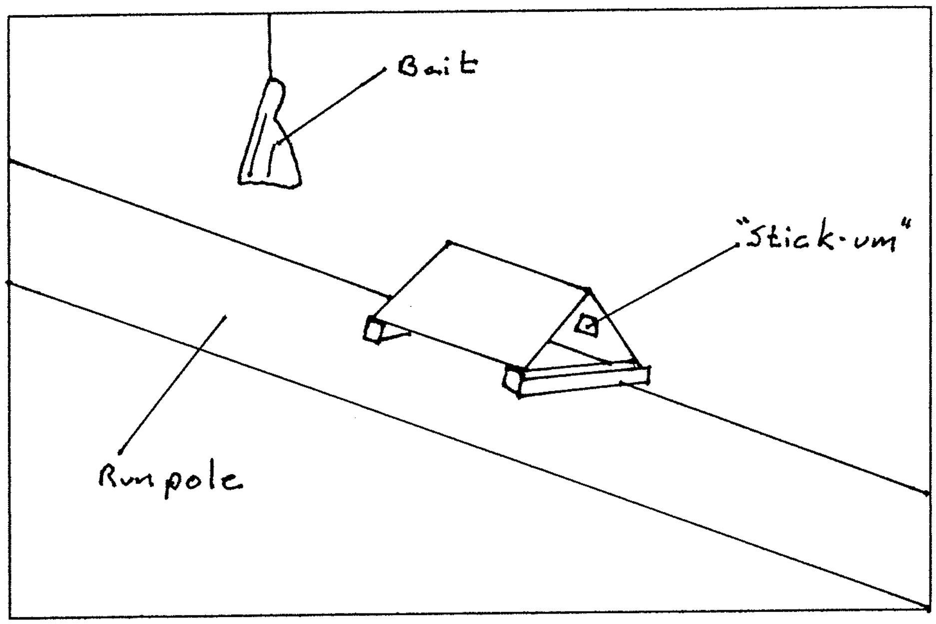
for Session 3:

