Abundance and Distribution of Wolverine in the Kootenay Region

2013 Field Season Report: Purcell Mountains

Prepared For:

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Abstract

Wolverine (*Gulo gulo*) is a species of conservation priority provincially and nationally and is harvested regionally, yet no inventory has been conducted to estimate population abundance and connectivity in the southern portion of the Kootenays. Thus, a non-invasive genetic study was initiated in 2012 with the objectives of estimating abundance and assessing meta-population connectivity to inform harvest management and contribute to international conservation efforts. Our estimates of population size in the south Purcell Mountains were lower than previously published habitat-based values. We also found evidence of low genetic connectivity between the south Purcell population and other populations in southeastern British Columbia. At the same time, we detected at least one individual that had dispersed from the southern Rocky Mountains. Based on these revised population estimates, recruitment may not be sufficient to meet recent levels of harvest. We also detected wolverine south of Highway 3 in the Purcells in habitat contiguous with Montana and Idaho.

Introduction

Wolverine (*Gulo gulo*) is a species of conservation priority provincially and nationally (BC CDC 2013, COSEWIC 2003) and is classified as Identified Wildlife under the Forest and Range Practices Act (MWLAP 2004). Population estimates for British Columbia have been derived from habitat modeling based on mark-recapture in the Omenica and Northern Columbia Mountains (Lofroth and Krebs 2007) but lack verification for much of the province, including the southern portion of the Kootenays. Considering that adjacent U.S. populations are known to be at critically low levels (USFWS 2013), with wolverine absent from potentially viable habitat, reliable abundance estimates are crucial for species conservation in the region.

In the Kootenays, wolverine populations are characterized by small and declining fur yields (~8 pelts/year) and harvest rates in parts of the region may be unsustainable (Lofroth and Ott 2007). Populations with high connectivity are resilient to local overharvest or high mortality from other sources because of source/sink dynamics (Pulliam 1988). Although genetic evidence indicates increasing population fragmentation in a north to south gradient in B.C. (Cegelski et al. 2006), the extent of gene flow between neighboring ranges in the southern Kootenay region is unknown. Hence, assessing connectivity is important to local population resilience and evaluating harvest sustainability.

Barriers to dispersal include transportation routes, hydroelectric and residential development and land use changes (Gardner et al. 2010, Krebs et al. 2007, Slough 2007, Austin 1998). Similarly, wolverine habitat use and density are associated negatively with winter recreation, forest harvest, and positively with roadless areas (Fisher et al. 2013, Krebs et al. 2007). Mapping occupied habitat in the Kootenays and identifying factors contributing to the persistence of wolverine in these areas is an essential step to identifying where conservation efforts to improve habitat and connectivity should be focused. Additionally, the Kootenay region is one of only a few areas identified as a potential corridor for trans-boundary movement of wolverine into the US (McKelvey et al. 2011, Schwartz et al. 2009, Singleton et al. 2002). Such movement is critical for the persistence of US populations, and this project will provide vital information for wolverine conservation in the trans-boundary region.

Project objectives were to: (1) assess occupancy/abundance of wolverine in the Purcell Mountains; (2) assess genetic connectivity between the Selkirk and Purcell populations; (3) evaluate current harvest levels; (4) evaluate broad-scale habitat factors that are associated with wolverine presence and; (5) cooperate inter-jurisdictionally for wolverine research.

Methods

Field surveys

The southern Purcell Mountains study area was partitioned into 10 by 10 km cells that approximate the minimum size of a home range. These 65 quadrats were sampled twice in 21 day sampling intervals, from February to April, 2013 (Figure 1). Additionally, three sites from the South Selkirk region were resampled in 2013 (January-April). Because of the rugged nature of the terrain, sites within cells were selected for ease of access by helicopter, snow machine or skis, using local knowledge of wildlife movements when available. Hair trap sites were created by affixing a bait item (beaver or deer quarter or deer head) to a tree approximately two meters from the ground or snow surface to entice the animal to climb (Fisher 2004). The bait item was nailed to the tree and wrapped several times in wire. The tree was wrapped with barbed wire to capture hair. During each check, the barb wire was examined for hairs or hair tufts, and the bait replenished if necessary. Hairs were collected with forceps and stored in paper envelopes in a dry environment.

We utilized six Rencoynx Rapidfire trail cameras during the first session of sampling (approximate duration three weeks) and nine during the second (approximate duration four weeks; Figure 1). These cameras were deployed in sites in the Selkirk and Purcell ranges adjacent to Highway 3 to increase wolverine detectability in the event that they were visiting sites and not leaving samples and to assess linkage zones for wolverine across this putative barrier.

