Mapping the Wolverine Way: Identifying conservation corridors and transboundary linkages in the Canadian Crown of the Continent

2015 Summary Report
Alberta-British Columbia Survey

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Executive summary

The Canadian portion of the Crown of the Continent (COTC) ecosystem has been identified as crucial for wolverines north of the US border to 'rescue' or supply individuals and genes through dispersal to the highly fragmented population in the northern US Rocky Mountains. Highway 3, motorized recreation, and resource extraction, however, increasingly fragments this critical landscape.

Our project capitalizes on multi-year wolverine occupancy and genetic data collected noninvasively in a >51,000 km^2 area encompassing the core protected areas of the central Canadian Rocky Mountains to the north; and Glacier-Waterton Lakes National Park complex in the south. Our goal is to obtain spatially-explicit information on the wolverine population, connectivity, and habitat relationships in the largely unstudied and vitally important international transboundary linkage region. Our 2015 study area was situated in the Canadian COTC ecosystem in Alberta and British Columbia and straddled the Continental Divide.

Data collection

From January to April 2015, we deployed 64 hair-camera sampling sites over an area of >9200 km^2 in southwest Alberta and southeast British Columbia (BC). A total of 47 sites were set in BC, while 17 were set in Alberta and checked three times on a monthly basis. Of the 64 sites set, 12 (19%) were located inside or less than 1.5 km of a protected area (national park, provincial park), while the remaining 52 sites were situated in provincial multi-use lands.

In Alberta, only 3 sites (17%) had confirmed wolverine camera detections and a total of 4 visits. The three sites were all situated along the spine of the Continental Divide. In BC, 12 sites (25%) had confirmed wolverine photo-detections and a total of 24 confirmed visits during the monthly sampling sessions. The probability of photo-detection increased between the first and second sessions, but slightly decreased between the second and final round.

A total of 447 hair samples from 31 sites were obtained from sites/sessions where wolverines were detected by camera. The hair samples in addition to seven scat samples collected at five sites are currently being analysed at the US Forest Service Conservation Genetics lab in Missoula, Montana.

Occupancy

Our estimate of wolverine occupancy in our Alberta-BC study area was 25% (s.e.=0.05). Over the three sampling sessions the probability of false absences was low, a 7% chance of missing wolverines that were actually present. We found a distinct north-south gradient in wolverine occupancy as estimates decreased from north to south. There was no difference in wolverine occupancy from east-west.

Wolverine occupancy differed markedly between the 2014 Waterton-Crowsnest Pass and 2015 Alberta-BC study areas. In the former, wolverine occupancy was extremely low, occupying an estimated 15% of the landscape. This is lower than estimates from Kananaskis Country, Alberta,

and lower still than occupancy estimates from the heavily developed Alberta foothills farther north where occupancy increased east to west.

Wolverine occupancy was greater in the Alberta-BC study area, but varied markedly through space. The clear pattern of decreasing occupancy from north to south is remarkably similar to wolverine occurrence in the Columbia Mountains, where a notable decline was found in wolverine detections in a north-south gradient in both the south Selkirk and Purcell Mountains. These findings are noteworthy given the Columbia and Rocky Mountains are two of the three remaining areas where wolverines and other wide-ranging carnivores can move between Canada and the U.S. The mechanisms for this north-south decrease in occupancy have yet to be explained but will be the focus of future analysis.

The north-south pattern from our study area differs from occupancy patterns observed in Banff-Yoho park complex – Kananaskis Country and the Willmore Wilderness – Foothills where a decreasing west-east pattern of wolverine occurrence was reported.

Wolverine camera-detections in our Alberta-BC study area were moderately associated with areas protected from landscape disturbance. Previous surveys in the Canadian Rockies revealed wolverine more abundant in rugged areas protected from anthropogenic development. Similar patterns of wolverine occurrence were found in the Columbia Mountains where the majority of wolverine detections were within or immediately adjacent to large protected areas. The location of these relatively protected areas may account for the north to south gradient in distribution in both ranges.

Although our results are preliminary our trans-provincial data suggests lower populations than expected and lower connectivity between the US-Canada border and populations to the north. Clustered wolverine occupancy to the north may be a result of land management practices and/or motorized recreation on wolverine distribution. Consequently harvest should be carefully considered and managed to ensure long-term persistence and viability of wolverines in one of the two remaining linkage zones with populations in the northern US Rockies. Additional modeling with environmental covariates is planned to help understand the spatial variability in wolverine occurrence in both the north-south and east-west planes.

Future

Next winter we will sample approximately 75 sites in the Flathead and Elk Valleys to complete the Rockies range-wide sampling. Occupancy and genetic data (n=100 genotyped individuals) obtained from all sites sampled over 51,000-km2 will ultimately be pooled. Future analyses will focus on occupancy estimates, habitat modeling, density estimations and linking landscape characteristics to wolverine abundance. The results from our collective 6-year research will inform decision making regarding wolverine harvest levels and land use management that influence wolverine management at federal, provincial/state levels and transboundary coordination in the COTC.

Background

The Canadian portion of the Crown of the Continent ecosystem has been identified as crucial for wolverines north of the US border to 'rescue' or supply individuals and genes through dispersal to the highly fragmented population in the northern US Rocky Mountains. Highway 3, motorized recreation, and a growing resource extraction industry, however, increasingly fragment this critical landscape. Our project capitalizes on multi-year wolverine occupancy and genetic data collected noninvasively in a >51,000 km2 area encompassing the core protected areas of the central Canadian Rocky Mountains to the north and Glacier-Waterton Lakes National Park complex in the south. Surveys have been coordinated with provincial parks, national parks and research institutions in Alberta and British Columbia (BC). Our goal is to obtain spatially-explicit information on the wolverine population, connectivity, and habitat relationships in the southern Canadian Rockies and largely unstudied and vitally important international transboundary linkage region. Herein we summarize 2015 field research carried out in southwest Alberta and southeast BC.