D = 2000 km^2 / 36.5 wolverine; D = 54.80 km^2 / wolverine

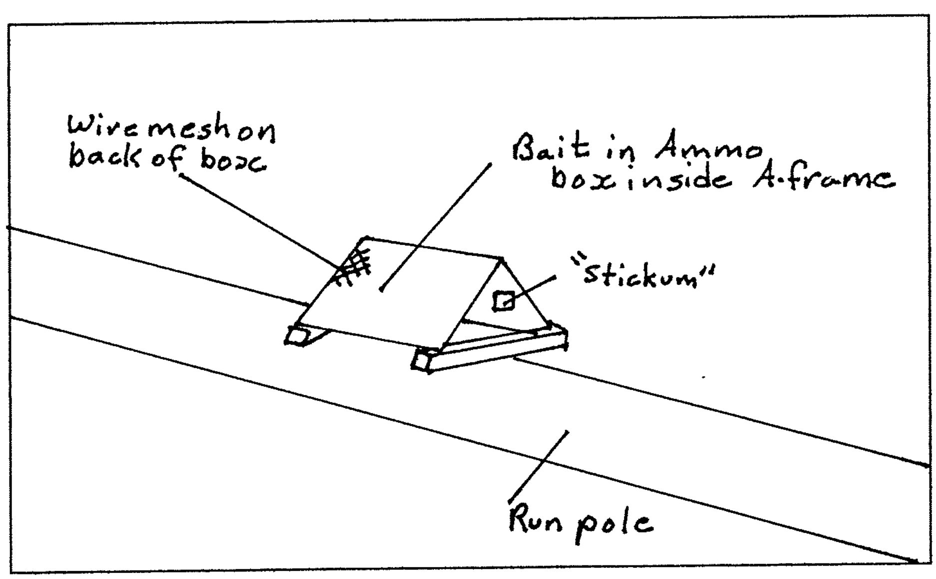
Appendix II

Hair Collection Devices

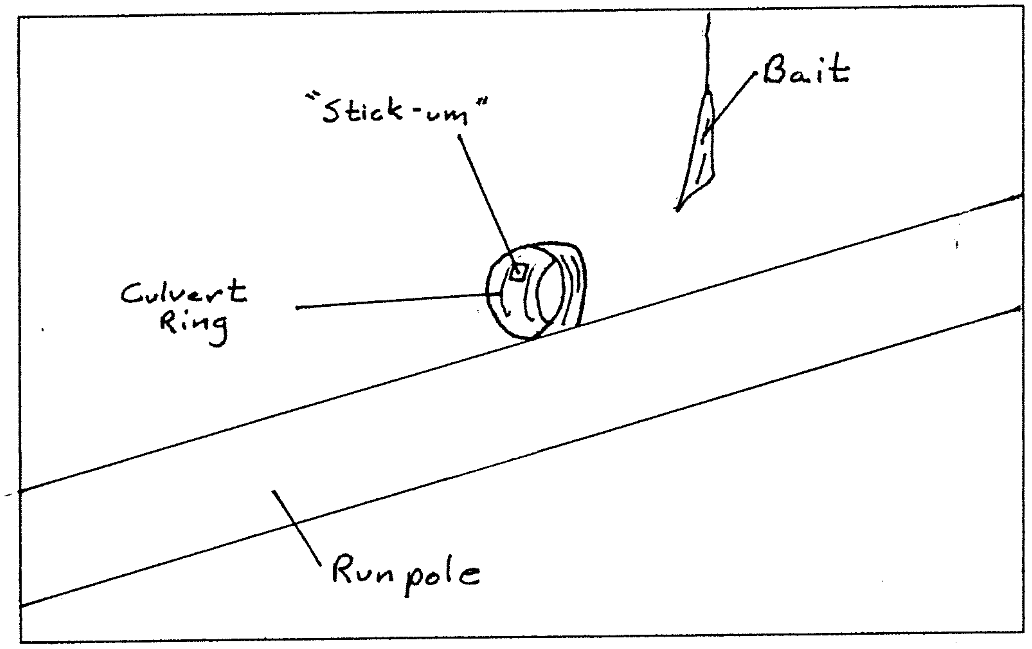
Baited A-frame



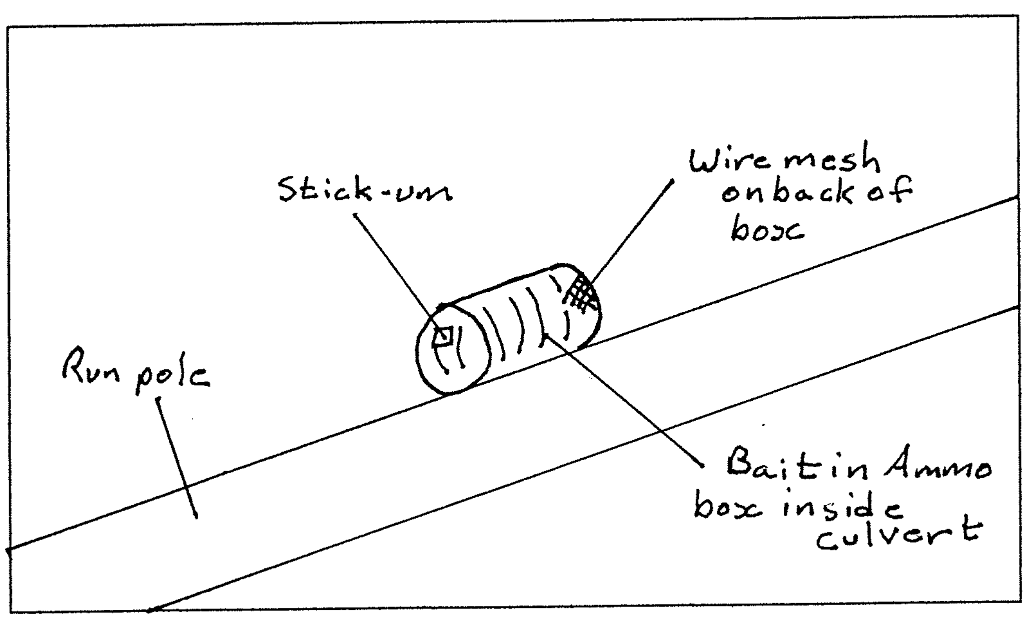
A-frame with Scent



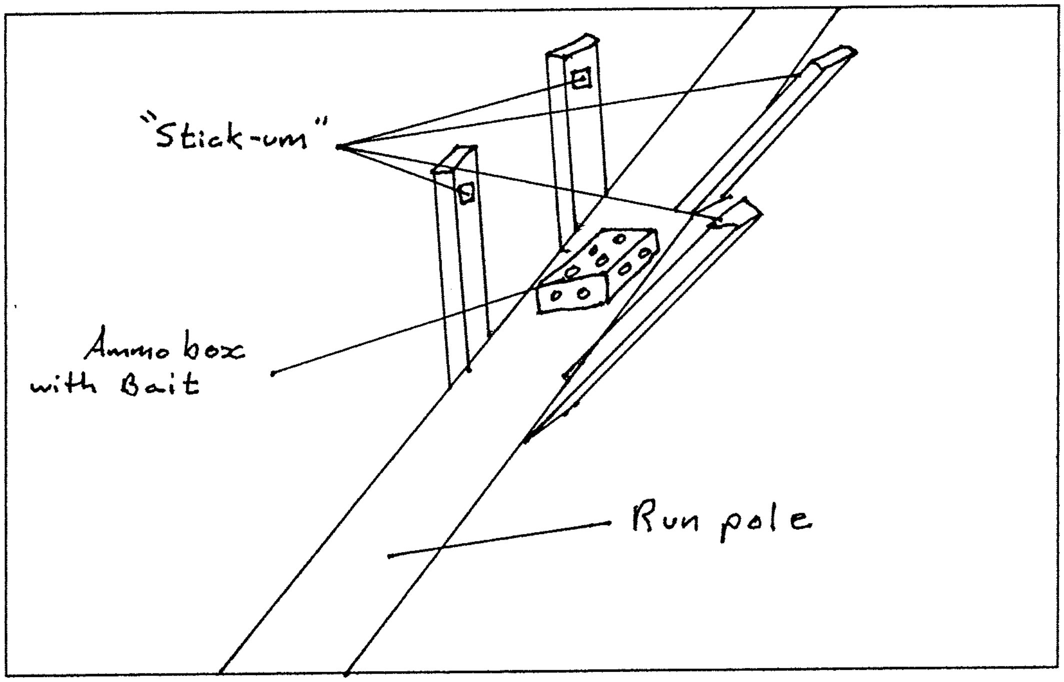
Baited Short Culvert



Long Culvert with Scent



V-formation with Scent



Appendix III

Compiled Photograph Data

Grid Number	Location	Dates	Session	Captures	Recaptures	Description
1	42 Manson	Feb 4 - Feb 23	1	0	0	
		Mar 4 - Mar 23	2	0	0	
		Apr 4 - Apr 23	3	0	0	
2	River Main	Feb 4 - Feb 23	1	0	0	