Additionally, we submitted a letter to all trappers in the provincial database in the Kootenay region soliciting genetic samples from wolverines obtained by trappers. From each carcass a tissue sample was taken and carcasses were necropsied to determine body condition, age, sex and number of pregnancies. Necropsy data was submitted into a regional database and will contribute to long-term modeling of population structure.

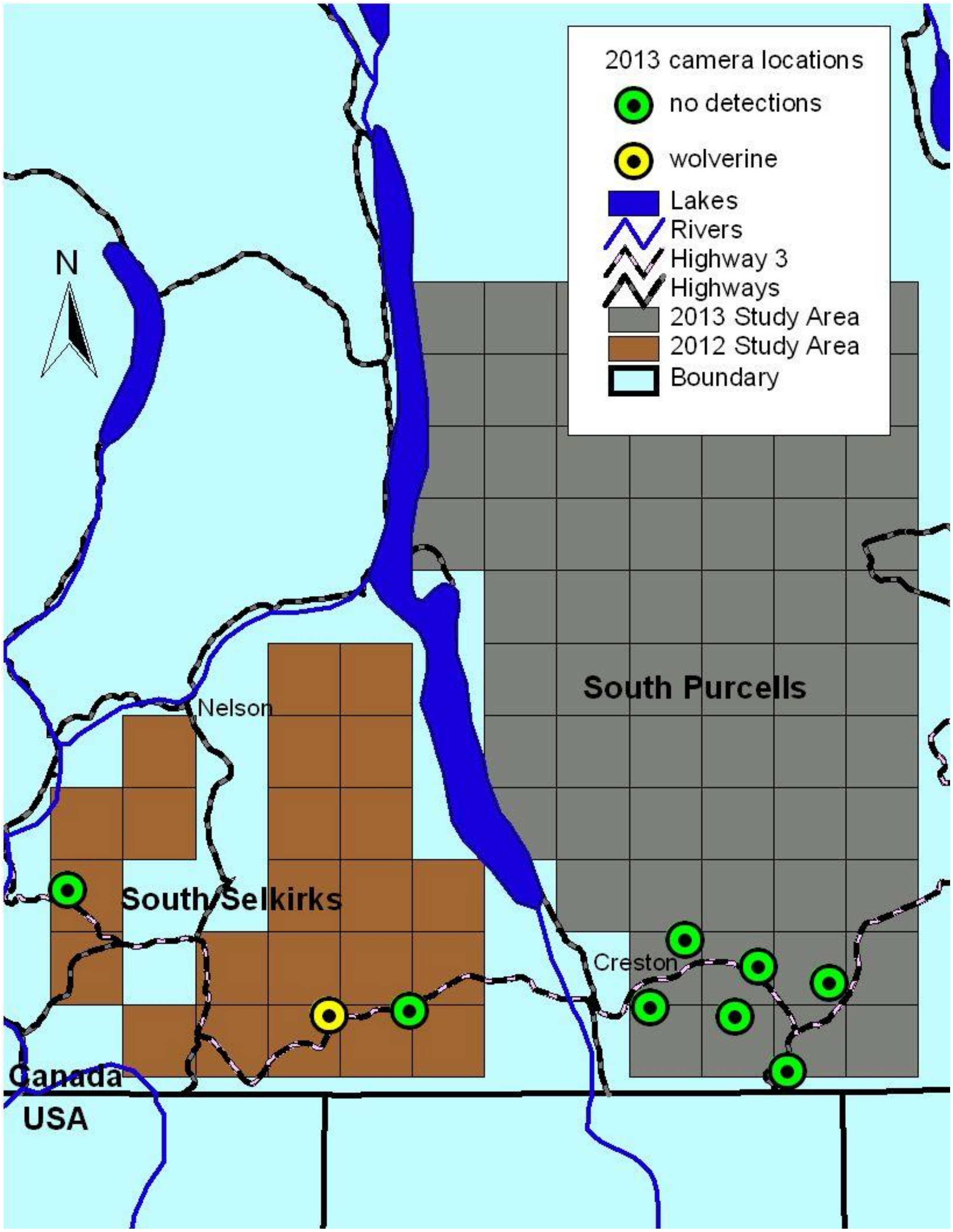

Figure 1. Trail camera locations along Highway 3 to detect wolverine at bait stations in the south Selkirk (2012) and south Purcell Mountain (2013) study areas.