Study area and methods

The 2015 study area was situated in the Canadian Crown of the Continent ecosystem in Alberta and British Columbia, focused in two areas straddling the Continental Divide (Figure 1):

1. *Southwest Alberta*: North of Highway 3 in the Crowsnest Pass to southern boundary of Kananaskis Country, primarily west of Hwy 22 to the BC-AB border (Continental Divide) and
2. *East Kootenays of BC*: Southern portion of Kootenay National Park south to Highway 3 and east of Hwy 93/95 to the Continental Divide.

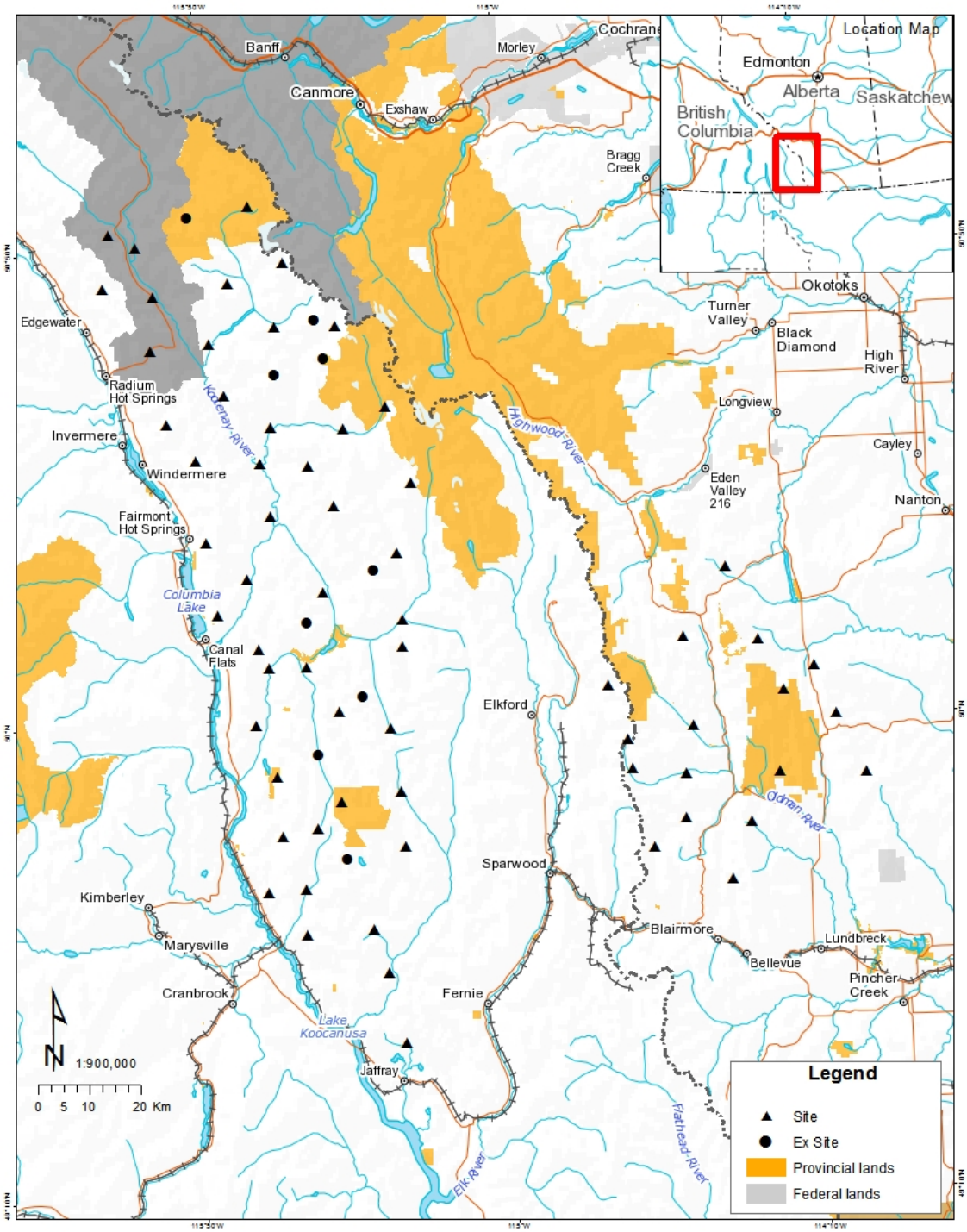
Data collection

We surveyed wolverine occurrence using a systematic sampling design consistent with our previous wolverine research to enable data pooling and large-scale analyses. We overlaid a 12 x 12 km grid on the study area. In each grid cell we placed a sampling site consisting of a hair trap and remote camera aimed at the hair trap. Hair traps consisted of a whole skinned beaver carcass nailed to a tree and secured with baling wire (Fisher and Bradbury 2014). Barbed wire was wrapped from the carcass down to ground level. Wolverines climb the tree several times before removing the carcass, and in doing so leave hair (their DNA) on the barbs. Sites were set up during the first month (January 2015) and revisited three times at monthly intervals to rebait, collect hair samples and service cameras. Three replicate monthly surveys were conducted within each survey year to incorporate detectability into occupancy estimates.

Occupancy and probability of detection

Occupancy estimation methods strive to estimate the proportion of the survey area that is occupied (or used) by the species of interest (Long et al. 2008). While the presence of a wolverine at a sampling site can be confirmed through remote cameras, it is generally

Figure 1. Location of camera/hair sampling sites surveyed from in the Alberta-British Columbia study area, January-April 2015. Systematically sampled sites and "Extra sites" (EX) are shown in relation to federal and provincially protected areas in both provinces.



impossible to confirm their absence. Highly mobile and elusive wolverines can have low detectability, but sampling for three winter months using this double method has been shown to greater increase detectability and provide confidence in our estimates of occupancy, and conversely, of absence (Fisher and Bradbury 2014).

For this report we used a single season model in program Presence (ver. 8.6; MacKenzie et al. 2006) to estimate the proportion of sampling sites occupied by wolverines during the 2015 field survey. For comparative purposes we ran the same analysis for the 2014 survey data collected in the Waterton-Crowsnest Pass area. Presence estimates 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 (survey sessions) need to be conducted over a period of time during which site occupancy is assumed to be constant.