		Mar 4 - Mar 23	2	2	1	2 Unk Gulo 1(Mar 21), Alison (Mar 23)
		Apr 4 - Apr 23	3	1	1	2 Jessica (Apr 10/ Apr 18)
3	26 Manson	Feb 4 - Feb 23	1	0	0	
		Mar 4 - Mar 23	2	0	0	
		Apr 4 - Apr 23	3	0	0	
4	46 Manson	Feb 4 - Feb 23	1	0	0	
		Mar 4 - Mar 23	2	0	0	
		Apr 4 - Apr 23	3	1	0	Unk Gulo 3 (Apr 8)
6	12.5 Manson	Feb 4 - Feb 23	1	0	0	
		Mar 4 - Mar 23	2	0	0	
		Apr 4 - Apr 23	3	0	0	
7	97 Finlay	Feb 4 - Feb 23	1	0	0	
		Mar 4 - Mar 23	2	0	0	
		Apr 4 - Apr 23	3	0	0	
9	Jackfish	Feb 4 - Feb 23	1	0	0	
		Mar 4 - Mar 23	2	0	0	
		Apr 4 - Apr 23	3	0	0	
11	Up. Ecklund	Feb 4 - Feb 23	1	0	0	
		Mar 4 - Mar 23	2	0	0	
		Apr 4 - Apr 23	3	1	0	Unk Gulo 4 (Apr 13)