Genetic Analysis

Hair samples were submitted to Wildlife Genetics International in Nelson B.C. for dioxy ribonucleic acid (DNA) analysis. Samples that did not contain guard hairs or >5 underfur were screened out because of insufficient genetic material. From the remaining samples, DNA was extracted using QIAGEN DNeasy Tissue kits, following the manufacturer's instructions (Qiagen Inc., Toronto, ON).

Species identification was based on a sequence-based analysis of a segment of the mitochondrial 16S rRNA gene (Johnson and O'Brien 1997). For samples that yielded wolverine DNA, WGI utilized multilocus genotyping, consisting of a *ZFX/ZFY* sex marker, and 12 additional microsatellite markers (13 markers total) for individual identification.

Occupancy and abundance

We used the single-season model in program PRESENCE (MacKenzie et al. 2002) to estimate the proportion of sample stations occupied by wolverine. A non-detection at a surveyed site could have meant wolverine were not present at the site or that we failed to detect an individual when it was present. PRESENCE uses a joint likelihood model to estimate the probability of missing a species when it is present at the site (p = detectability) and the probability that a site is occupied (Ψ). To estimate these parameters repeat observations need to be conducted over a period of time during which site occupancy is assumed to be constant. In this way, a non-detection from a site with at least one detection can be treated as a false negative and the detection probability can be estimated.

We used both track detections and genetic data to estimate occupancy. Locations of sampling sites and genetic samples were mapped in ARCVIEW 3.1 (ESRI Inc. 1998, Jenness 2005).

Estimates of occupancy can act as a surrogate for abundance for territorial species such as wolverine when the sites sampled approximate territory sizes (MacKenzie et al. 2006). We selected a grid resolution (10 x 10 km) that corresponded to a minimum home range size for female wolverine. However, average home range size in the Columbia Mountains was 300 km^2 and 1000 km^2 for exclusive female and overlapping male wolverine, respectively (Krebs et al. 2007). We applied the female density to our occupied habitat in the south Purcells and assumed a 1:1 sex ratio (Magoun 1985, Banci 1987) to derive a population estimate (female density times two), recognizing that animal distribution, population structure, habitat quality and edge effects may affect the accuracy of this estimate.

Additionally, a simple Lincoln-Peterson Method was used to estimate the population independent of occupancy; N = MN/R, where N is the estimated population size, M is the number of animals identified in the first sampling session, R is the number of animals identified in the first session which are recaptured in the second session and N is the total number of animals identified in the second sampling session (Seber 1982).

Population genetics

The program POPULATIONS (Langella 1999) was used to calculate shared allele distance (Chakraborty and Jin 1993), a simple measure of the degree of relatedness between individual genotypes in our samples. The proportion of shared alleles is estimated by $P_{SA} = \sum_u S / 2u$ where S is the number of shared alleles, summed over all loci u. Distance between individuals is estimated by $D_{SA} = 1- P_{SA.}$ To illustrate population substructure, these distances were used to plot a neighbour-joining tree (Saitou and Nei 1987) in DRAWTREE (part of the PHYLIP program package: Felsenstein 2013).

Results

During the course of the field season we monitored 65 sites in the Purcells and three in the Nelson and Bonnington ranges (Figure 1). Fourteen field days were required for setup and an additional 30 days for site monitoring. Other carnivores detected, using snow tracking, included wolf (*Canis lupis*), cougar (*Puma concolor*), lynx (*Lynx canadensis*), red fox (*Vulpes vulpes*) and coyote (*Canis latrans;* Appendix 1).

Using trail cameras, we collected 24,537 images over 9,476 hours of monitoring at bait sites. Species detected included flying squirrel (*Glaucomys sabrinus*), American marten (*Martes americana*, grey jay (*Perisoreus canadensis*), stellars jay (*Cyanocitta stelleri*), short-tailed weasel (*Mustela ermine*), red squirrel (*Sciurus vulgaris*), coyote, wolverine, bobcat (*Lynx rufus*), sharp-shinned hawk (*Accipiter striatus*), hairy woodpecker (*Picoides villosus*), human (*Homo sapien*) and mouse (*Peromyscus* spp.). We detected wolverine at one site, north of Highway 3 in the Nelson range, close to Kootenay Pass (Figure 1).