We ran several competing single-season models in program Presence using maximum likelihood estimation; each model had different assumptions about how detectability and site occupancy varied through time and space. For both the Waterton-Crowsnest Pass (n=20 sites) and the Alberta-BC (n=64) datasets, we tested whether the probability of detection was constant, varied among surveys, or varied as a trend through time. We likewise tested whether site occupancy was either constant, or varied east-west (UTME), or varied north-south (UTMN). For the 2015 dataset, we also tested whether detectability and occupancy varied by Province in the 2015 dataset.

We ranked competing models using Akaike's Information Criterion (AIC) scores, which provide a balance between the variance in the wolverine data explained by the model, and the number of variables needed to explain that variance (Burnham and Anderson 2002). Lower AIC scores indicate a parsimonious model that explains more variance than other models. From AIC_w we calculated evidence ratios for each variable (ER). This is the ratio of the sum of all AIC_w of all models that included a given covariate, *vs.* those models that did not include that covariate. For example, ER=2 suggests there is twice as much evidence supporting the inclusion of a covariate, than evidence supporting omitting that variable.

Results

<u>Data collection – Alberta - BC study area</u>

From January to April 2015, we deployed 64 sites over an area of >9200 km^2 that were surveyed systematically: 47 sites were set in BC, while 17 were set in Alberta (Figure 1). Of the 64 sites, 49 were accessed by vehicle or snowmobile, while 15 of the more remote sites were set and checked using helicopters. To increase the number of individual detections and generate more precise estimates of abundance we set an additional 9 sites at random locations in the study area during the first check of the 64 systematic sites. Extra sites were only set in BC and consisted of a hair trap without camera. Overall a total of 73 sites were set within the study area.

Of the 64 sites set, 12 (19%) were located inside or less than 1.5 km of a protected area (national park, provincial park) and all were in BC (Figure 1). Four sites were located in Kootenay National Park, while 8 sites were located in BC provincial parks (Mt Assiniboine, Height of the Rockies, Top of the World). The remaining 52 sites were situated in provincial multi-use lands.

In Alberta, of the 17 sampling sites (including Beehive and Tornado Pass), only 3 sites (17%) (Beehive, Tornado Pass, Racehorse Pass) had confirmed wolverine camera detections and a total of 4 visits (two visits occurred at Tornado Pass) (Figure 2). The three sites were all situated along the spine of the Continental Divide.

In British Columbia, 12 sites (25%) had confirmed wolverine photo-detections and a total of 24 confirmed visits during the monthly sampling sessions (Figure 3).

Of a total of 192 photo-sampling opportunities during the three sessions, wolverines visited the sampling sites 28 times (15%) (Appendix: Table A1). Seven sites were visited once (Beehive, Racehorse Pass, Luxor, Spur Valley, Upper Cross River, Franklin Peaks, North Galbraith), three sites were visited twice (Tornado Pass, Mt Queen Mary, Blackfoot Creek), and five sites were visited all three sampling sessions (Octopus, Harkin, BayMag, North White River, Wildhorse Creek). Overall, 15 sites (23%) were visited during at least one occasion.

Occupancy – Alberta-British Columbia study area

There were relatively greater wolverine detections in the 2015 Alberta-BC dataset compared to Waterton-Crowsnest Pass 2014 survey. The probability of photo-detection increased between the first and second sessions, but slightly decreased between the second and final round. The detection probability during the first session was 43.5% (s.e.=12.8), the second session 68.3% (s.e.=12.8) and the final session 62.1% (s.e.=13.1). The weight of evidence suggests the probability of detection was constant (Table 1). Our estimate of wolverine occupancy in our study area was 25.4% (s.e.=0.05). The top model estimated p = 0.58 (s.e. = 0.09), meaning in this area we detected wolverines via cameras over half the time. Over three sampling sessions, the probability of false absences $(1\text{-}p)^K$ = 0.07, meaning that we had a 7% chance of missing wolverines (via camera-traps) that were actually present. Detectability did not vary with survey (ER = 0.15), trending through time (ER = 0.27), or between Provinces (ER = 0.48).

There was a distinct north-south gradient in wolverine occupancy (ER = 2.5). Model-averaged occupancy estimates decrease from north to south (Figure 4). There was no difference in wolverine occupancy from east-west (ER = 0.09) or more coarsely, between the two provinces (ER = 0.07).

Occupancy - Waterton-Crowsnest Pass 2014

There were very few wolverine detections in the Waterton-Crowsnest Pass area during 2014. The probability of detection was very low, and varied with each month-long survey (Table 2; ER = 4.71). Detectability in January was 0.65 (s.e. = 0.28), 0.00 in February, and an estimated 1.0 in March (s.e. = 0.0), although such border estimates can be unreliable and should be interpreted with caution. The top model suggested occupancy across the study area was 0.15 (s.e. = 0.08). There was little evidence that occupancy varied north-south (UTMN; ER = 0.48), or east-west (UTME; ER = 0.23).

Figure 2. Sites with the number of 30-day sampling sessions with camera-based wolverine detections (visits) in the Alberta portion of study area, January-April 2015.