Grid Number	Location	Dates	Session	Captures	Recaptures	Description
12	Meadow Ck.	Feb 4 - Feb 23	1	0	0	
		Mar 4 - Mar 23	2	0	0	
		Apr 4 - Apr 23	3	0	0	
13	105 Finlay	Feb 4 - Feb 23	1	0	0	
		Mar 4 - Mar 23	2	0	0	
		Apr 4 - Apr 23	3	0	0	
14	Evans Ck.	Feb 4 - Feb 23	1	0	0	
		Mar 4 - Mar 23	2	0	0	
		Apr 4 - Apr 23	3	0	0	
16	S. Blue Lk.	Feb 4 - Feb 23	1	0	0	
		Mar 4 - Mar 23	2	0	0	
		Apr 4 - Apr 23	3	0	0	
17	Up. Fries	Feb 4 - Feb 23	1	0	0	
		Mar 4 - Mar 23	2	0	0	
		Apr 4 - Apr 23	3	0	0	
19	125 Finlay	Feb 4 - Feb 23	1	0	0	
		Mar 4 - Mar 23	2	0	0	
		Apr 4 - Apr 23	3	0	0	
20	Nina Lk.	Feb 4 - Feb 23	1	1	0	Unk Gulo 5 (Feb 22)
		Mar 4 - Mar 23	2	0	0	
		Apr 4 - Apr 23	3	3	1	2 Unk Gulo 6 (Apr 5/ Apr 20), 3 Borris (Apr 15), Unk Gulo 5 (Apr 18)
21	Blue Grouse	Feb 4 - Feb 23	1	0	0	
		Mar 4 - Mar 23	2	0	0	
		Apr 4 - Apr 23	3	1	0	Unk Gulo 8 (Apr 14/ Apr 22)

Grid Number	Location	Session	Dates	Camera Working	Hair	Events	Film	Photo #	Description of photos
		3	Apr 11 - Apr 18	y	y	19	changed	10	4 MAAM / 4 unknown / **Jessica (Apr 18)**
		3	Apr 18 - Apr 23	y	y	23	remove	20	15 MAAM / 4 unknown / 1 test
3	26 Manson	1	Jan 30 - Feb 13	y	y	0	changed	0	start on Feb 3
		1	Feb 13 - Feb 24	y	y	3	changed	0	
		1	Feb 24 - Mar 3	n	n	1	changed	0	
		2	Mar 3 - Mar 17	n	n	2	changed	1	unknown
		2	Mar 17 - Mar 24	y	n	1021	2	37	unknown
		2	Mar 24 - Apr 4	y	y	2		4	3 test / 1 snow
		3	Apr 4 - Apr 18	y	n	2	changed	3	2 test / unknown
		3	Apr 18 - Apr 23	y	n	2	5	3	2 unknown / test
4	46 Manson	1	Jan 30 - Feb 13	y	n	3	36	33	20 unknown / 14 MAAM
		1	Feb 13 - Feb 24	y	n	112	changed	33	27 unknown / 6 MAAM
		1	Feb 24 - Mar 3	y	n	4		1	unknown
		2	Mar 3 - Mar 15	y	n	751		37	unknown
		2	Mar 15 - Mar 28	n	n	1	changed	1	unknown
		3	Mar 28 - Apr 4	y	n	1019	changed	37	unknown
		3	Apr 4 - Apr 11	y	n	70	changed	25	21 unknown / 2 MAAM / test / **Unk Gulo 3 (Apr 8)**