Genetic analysis

We obtained genetic results from 356 hair, tissue, scat and skull samples. The species identified by mitochondrial DNA analysis included American marten (*n* = 102), wolverine (*n* = 49), deer (*Odocileus* spp., *n* =11), cougar (*n* =7) northern flying squirrel (*n* = 6), elk (*Cervus canadensis*, *n* = 3), red squirrel (*n* = 2), coyote (*n* = 2), short-tailed weasel (*n* = 1), human (*n* = 1) and housecat (*Felis catus*, *n* = 1). Wolverine DNA was detected at ten sites. From those ten sites, we were able to identify eight individual wolverines, all females (Figure 2). At one of the three sites we re-sampled in 2013 in the south Selkirk we were able to confirm an individual identification where we had inadequate samples in 2012. Another individual in the south Selkirks was identified from hairs obtained opportunistically on a wolverine track. Both these individuals were previously detected at other sites in 2012.

Ten wolverine carcasses (six males, four females) were submitted by the trapping community in 2013 (Figure 2). This is in addition to four (two males, two females) submitted in 2012.

One of the submitted carcasses was a female wolverine that had been previously captured in a radio-telemetry study in the Flathead River in 2012. She was trapped just outside the south Purcell study area near Yahk in 2013 after travelling a distance of approximately 100 km across the East Kootenay Trench, likely crossing Highway 93 and the Koocanusa Reservoir (Figure 2).