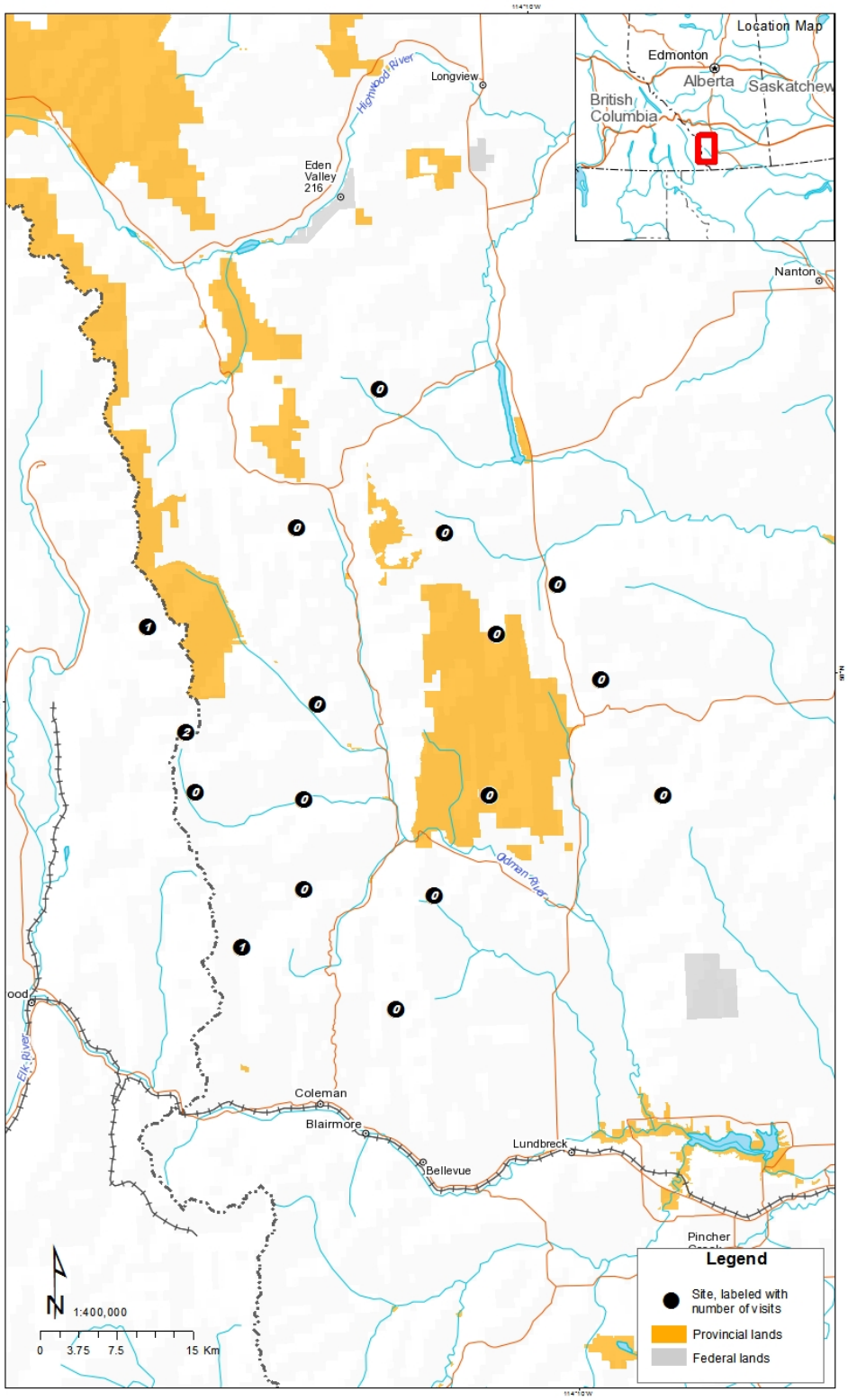


Figure 3. Sites with the number of 30-day sampling sessions with camera-based wolverine detections (visits) in the British Columbia portion of study area, January-April 2015. Wolverine detections could not be confirmed at extra sites since cameras were not deployed.