Grid Number	Location	Dates	Session	Captures	Recaptures	Description
22	Blue Lk.	Feb 4 - Feb 23	1	0	0	
		Mar 4 - Mar 23	2	1	1	Houdini (Mar 23)
		Apr 4 - Apr 23	3	0	0	
23	Blue to Stranberg Pass	Feb 4 - Feb 23	1	0	0	
		Mar 4 - Mar 23	2	0	0	
		Apr 4 - Apr 23	3	0	0	
24	137 Finlay	Feb 4 - Feb 23	1	0	0	
		Mar 4 - Mar 23	2	0	0	
		Apr 4 - Apr 23	3	1	0	Unk Gulo 9 (Apr 11)
28	Pass thru Wolverines	Feb 4 - Feb 23	1	0	0	
		Mar 4 - Mar 23	2	0	0	
		Apr 4 - Apr 23	3	1	1	Diana (Apr 7)

Appendix IV

Camera and Hair Collection Data

Grid Number	Location	Session	Dates	Camera Working	Hair	Events	Film	Photo #	Description of photos
1	42 Manson	1	Feb 1 - Feb 13	y	n	0		0	
		1	Feb 13 - Feb 24	y	n	6		3	
		1	Feb 24 - Mar 3	n	n	1	changed	0	
		2	Mar 3 - Mar 15	n	n	2			
		2	Mar 15 - Mar 28	y	n	2	changed	1	test
		3	Mar 28 - Apr 4	y	n	1		0	
		3	Apr 4 - Apr 11	y	n	97	changed	36	36 unknown
		3	Apr 11 - Apr 18	y	n	19	changed	1	unknown
		3	Apr 18 - Apr 23	y	y	90	27	25	24 unknown / 1 Eric
2	River Main	1	Feb 3 - Feb 13	n	n	14		0	
		1	Feb 13 - Feb 24	y	n	28	changed	23	18 MAAM / 5 unknown
		1	Feb 24 - Mar 3	n	n	12	changed	10	6 MAAM / 4 unknown
		2	Mar 3 - Mar 15	n	n	19	changed	12	9 MAAM / 3 unknown
		2	Mar 15 - Mar 21	y	y	32	changed	23	16 MAAM / 4 unknown / **2 Unk Gulo 1** (Mar 21)/ 1 GAJA
		2	Mar 21 - Mar 28	y	y	26	changed	20	13 MAAM / 3 unknown / **Alison (Mar 23)/ 2 Unk Gulo 2 (Mar 24)**/ 1 test
		3	Mar 28 - Apr 4	y	y	15		12	7 MAAM / 4 unknown / **Unk Gulo 2 (Mar 29)**
		3	Apr 4 - Apr 11	y	y	10	changed	7	3 MAAM / 2 unknown / test / **Jessica (Apr 10)**

Grid Number	Location	Session	Dates	Camera Working	Hair	Events	Film	Photo #	Description of photos
		3	Apr 11 - Apr 18	y	n	1017	36	37	unknown
		3	Apr 18 - Apr 23	y	n	1018	36	37	unknown
6	12.5 Manson	1	Jan 30 - Feb 13	n	n	2	changed	0	
		1	Feb 13 - Feb 24	y	n	0	changed	0	
		1	Feb 24 - Mar 3	n	n	1	changed	0	
		2	Mar 3 - Mar 17	n	n	455	changed	37	unknown
		2	Mar 17 - Mar 24	n	y	63	changed	11	unknown
		2	Mar 24 - Apr 5	y	y	7		6	4 MAAM / 2 test
		3	Apr 5 - Apr 18	n	n	2	5	1	test
		3	Apr 18 - Apr 23	y	n	3	3	2	test / unknown
7	97 Finlay	1	Jan 30 - Feb 15	n	n	4	changed	0	
		1	Feb 15 - Feb 23	y	n	7	changed	4	GRJA
		2	Feb 23 - Mar 17	n	n	5	changed	2	unknown / snow
		2	Mar 17 - Apr 5	y	n	1	changed	0	
		2	Apr 5 - Apr 18	y	y	30	18	15	14 MAAM / 1 test
		3	Apr 18 - Apr 23	y	y	4	6	4	3 Martes sp. / test
9	Jackfish	1	Jan 30 - Feb 13					1	unknown