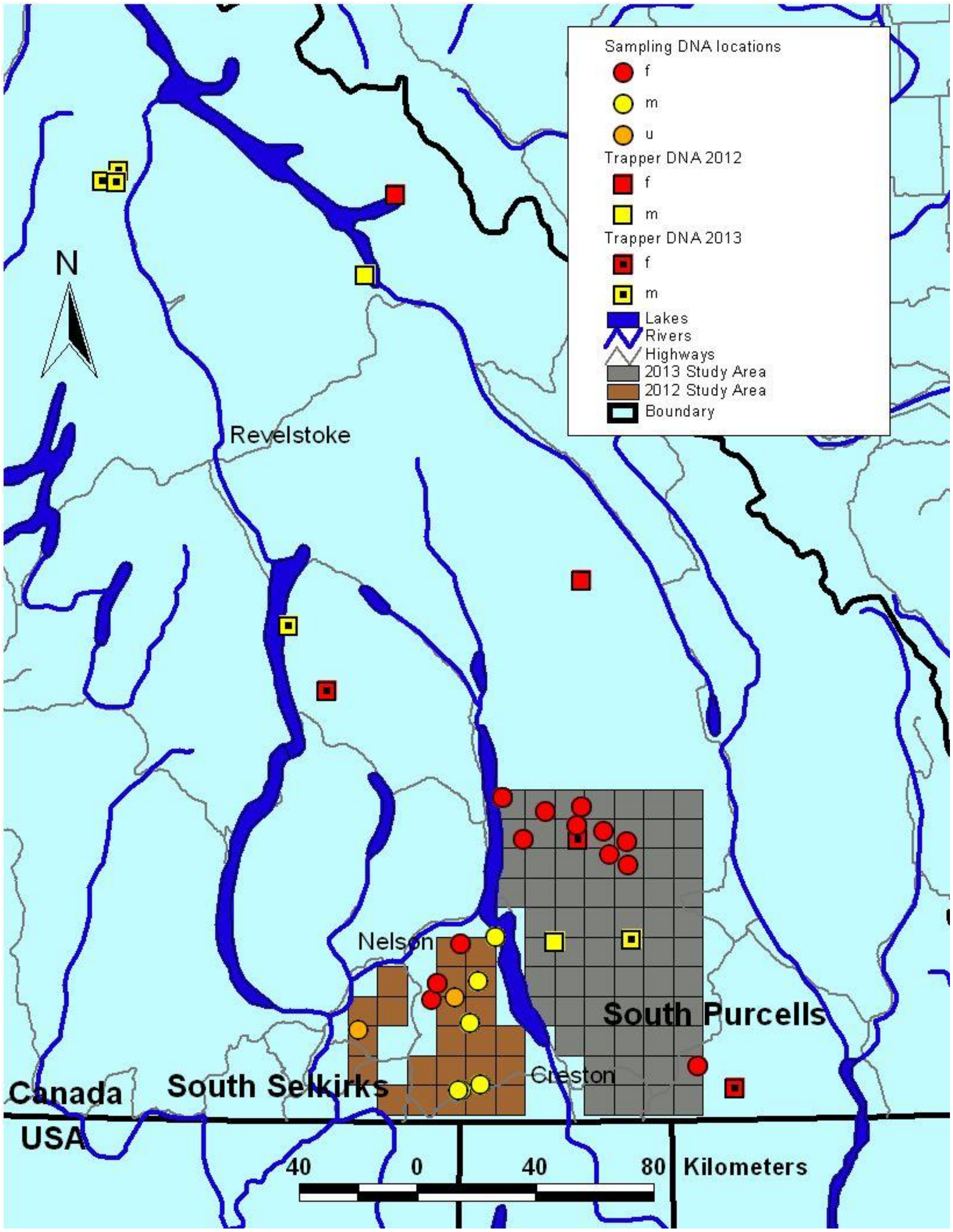

Figure 2. Wolverine non-invasive hair trapping results showing site locations and wolverines detected (orange circles) in the south Selkirk (2012) and south Purcell Mountains (2013). An individual may be represented by more than one sample. M is male, F is female and U is unknown sex. Trapper carcass collection is represented by squares (2012) and squares with dots (2013). Two carcasses in 2013 lacked location information and were assigned to a management unit but not plotted on this map.

Occupancy and abundance

Detections of wolverine occurred by snow tracking and/or genetic analysis (Figure 3). The naïve occupancy estimate, or number of cells occupied in the south Purcell Mountains was 27.3%. Taking detection rates into account (by calculating the probability of missed wolverine observations), the estimate of wolverine occupancy in the south Purcell mountains was 38.3% (*SE* = 10.2). Two models need to be considered as competing models (Δ AICc < 2; Table 1). The best model was one in which detection probabilities changed with sampling session. The probability of detection was 19.8% (*SE* = 9.0) in repetition one, 31.6 % (*SE* =11.5) in repetition two and 47.4 % (*SE* = 14.2) in repetition three. The competing model is one in which detection and occupancy is constant through sampling sessions.

Our occupancy-based population estimate was 17 wolverine for the south Purcell population. Using mark-recapture, the population was estimated at 18 (*SE* = 4.83, 95% *CI* = 9-27 individuals).