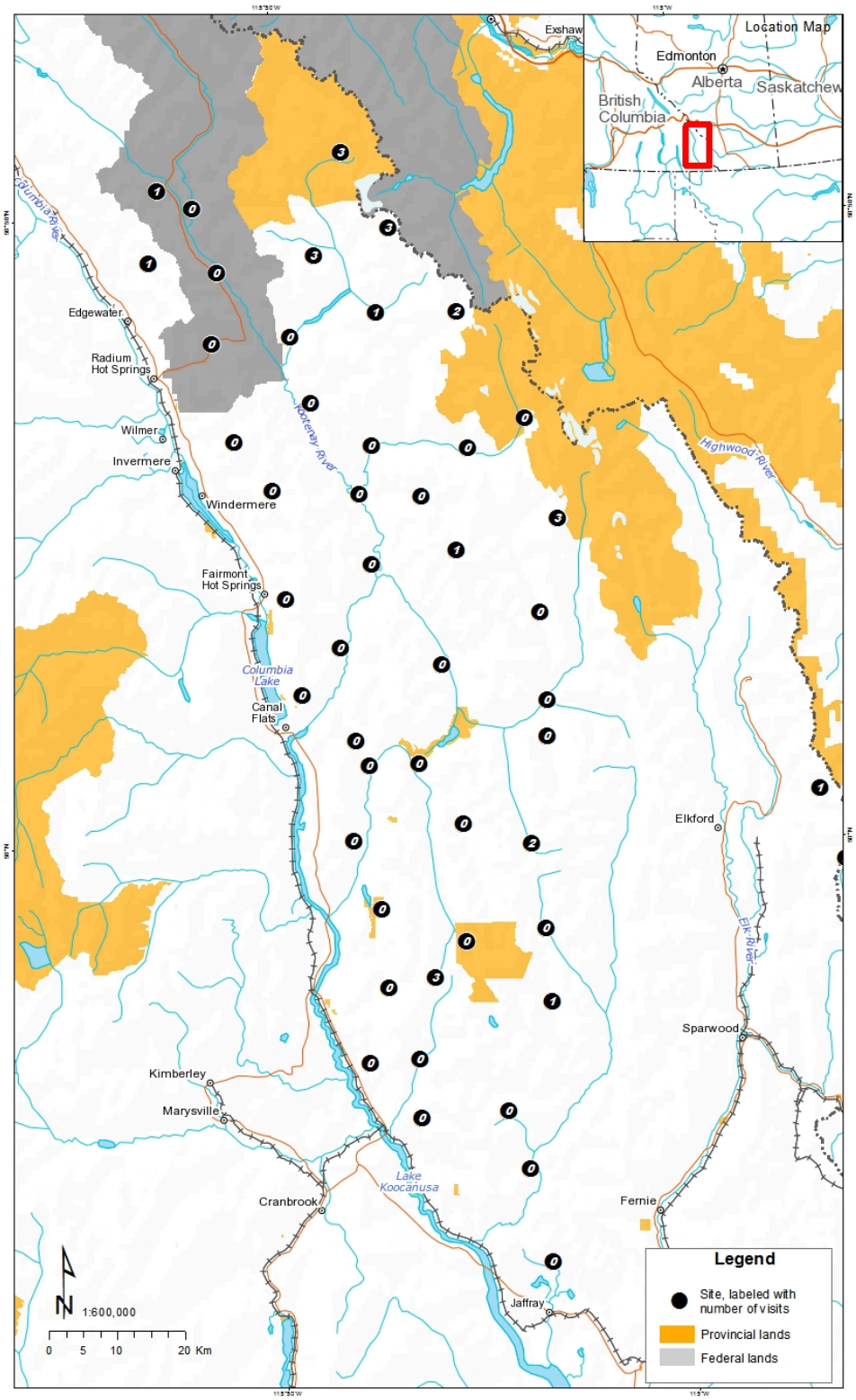


Table 1. Selection of occupancy models for wolverines detected by cameras in the Alberta-British Columbia study area, 2015. Detectability (p) could be constant (.), vary independently among SURVEYs, a TREND among surveys, or between PROVinces. Occupancy (ψ) could be constant (.), vary north-south (UTMN), east-west (UTME), or among PROVinces.

Model	AIC	ΔAIC	AICw	Model Likelihood	K	.-2LL
ψ(UTMN),p(.)	127.91	0.00	0.24	1.00	3.00	121.91
ψ(UTMN),p(PROV)	128.09	0.18	0.22	0.91	4.00	120.09
ψ(UTMN),p(TREND)	128.76	0.85	0.16	0.65	4.00	120.76
ψ(UTMN),p(SURVEY)	129.70	1.79	0.10	0.41	5.00	119.70
ψ(.),p(PROV)	130.71	2.80	0.06	0.25	3.00	124.71
ψ(.),p(.)	131.38	3.47	0.04	0.18	2.00	127.38
ψ(.),p(TREND)	132.24	4.33	0.03	0.11	3.00	126.24
ψ(UTME),p(.)	132.29	4.38	0.03	0.11	3.00	126.29
ψ(UTME),p(PROV)	132.49	4.58	0.02	0.10	4.00	124.49
ψ(PROV),p(PROV)	132.70	4.79	0.02	0.09	4.00	124.70
ψ(PROV),p(.)	132.93	5.02	0.02	0.08	3.00	126.93
ψ(UTME),p(TREND)	133.14	5.23	0.02	0.07	4.00	125.14
ψ(.),p(SURVEY)	133.19	5.28	0.02	0.07	4.00	125.19
ψ(PROV),p(TREND)	133.79	5.88	0.01	0.05	4.00	125.79
ψ(UTME),p(SURVEY)	134.09	6.18	0.01	0.05	5.00	124.09
ψ(PROV),p(SURVEY)	134.73	6.82	0.01	0.03	5.00	124.73

*number of parameters in the model
**-2 log likelihood of the model (variance explained)

Combined study areas

With the two datasets combined, the probability of detection is estimated at 0.56 (s.e. = 0.08). The geographic pattern observed in the 2015 study area becomes less obvious. There is no substantial evidence that *p* varies with any covariate, or that ψ varies with any covariate, including UTM North (ER = 0.98; Table 3). The estimated ψ estimates do seem to decrease moving south, but the explanatory power of that variable is weak.

Figure 4. Model-averaged estimates of wolverine occupancy at camera-trapping sites in the Alberta-British Columbia study area decrease from north to south. Bars represent standard errors.

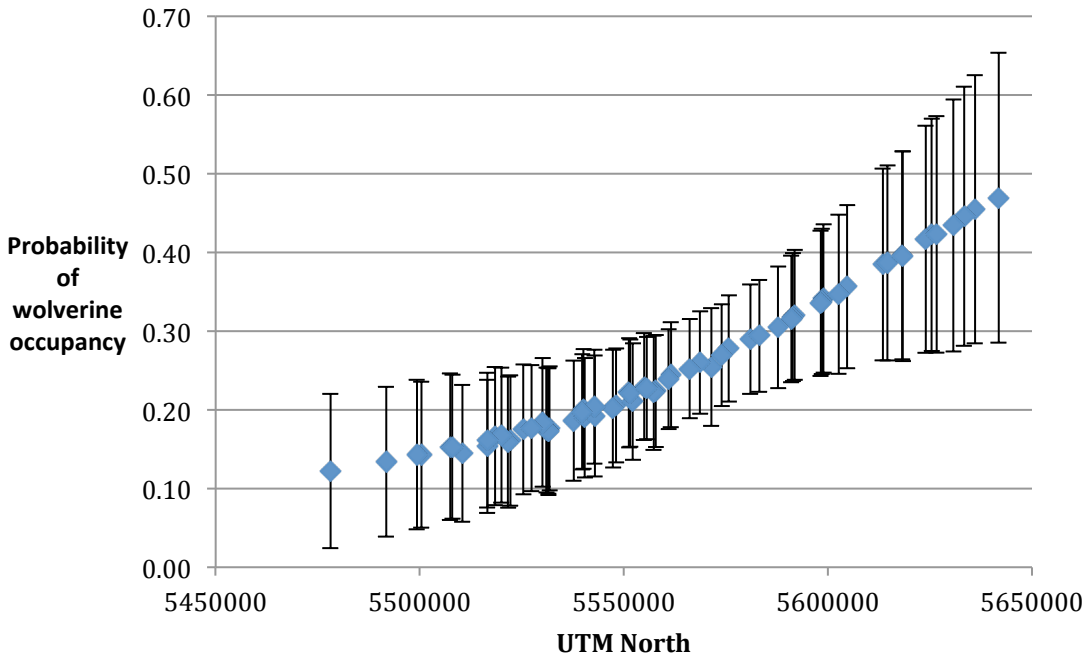


Table 2. Selection of occupancy models for wolverines detected by cameras in the Waterton-Crowsnest Pass area. Detectability (p) could be constant (.), vary independently among SURVEYs, or as a TREND among surveys. Occupancy (ψ) could be constant (.), vary north-south (UTMN), or vary east-west (UTME).