Grid Number	Location	Session	Dates	Camera Working	Hair	Events	Film	Photo #	Description of photos
		1	Feb 13 - Feb 23	y	n	1	changed	0	
		1	Feb 23 - Mar 3	n	n	1	changed	0	
		2	Mar 3 - Mar 15	n	n	2		0	
		2	Mar 15 - Mar 21	y	y	2	14	9	3 GAJA / 3MAAM / Squirrel / error / test
		2	Mar 21 - Mar 28	y	n	3	changed	1	MAAM
		3	Mar 28 - Apr 4	y	n	264		37	unknown
		3	Apr 4 - Apr 11	y	n	11	changed	5	2 MAAM / Weasel / unknown / test
		3	Apr 11 - Apr 18	y	n	5	changed	1	unknown
		3	Apr 18 - Apr 23	y	n	15	7	5	2 MAPE / GRJA / unknown / test
11	Up. Ecklund	1	Jan 31 - Feb 14	y	n	3	changed	0	
		1	Feb 14 - Feb 25	n	n	10	changed	8	7 unknown / 1 MAAM
		1	Feb 25 - Mar 4			0		1	unknown
		2	Mar 4 - Mar 16	n	n	3		0	
		2	Mar 16 - Mar 22	y	n	1	changed	1	unknown
		2	Mar 22 - Mar 27	y	n	1	changed	1	unknown
		3	Mar 27 - Apr 3	y	n	2		1	snow
		3	Apr 3 - Apr 10	y	n	1022	1	36	unknown

Grid Number	Location	Session	Dates	Camera Working	Hair	Events	Film	Photo #	Description of photos
		3	Apr 10 - Apr 17	y	n	2	changed	2	test / **Unk Gulo 4(Apr 13)**
		3	Apr 17 - Apr 24	n	n	1		1	unknown
12	Meadow Ck.	1	Jan 29 - Feb 12	y	n	11	changed	5	unknown
		1	Feb 12 - Feb 22	n	n	3	changed	1	unknown
		1	Feb 22 - Mar 2	y	n	3	changed	0	
		2	Mar 2 - Mar 18	n	n	7		0	
		2	Mar 18 - Mar 23	y	n	207	36	37	unknown
		2	Mar 23 - Mar 30	y	n	1020	changed	37	36 unknown / 1 Lynx
		3	Mar 30 - Apr 6	y	n	746	36	37	33 unknown / 4 blank
		3	Apr 6 - Apr 11	y	n	1	changed	0	
		3	Apr 11 - Apr 18	y	n	1	changed	0	
		3	Apr 18 - Apr 23	y	n	3		1	unknown
13	105 Finlay	1	Jan 30 - Feb 15	y	n	4	changed	0	
		1	Feb 15 - Feb 22	y	n	1021	4	37	unknown
		1	Feb 22 - Mar 4	n	n	1		8	5 error / 1 unknown / 2 ?
		2	Mar 4 - Mar 17	n	n	3	6	2	unknown
		2	Mar 17 - Mar 24	n	n	29	changed	4	unknown

Grid Number	Location	Session	Dates	Camera Working	Hair	Events	Film	Photo #	Description of photos
		2	Mar 24 - Mar 30	y	n	3	changed	2	MAAM / unknown
		3	Mar 30 - Apr 6	y	n	0		0	
		3	Apr 6 - Apr 11	y	n	1	changed	0	
		3	Apr 11 - Apr 18	y	n	5	changed	4	2 MAAM / 2 unknown
		3	Apr 18 - Apr 23	y	n	1	3	1	test
14	Evans Ck.	1	Jan 31 - Feb 4					0	
		1	Feb 4 - Feb 14	n	n	12	2	18	unknown
		1	Feb 14 - Feb 25	y	?	834	36	34	unknown
		2	Feb 25 - Mar 4	n	n	639	changed	37	32 unknown / 2 test
		2	Mar 4 - Mar 17	y	n	1015	changed	23	22 unknown / spoiled
		3	Mar 17 - Mar 22	y	n	1019	36	37	unknown
		3	Mar 22 - Apr 3	y	n	85	changed	38	33 unknown / 3 test / 2 snow
		3	Apr 3 - Apr 17	y	n	1	changed	3	test
		3	Apr 17 - Apr 24			1		1	test
16	S. Blue Lk.	1	Feb 2 - Feb 14	y	n	2		0	
		1	Feb 14 - Feb 25	y	n	33	changed		
		1	Feb 24 - Mar 4					6	Weasel