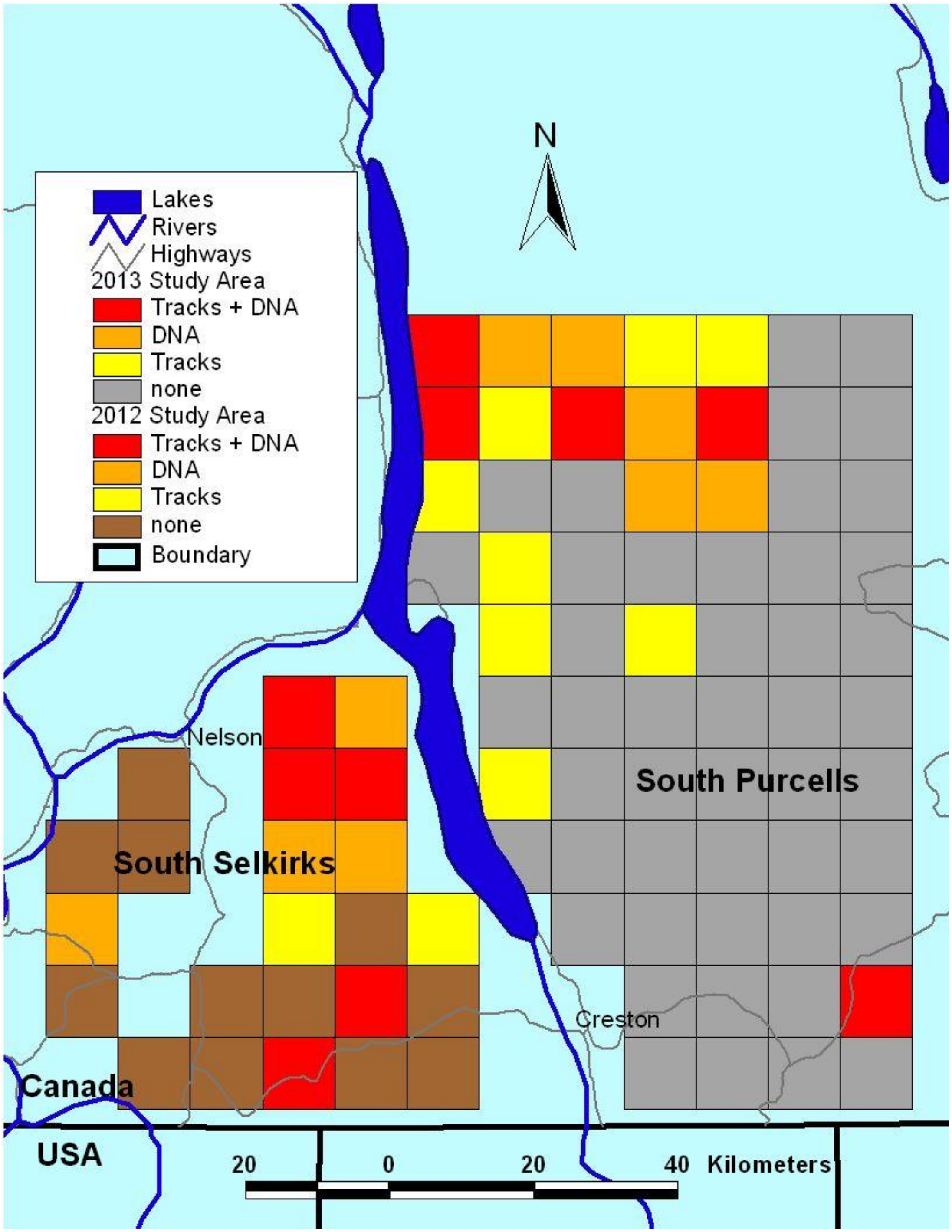

Figure 3. Wolverine detections by tracks and DNA in the south Selkirk and Purcell Mountains, 2012 and 2013.

Table 1. Ranking for models of occupancy (ψ) and detectability (p) for track and genetic data of Wolverine in the south Purcell Mountains in 2013. Models were developed in Program PRESENCE and compared using AICc weights of evidence (Burnham and Anderson 1998).

Model	AICc	Delta AICc [a]	AICc Weights	Number of Parameters
ψ (.) p(survey specific) [b]	146.7	0.0	0.50	4
ψ (.) p(.)[c]	147.1	0.4	0.40	2
ψ (2 groups) p(.)[d]	151.6	4.3	0.06	4
ψ (2 groups) p(survey specific)	155.1	8.4	0.04	8

[a] A Δ AICc > 2 but < 4, provides weak evidence that the model is not the best fit for the data (Burnham and Anderson 1998).

[b]constant ψ, survey specific p= The species has constant occupancy but different detection rates

[c] constant ψ , constant p= The species has constant occupancy and detection rates

[d] 2 groups, constant p= there are two groups of sites where the species has the same detection probabilities

Population genetics

Visual inspection of the neighbour-joining tree shows 10 of 11 wolverines from the south Purcells clustered on the same branch, and all three wolverines from the central Selkirk Mountains clustered together as well (Figure 4). Three of four south Selkirk wolverines share the same branch (Figure 4), although this cluster also includes individuals from the south Rockies and north Monashees. Individuals from the north Purcells (1), central Purcells (1), north Monashees (3), south Rockies (1) and central Rockies (2) populations do not appear to be clustered geographically (Figure 4).