Model	AIC	ΔAIC	AICw	Model Likelihood	K*	-2LL**
ψ(.),p(SURVEY)	28.61	0.00	0.40	1.00	4.00	20.61
ψ(UTMN),p(SURVEY)	29.43	0.82	0.27	0.66	5.00	19.43
ψ(UTME),p(SURVEY)	30.52	1.91	0.16	0.38	5.00	20.52
ψ(.),p(.)	32.52	3.91	0.06	0.14	2.00	28.52
ψ(UTMN),p(.)	33.37	4.76	0.04	0.09	3.00	27.37
ψ(.),p(TREND)	33.90	5.29	0.03	0.07	3.00	27.90
ψ(.),p(UTME)	34.42	5.81	0.02	0.05	3.00	28.42
ψ(UTMN),p(TREND)	34.73	6.12	0.02	0.05	4.00	26.73
ψ(UTME),p(TREND)	35.81	7.20	0.01	0.03	4.00	27.81

*number of parameters in the model
**-2 log likelihood of the model (variance explained)

Table 3. Selection of occupancy models for wolverines detected by cameras in the combined study areas. Detectability (p) could be constant (.), vary independently among SURVEYs, a TREND among surveys, or between PROVinces. Occupancy (ψ) could be constant (.), vary north-south (UTMN), east-west (UTME), or among PROVinces.

Model	AIC	ΔAIC	AICw	Model Likelihood	K	.-2LL
psi(UTME),p(.)	158.77	0.00	0.16	1.00	3.00	152.77
psi(UTME),p(PROV)	158.96	0.19	0.15	0.91	4.00	150.96
psi(UTME),p(TREND)	159.09	0.32	0.14	0.85	4.00	151.09
psi(.),p(PROV)	159.87	1.10	0.09	0.58	3.00	153.87
psi(.),p(.)	160.77	2.00	0.06	0.37	2.00	156.77
psi(UTMN),p(.)	160.93	2.16	0.05	0.34	3.00	154.93
psi(.),p(TREND)	161.07	2.30	0.05	0.32	3.00	155.07
psi(UTME),p(SURVEY)	161.09	2.32	0.05	0.31	5.00	151.09
psi(UTMN),p(PROV)	161.17	2.40	0.05	0.30	4.00	153.17
psi(UTMN),p(TREND)	161.25	2.48	0.05	0.29	4.00	153.25
psi(PROV),p(PROV)	161.67	2.90	0.04	0.23	4.00	153.67
psi(PROV),p(.)	161.70	2.93	0.04	0.23	3.00	155.70
psi(PROV),p(TREND)	162.01	3.24	0.03	0.20	4.00	154.01
psi(.),p(SURVEY)	163.07	4.30	0.02	0.12	4.00	155.07
psi(UTMN),p(SURVEY)	163.25	4.48	0.02	0.11	5.00	153.25
psi(PROV),p(SURVEY)	164.01	5.24	0.01	0.07	5.00	154.01

Discussion

Alberta-British Columbia study area

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). Our 2015 Alberta-BC survey covered approximately 9200 km2 and was designed around a 12 x 12 km sampling grid, which is based on the average home range size for female wolverines (Banci and Harestad 1990, Inman et al. 2012). The estimate of wolverine occupancy in our study area was 25.4% (s.e.=0.05) (Table 4). Previous estimates of occupancy in the Canadian Rockies have ranged from 88% (s.e.=0.05) in the Banff-Yoho-Kootenay park complex (Clevenger and Barrueto 2014) to 36% (s.e.=0.11) in Kananaskis Country (Heim 2015). Last years survey in the Waterton-Crowsnest Pass area had the lowest estimate of occupancy to date of 17% (s.e.=0.09). In the Columbia Mountains occupancy estimates have ranged from 38% (s.e.=0.10) in the southern Purcells to 71% in the main Purcell Range (s.e.=0.10) (Kortello and Hausleitner 2012, 2013; Hausleitner and Kortello 2014). These results suggest that the area we sampled during winter 2015 in British Columbia had moderate wolverine abundance relative to other areas we have sampled, while abundance in Alberta was low and comparable to the Waterton-Crowsnest Pass area.

Table 4. Estimates of wolverine occupancy (Ψ) with standard error (SE) and confidence intervals (CI) from the Rocky and Columbia Mountains.

Area	Ψ	SE	CI	Naïve[2]
Rocky Mountains				
BC – Alberta 2015	25.4	0.05	0.15-0.38	23.4
Waterton-Crowsnest 2014	17.5	0.09	0.05-0.45	15.0
Banff-Yoho-Kootenay[1]	88.0	0.05	0.72-0.95	79-84
Kananaskis Country[1]	36.0	0.11	0.12-0.56	25
Willmore Wilderness				89
West-central Alberta				12-13
Glacier NP, Montana				25
Columbia Mountains				
South Selkirks	55.4	0.13	na	
South Purcells	38.0	0.10	na	
Purcells	71.0	0.10	0.05-0.45	

[1] Multi-season model.
[2] Naïve occupancy (unadjusted).

Combined study areas

Wolverine occupancy differed markedly between the two study areas. In the southern Alberta region within and around Waterton Lakes National Park, wolverine occupancy was extremely low: wolverines occupy an estimated 15% of the landscape. This is lower than estimates from Kananaskis Country, Alberta (Heim 2015), and lower still than occupancy estimates from the heavily developed Alberta foothills farther north (Fisher et al. 2013) where occupancy increased east to west. The probability of detection varied monthly, but evidence suggests was fairly high by March, lending confidence that where wolverines were not detected, they did not occur. The probability of false absence was 0.07, meaning there was a 93% chance that we detected a wolverine given it was present at a camera site, again lending confidence to our results.

Wolverine occupancy was greater in the Alberta-BC study area, but varied markedly through space. The clear pattern of decreasing occupancy from north to south is remarkably similar to wolverine occurrence in the Columbia Mountains (Kortello and Hausleitner 2013, 2014), west of the Canadian Rocky Mountains. They found a notable decline in wolverine detections in a north to south gradient in both the south Selkirk and Purcell Mountains and evidence of low genetic

connectivity between the south Purcell population and other populations in southeastern British Columbia (Kortello and Hausleitner 2014). These findings are noteworthy given the Columbia and Rocky Mountains are two of the three remaining areas where wolverines and other wide-ranging carnivores can move between Canada and the U.S.