Grid Number	Location	Session	Dates	Camera Working	Hair	Events	Film	Photo #	Description of photos
		2	Mar 4 - Mar 16	n	n	15	changed	0	
		2	Mar 16 - Mar 22	y	n	6	changed	3	spoiled / unknown / error
		2	Mar 22 - Mar 27	y	n	6	changed	5	unknown
		3	Mar 27 - Apr 3	y	y	53	changed	10	unknown
		3	Apr 3 - Apr 10	n	n	3	changed	1	unknown
		3	Apr 10 - Apr 17	y	n	9	10	10	8 unknown / 2 test
		3	Apr 17 - Apr 24	y	n	3	5	2	unknown / test
17	Up. Fries	1	Jan 31 - Feb 25	y	n	17	changed	7	6 MAAM / blank
		1	Feb 25 - Mar 4	n	n	1	changed	0	
		2	Mar 4 - Mar 16	n	n	13		6	4 MAAM / 2 unknown
		2	Mar 16 - Mar 22	y	n	1021		36	unknown
		2	Mar 22 - Mar 27	y	y	1	changed	0	
		3	Mar 27 - Apr 3	y	n	8		5	3 snow / 2 unknown
		3	Apr 3 - Apr 10	n	n	2	changed	1	MAAM
		3	Apr 10 - Apr 17	y	n	3	changed	1	test
		3	Apr 17 - Apr 24	n	n	2		1	test
19	125 Finlay	1	Jan 29 - Feb 15	y	n	4	changed	0	

Grid Number	Location	Session	Dates	Camera Working	Hair	Events	Film	Photo #	Description of photos
		1	Feb 15 - Feb 22	n	n	1	changed	0	
		2	Mar 3 - Mar 18	n	n	4	changed	36	unknown
		2	Mar 18 - Mar 24	y	n	1		2	unknown
		2	Mar 24 - Mar 30	y	n	1	changed	2	test
		3	Mar 30 - Apr 6	y	n	1		0	
			Apr 6 - Apr 13					0	
		3	Apr 13- Apr 16					0	
		3	Apr 16 - Apr 23	y	n	2		1	test
20	Nina Lk.	1	Jan 31 - Feb 14	n	n	5	changed	2	MAAM
		1	Feb 14 - Feb 25	y	n	84	changed	18	17 unknown / **Unk Gulo 5 (Feb 22)**
		1	Feb 25 - Mar 4					7	5 **Unk Gulo 5** (Feb 27)/ blank / test
		2	Mar 4 - Mar 17	n	n	1019	changed	0	
		2	Mar 17 - Mar 22	y	n	1		1	test
		2	Mar 22 - Mar 27	y	y	4	changed	1	**Unk Gulo 6 (Mar 26)**
		3	Mar 27 - Apr 3	n	n	26		13	12 unknown / 1 MAAM
		3	Apr 3 - Apr 10	y	y	10	changed	3	2 MAPE / **Unk Gulo 6 (Apr 5)**
		3	Apr 10 - Apr 17	y	n	12	changed	9	3 **Borris** (Apr 15)/ 2 test / 2 unknown / 2 MAAM