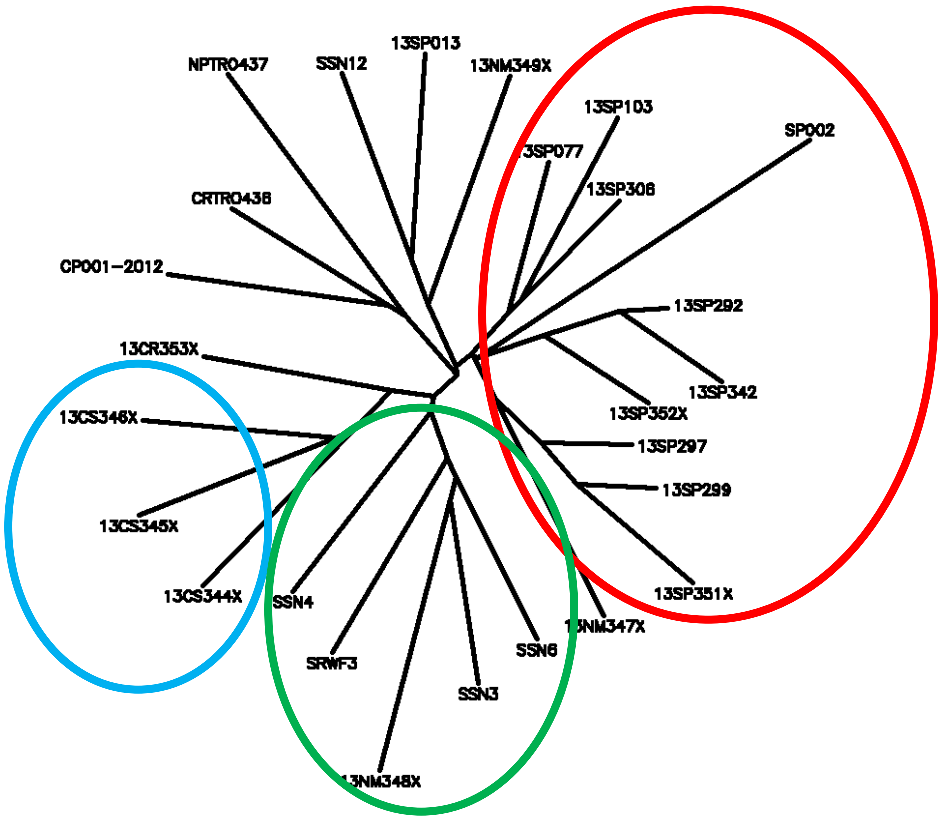

Figure 4. Neighbour-joining tree showing genetic distances between 26 wolverine in the south Selkirk (SS), central Selkirk (CS), south Purcells (SP),central Purcells (CP), north Purcells (NP), south Rockies (SR), central Rockies (CR), and north Monashees (NM) populations, 2012-2013. The three main clusters are the southern Purcells (red circle), southern Selkirks (green circle), and central Selkirks (blue circle).

Discussion

This research represents the first on-the-ground attempt to inventory wolverine populations in the southern Kootenay region. The south Purcell wolverine population was of particular interest because it had been identified as a management concern with respect to potential overharvest (Lofroth and Ott 2007).

Compared to 2012 results in the south Selkirks, the south Purcells had lower naïve (27.3% vs 47.8) and estimated occupancy (38.3% vs 55.4%) rates. Additionally, the south Purcells had lower detection probabilities (19.8% vs 23.6%; 31.6% vs 39.3%; 47.4% vs 70.7%) in all repetitions (Kortello and Hausleitner 2012).

Lofroth and Krebs (2007) analysis of wolverine habitat in British Columbia rated most of the southern Purcells as high quality habitat, and the southern Selkirks as moderate. Given the habitat ratings, and a larger contiguous area in the southern Purcells, we expected higher wolverine occupancy rates in the southern Purcells than in the southern Selkirks, but we found the opposite. Contributing factors may be related to harvest, forest management, prey abundance and habitat fragmentation, and likely a combination of factors. The south Selkirks has a higher proportion of land in protected areas with difficult access. Additionally, there is a difference in harvest rates between the two regions; there has been no reported trapping in the south Selkirk region since before 1985 (Lofroth and Ott 2007). In contrast, average annual harvest rate in the south Purcell management units sampled (4-5, 4-6, 4-19 and 4-20; 1985-2013; data for 2011 is unavailable) has been 1.4 wolverine. However, annual harvest is variable with an increase in the past five years (ten year average (2003-2013) = 1.2, five year average (2008-2013) = 2.0).

Our estimate of occupancy translates to 17 wolverine based on average home range sizes (Krebs et al. 2007). This estimate, in addition to the population estimate based on mark-recapture of 18 (CI 9-27) individuals, is below the published habitat-based estimate of population size for the south Purcells: 27 (CI 20-39), although confidence intervals overlap (Lofroth and Ott 2007). Additionally, we sampled a slightly larger area than the South Purcell population unit boundaries of Lofroth and Ott (2007). For our estimated population of 18 wolverine, annual recruitment is expected to be around one (Lofroth and Ott 2007). It appears that, in this population, harvest may be exceeding recruitment in some years.

Female productivity is strongly linked to body condition and hence food availability, particularly large ungulate carcasses (Lofroth et al. 2007, Persson 2005). Consequently net recruitment might be greater in unusually productive environments. However, a consistently high (relative to recruitment) harvest rate in the south Purcells might also explain the large number of females in our genetics sample and apparent lack of connectivity with other populations. Males have larger home ranges (Krebs et al. 2007) and are found at lower elevations (Lofroth 2001) than females, making them more susceptible to harvest. Dispersing wolverine would also be more vulnerable to harvest for similar reasons. Three of four wolverine harvested in the Purcells in the past two years fit these criteria (male or disperser).

There was a notable decline in wolverine detections in a north to south gradient in both the south Selkirk and Purcell Mountains. Fisher et al. (2013) found wolverine more abundant in rugged areas protected from anthropogenic development, similarly, although most of the terrain in our study area is quite rugged, the majority of wolverine detections have been within cells in or immediately adjacent to large protected areas; West Arm Provincial Park, Darkwoods Nature Conservancy, Purcell Wilderness Conservancy, and St. Mary's Alpine Provincial Park. The location of these areas may account for the north to south gradient in distribution in both ranges.