The north-south pattern from our study area differs from occupancy patterns observed in Banff-Yoho park complex – Kananaskis Country and the Willmore Wilderness – Foothills where a decreasing east-west pattern of wolverine occurrence was reported (Fisher et al. 2013, Heim 2015). Wolverine occupancy in our study area decreased significantly moving south and the mechanisms for this variability have yet to be explained but will be the focus of future analysis (see below).

Wolverine camera-detections in our Alberta-BC study area were moderately associated with areas protected from landscape disturbance. Previous surveys in the Canadian Rockies revealed wolverine more abundant in rugged areas protected from anthropogenic development (Fisher et al. 2013, Clevenger and Barrueto 2014, Heim 2015). Similar patterns of wolverine occurrence were found in the Columbia Mountains where the majority of wolverine detections have been within cells in or immediately adjacent to large protected areas; provincial parks, nature and wilderness conservancies (Kortello and Hausleitner 2014). The location of these relatively protected areas may account for the north to south gradient in distribution in both ranges.

Although our results are preliminary our trans-provincial data suggests lower populations than expected and lower connectivity between the US-Canada border and populations to the north. Aggregated wolverine occupancy to the north may be a result of land management practices and/or motorized recreation on wolverine distribution. Consequently harvest should be carefully considered and managed to ensure long-term persistence and viability of wolverines in one of the last two remaining linkage zones with populations in the northern US Rockies. Additional modeling with environmental covariates is needed to understand the spatial variability in wolverine occurrence in both the north-south and east-west planes (see below).

Tree climbing behaviour

During 28 sampling sessions wolverines in the BC-Alberta study area were photographed at the site of which 26 occasions we could assess behaviour. At nearly 70% of the visits (18 of 26) wolverines climbed the bait tree, while 30% (n=8) of the visits wolverines were not observed climbing. Over 90% of the sites/sessions during the Banff-Yoho-Kootenay sampling wolverines climbed bait trees (Clevenger and Barrueto 2014), while in Kananaskis Country climbing occurred at 57% (4 of 7 sites) of the sites (Fisher and Heim 2012). A reluctance to climb bait trees may affect detectability using noninvasive genetic sampling and result in fewer individuals identified in the study area through genotyping. The double-sampling method we used can help correct for error due to detectability (Fisher and Bradbury 2014). An area of research is using this information to correct density estimates by estimating numbers of individuals missed via genotyping, by incorporating detectability into SECR models (Kery et al. 2010).

Non-target species

In reviewing the photographs obtained from the hair trap sites we were able to document the presence of many non-target species during the survey. Species detected included bobcat, lynx,

cougar, American marten, striped skunk, red fox, coyote, wolf, black bear, grizzly bear, moose, elk, white-tailed deer and mule deer.

Genetic analysis

A total of 447 hair samples from 31 sites were obtained from sites/sessions where wolverines were detected by camera. The hair samples in addition to seven scat samples collected at five sites are currently being analysed at the US Forest Service Conservation Genetics lab in Missoula, Montana. We expect the genetics analysis to be completed by the end of summer 2015.

Future

Density estimation. Once the genetic analysis is completed we will use spatial mark-recapture models to estimate density using the genetic identity data for each sampling area. The density estimates can be used to derive abundance, which can then be used to calculate recent kill rates using the trapper and hunter mortality data. Sample sizes are very small for wolverine because of their rarity and we anticipate pooling spatial and perhaps detection parameters among study areas to maximize precision.

Linking landscape characteristics to wolverine abundance. Relationships between wolverines and landscape attributes will be investigated using occupancy and general linear modeling. However, to identify priority conservation and management actions it will be equally important to eventually link wolverine density estimates to landscape attributes at a regional and ecosystem-wide scale. We will be pursuing future funding to develop a hierarchical model that extends the existing occupancy and count models by using spatially explicit variables that may influence wolverine abundance (Graves et a. 2011).

2016 Survey. Next years survey will complete the Rockies range-wide sampling and will consist of approximately 75 sites monitored in the Flathead and Elk Valleys in BC. Wolverine occupancy and genetic data obtained from all sites will ultimately be pooled with data collected using the same methods and experimental design over our greater study area (Appendix: Figure A1). This regional-scale multi-partner approach is needed to achieve a sufficient sample size to make robust conclusions about wolverine occurrence, density, genetic connectivity and habitat selection at a regional and transboundary metapopulation scale. The results from our collective 6-year research will inform decision making regarding wolverine harvest levels and land use management that influence wolverine conservation and management at federal, provincial/state levels and transboundary coordination in the COTC.

Partnership

'Mapping the Wolverine Way' is being conducted through an international, public-private partnership including the Western Transportation Institute (WTI) at Montana State University, British Columbia Ministry of Forests, Lands and Natural Resource Operations; Alberta Environment and Sustainable Resource Development, Parks Canada Agency, US National Park Service (Glacier National Park), Alberta Innovates Technology Futures, the Yellowstone to Yukon Conservation Initiative, and USDA Forest Service Rocky Mountain Research Station. Other project partners were Ktunaxa Nation Council and Wildsight.

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APPENDIX

Table A1. Sampling sites and wolverine camera-based detections by 30-day session (1=presence, 0=absence) in the Rocky Mountains of southwest Alberta (blue font) and southeast BC, January-April 2015. Sites with >=2 detections are shown in bold type. Helicopter-accessed sites are shaded in blue.