Grid Number	Location	Session	Dates	Camera Working	Hair	Events	Film	Photo #	Description of photos
		3	Apr 17 - Apr 24	y	n	17	15	14	10 unknown / 2 test / **Unk Gulo 5** (Apr 18)/ **Unk Gulo 6** (Apr 20)
21	Blue Grouse	1	Jan 31 - Feb 14	n	n	2		0	
		1	Feb 14 - Feb 25	y	n	0	changed	2	test / error
		1	Feb 25 - Mar 4			3		3	**Unk Gulo 5 (Mar 1)**/ MAAM / error
		2	Mar 4 - Mar 17	y	n	2		1	unknown
		2	Mar 17 - Mar 22	y	n	4		1	error
		2	Mar 22 - Mar 27	y	n	1	changed	1	test
		3	Mar 27 - Apr 3	y	n	5		2	**Unk Gulo 7** (Apr 3)/ test
		3	Apr 3 - Apr 10	y	y	4	changed	6	3 mustelid / 2 stickum / test
		3	Apr 10 - Apr 17	y	n	4	changed	5	3 test / Martes sp. / **Unk Gulo 8 (Apr 14)**
		3	Apr 17 - Apr 24	y	n	5		4	2 test / mustelid / **Unk Gulo 8 (Apr 22)**
22	Blue Lk.	1	Feb 2 - Feb 14	y	n	55	changed	7	unknown
		1	Feb 14 - Feb 25	y	n	33	changed	3	unknown
		1	Feb 25 - Mar 4					0	
		2	Mar 4 - Mar 16	n	n	536	changed	8	unknown
		2	Mar 16 - Mar 22	y	n	1	changed	1	unknown
		2	Mar 22 - Mar 27	y	n	3	changed	2	**Houdini (Mar 23)**/ test

Grid Number	Location	Session	Dates	Camera Working	Hair	Events	Film	Photo #	Description of photos
		3	Mar 27 - Apr 3	y	n	1018		37	unknown
		3	Apr 3 - Apr 10	y	n	1	changed	2	test
		3	Apr 10 - Apr 17	y	n	1	changed	2	test
		3	Apr 17 - Apr 24	y	n	2		1	test
23	Blue to Stranberg Pass	1	Jan 31 - Feb 14	pos	n	4	changed	0	
		1	Feb 14 - Feb 25	n	n	3	changed	1	test
		1	Feb 25 - Mar 4					21	19 underexposed / test / unknown
		2	Mar 4 - Mar 16	n	n	339	changed	25	unknown
		2	Mar 16 - Mar 22	y	n	1018	changed	0	
		2	Mar 22 - Mar 27	y	n	2	changed	1	blank
		3	Mar 27 - Apr 3	n	y	4		2	unknown
		3	Apr 3 - Apr 10	n	n	2		1	unknown
		3	Apr 10 - Apr 17	y	n	1	changed	2	test
		3	Apr 17 - Apr 24	y	n	2		1	test
24	137 Finlay	1	Jan 29 - Feb 15	n	n	2	changed	2	unknown
		1	Feb 15 - Feb 22	y	n	6	changed	5	3 MAAM / 2 unknown
		1	Feb 22 - Mar 3						

Grid Number	Location	Session	Dates	Camera Working	Hair	Events	Film	Photo #	Description of photos
		2	Mar 3 - Mar 18	y	n	29	changed	17	11 unknown / 4 MAAM / 2 blank
		2	Mar 18 - Mar 24	y	n	5	changed	2	MAAM
		2	Mar 24 - Mar 30	y	n	5	changed	2	1 MAAM / 1 unknown
		3	Mar 30 - Apr 6					0	
		3	Apr 6 - Apr 13					2	**Unk Gulo 9** (Apr 11)/ test
		3	Apr 13 - Apr 16	y	n	0	changed	0	
		3	Apr 16 - Apr 23					1	test
28	Pass thru Wolverines	1	Jan 31 - Feb 14	y	n	6	3	0	
		1	Feb 14 - Feb 25	n	n	1		35	2 MAAM / 13 ?
		1	Feb 25 - Mar 4			471		37	MAAM
		2	Mar 4 - Mar 16	y	n	244		37	MAAM
		2	Mar 16 - Mar 22	y	n	47	changed	17	16 MAAM / test
		2	Mar 22 - Mar 27	y	n	6	5	4	2 unknown / test / MAAM
		3	Mar 27 - Apr 3	n	y	10	changed	4	unknown
		3	Apr 3 - Apr 10			6		2	**Diana** (Apr 7)/ unknown
		3	Apr 10 - Apr 17	y	n	6	changed	3	2 unknown / test
		3	Apr 17 - Apr 24	y	n	11		5	2 test / 3 MAAM