Despite very small sample sizes for populations, geographic clustering of genotypes supports other research suggesting some degree of population fragmentation for wolverine in southeastern British Columbia (Cegelski et al. 2006). The genetic similarity of the southern Purcell population is somewhat surprising, given the extent of the range northward and its close proximity to populations in the northern Selkirks. Additionally, the female wolverine from the Rockies that was later trapped in the southern Purcells indicates a viable travel corridor across the East Kootenay trench. Unfortunately, from the timing of when she was last detected in the Rockies, it is unlikely that this individual contributed reproductively to the south Purcell population prior to harvest. If this is the case for other dispersers, there is less probability of gene flow or demographic 'rescue' by immigrants.

Our camera array did not provide any insights into connectivity in the Purcells across Highway 3, but a repeat detection of a transboundary wolverine (detected in Idaho in 2011) at Kootenay Pass in the Selkirks highlights the importance of the Kootenay Pass area for movements between Canadian and US populations. Since DNA was collected at this site as well, the use of the camera did not improve our ability to detect wolverine but provided ancillary information on the timing of visits. We obtained DNA from two wolverine south of Highway 3 near Yahk. This area provides contiguous mountain habitat into the US without a major road crossing and might be a zone for wolverine movements into Montana and Idaho.

Our data, somewhat surprisingly suggest lower populations than expected and lower connectivity between this and other southern British Columbia populations, hence harvest should be carefully considered and managed with trapper input. Distinctly clustered wolverine detections also allude to the possible impact of land management practices and/or recreational access on wolverine distribution. This research is being expanded into the central Selkirk region in 2014. This, with continued carcasses donated from trappers, will increase the sample size of genotyped individuals, and continue to increase the strength of genetic analysis.

This project is beginning to fill a critical knowledge gap for a species that is a conservation priority in the U.S. and Canada. This information is crucial for identifying viable movement linkages and protecting habitat. These results will directly inform species harvest management. Further work will contribute to the management of crown land, acquisition of conservation properties, linkages and highway mitigation in the region. This study compliments similar research on grizzly bears to provide a multi-species perspective for regional conservation planning. Healthy, connected wolverine populations are an important ecosystem component of the Columbia River watershed, will sustain trapping opportunities for B.C. residents, and are critical for species persistence in the conterminous USA (Cegelski et al. 2006).

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Appendix 1. Carnivores detected by snow tracking during wolverine surveys in the south Purcells and south Selkirks January-April 2013.

Location	**UTM easting**	**UTM northing**	**Date (s)**	**Species**
Clearwater Creek	488451	5468811	19 Jan	Coyote (1)
Bombi Summit	462420	5455674	22 Jan, 19 Feb	Cougar (1), Lynx (1), Coyote (1)
Wolf Peak	498559	5438243	3 Feb, 1 April	Coyote (1)
Baribeau/Redding Confluence	533238	5498381	10 Feb	Coyote (1)
Redman Point	521371	5466658	11 Feb, 4 March	Coyote (1), Wolf (1)
Mount Thompson	542908	5439398	11 Feb	Coyote (1)
Hazel Creek	557901	5445092	11 Feb, 7 March	Coyote (1)
Kid Creek	562293	5456220	13 Feb	Cougar (1)
Englishman Creek	567682	5442896	14 Feb, 6 March	Red fox (1), Coyote (1)
Houghton Creek	516079	5505834	15 Feb, 10 March	Coyote (1)
Lamb Creek Headwaters	572409	5457717	19 Feb	Wolf (1)
Rabbitfoot Creek	576255	5463107	19 Feb	Lynx (1)
St Mary/Dewer Junction	544627	5507441	20 Feb	Wolves (>1)
Buhl/Skookumchuck Confluence	569600	5534736	21 Feb	Coyote (>1)
Kianuko Creek	540833	5476179	4 March	Red fox (1)
Leadville	549498	5453477	5 March	Coyote (1)
Kianuko/Goat Confluence	544464	5465158	5 March	Coyote (1)
Kitchener	547812	5448713	5 March	Coyote (1), Red fox (1)
Little Moyie	554758	5438204	5 March, 4 April	Coyote (1)
Mt Sommerfeld	556468	5450470	6 March	Coyote (1)
St. Mary’s	551216	5497089	15 March	Wolf (1), Cougar (1)
Maryland Creek	509671	5438961	1 April	Wolf (1)
Birchdale	512369	5537026	11 April	Coyote (1)
Mather/Cherry Creek	574678	5517433	11April	Lynx (1)