NAME	Session 1	Session 2	Session 3	Total
Plateau	0	0	0	0
Beehive Pass	0	0	1	1
Savanna	0	0	0	0
Saddle Hill Rd	0	0	0	0
Riley Rd/Ward Creek	0	0	0	0
Tornado Pass	**0**	**1**	**1**	**2**
Hidden Cr	0	0	0	0
Chaffern Cr	0	0	0	0
Trout Cr Rd	0	0	0	0
North Fork Pass	0	0	0	0
Dutch Cr	0	0	0	0
Bob Cr Rd	0	0	0	0
Skyline Rd	0	0	0	0
Racehorse Pass	0	1	0	1
S Racehorse Cr	0	0	0	0
Tod Cr	0	0	0	0
Gold Cr	0	0	0	0
Luxor	1	0	0	1
Hector G	0	0	0	0
Octopus	**1**	**1**	**1**	**3**
Spur Valley Cpgd	0	0	1	1
McLeod Meadow Cr	0	0	0	0
Harkin_	**1**	**1**	**1**	**3**
BayMag_	**1**	**1**	**1**	**3**

Kindersley Pass	0	0	0	0
Cross R_Corral	0	0	0	0
Upper Cross R	0	1	0	1
Mt Queen Mary	**0**	**1**	**1**	**2**
Shuswap	0	0	0	0
Nipika	0	0	0	0
Palliser	0	0	0	0
Palliser_Royale	0	0	0	0
Upper Palliser R	0	0	0	0
Mine	0	0	0	0
Palliser 3	0	0	0	0
Fenwick Cr	0	0	0	0
N White R	**1**	**1**	**1**	**3**
Fairmont	0	0	0	0
White-Koot	0	0	0	0
Franklin Peaks	1	0	0	1
White R	0	0	0	0
Columbia Lk_Interior	0	0	0	0
Koot Forest Rd	0	0	0	0
White Swan	0	0	0	0
White R_2	0	0	0	0
Lussier_OLD	0	0	0	0
Lussier	0	0	0	0
White Swan South	0	0	0	0
Thunder Cr	0	0	0	0
Larsen Lk	0	0	0	0
Coyote Cr	0	0	0	0
Blackfoot Cr	**0**	**1**	**1**	**2**

Premier_Yankee Lk	0	0	0	0
Lussier South	0	0	0	0
Quinn Cr	0	0	0	0
Premier_Lazy Lk	0	0	0	0
Wildhorse Cr	**1**	**1**	**1**	**3**
N Galbraith Cr	0	1	0	1
Saugum Lk	0	0	0	0
Lower Wildhorse Cr	0	0	0	0
Bull-Tanglefoot	0	0	0	0
Maus Cr	0	0	0	0
Bull R FS	0	0	0	0
Lower Bull-Lizard	0	0	0	0
TOTAL PRESENCE	**7**	**11**	**10**	**28**
TOTAL SITES	64	64	64	192
% DETECTION	**11**	**17**	**16**	**15**
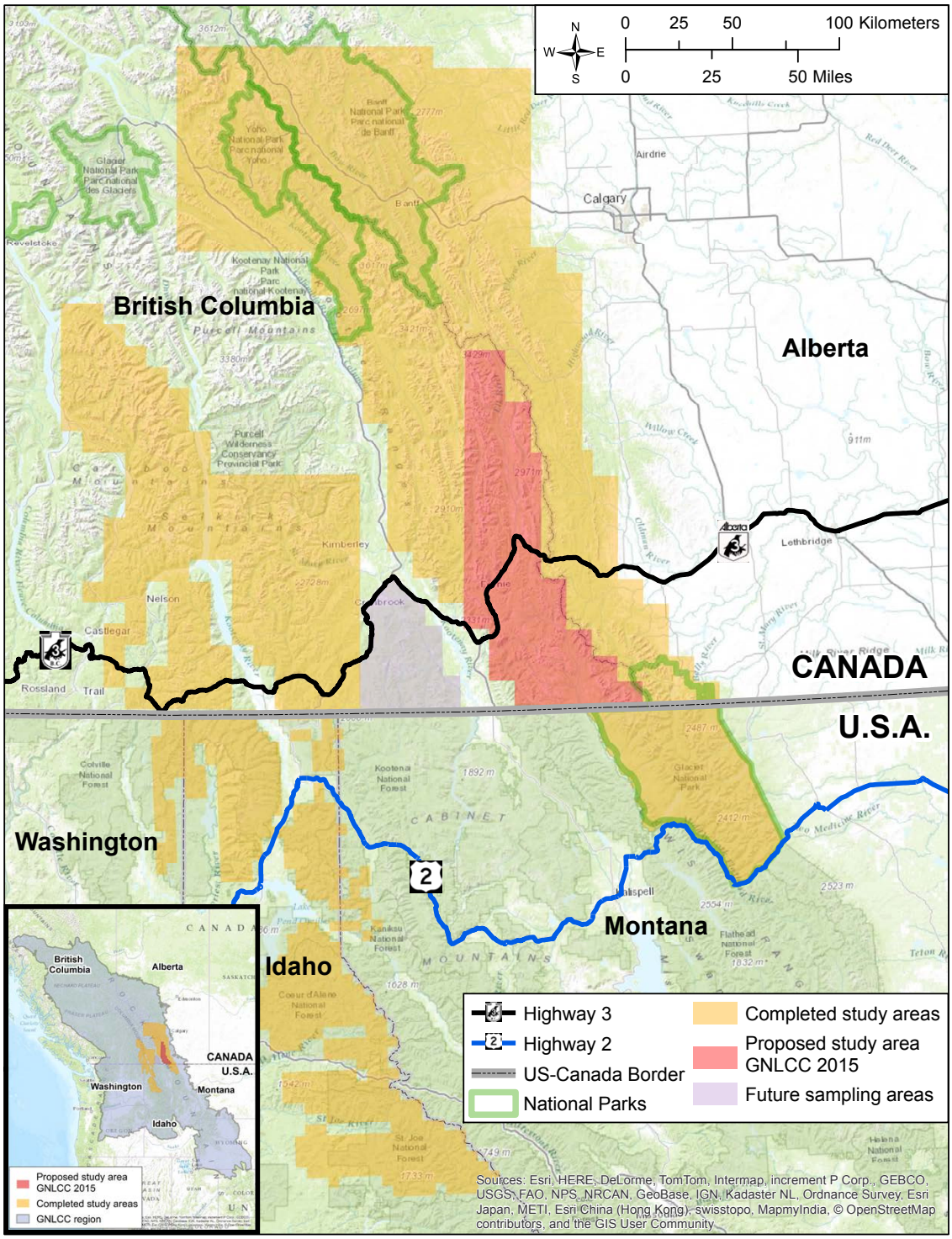
Figure A1. Greater study area for noninvasive sampling of wolverine population in context of areas previously sampled in the transboundary Rocky and Columbia Mountains. Study area for 2016 = Proposed GNLCC 2015.