
# Effects of Human Activities and Natural Processes on Wolverine Reproduction and Connectivity

*2020 Summary Report*

Prepared by:

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**Thank you to our partners and funders (2018 – 2020):**

University of Calgary
Yellowstone to Yukon Conservation Initiative
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NSERC CRSNG
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FESBC Forest Enhancement Society of British Columbia
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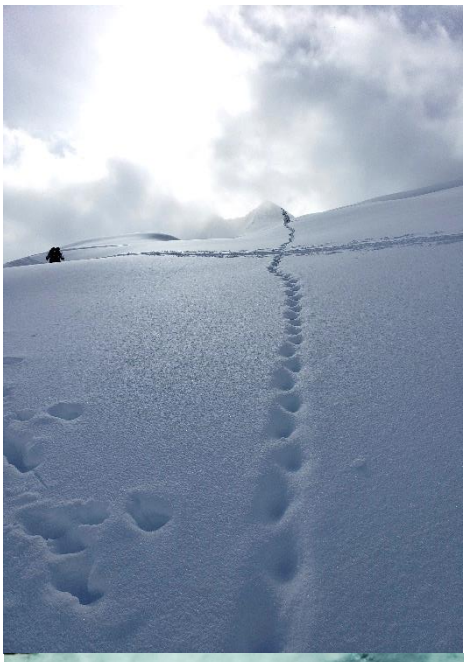
This project could not happen without the help and support of hundreds of people. It is a community effort.





# 1. CONTEXT



**Report.** This report contains an overview of the project, and outlines main data collection achievements to date, preliminary results and highlights and challenges of the 2020 season. It marks the end of the main, 3-year field data collection period (2018 – 2020), however, there is smaller-scale, targeted field work planned for 2021 and 2022. As would be expected, our activities in 2020 were strongly impacted by the worldwide Covid-19 pandemic.

**Wolverines.** Wolverine are listed as Special Concern in British Columbia and under the federal Canadian Species at Risk Act because a) populations are declining in the southern part of their range; b) wolverine habitat across Canada is increasingly fragmented by industrial activity and climate change especially in the southern part of their range; and c) wolverine have low reproductive rates, are sensitive to human disturbances, and require vast secure areas to maintain viable populations (COSEWIC 2014).

**Previous research.** Previous research in the Columbia Mountains, the Central Canadian Rockies and in Idaho indicates that:

a. Wolverine are susceptible to disturbance from high levels of human backcountry-use (Krebs et al. 2007; Stewart et al. 2016, Kortello et al. 2019). Female wolverines experience indirect habitat loss within their home ranges in areas with intense motorized (snowmobile) or non-motorized (ski touring) winter recreation. Off-road snowmobiling elicited a stronger response than road-based snowmobiling (Heinemeyer et al. 2019).
b. The Trans-Canada Highway is a barrier to female dispersal (Sawaya et al. 2019).
c. Wolverine density across >100,000 $km^2$ in the southern Columbia and Canadian Rocky Mountains averaged 2 wolverines/1,000 $km^2$ and was positively related to spring snow cover and negatively related to forestry road density (Mowat et al. 2019).
d. Current levels of trapping in the Kootenay Region are unsustainable (Mowat et al. 2019).
e. Within a 9000 $km^2$ study area in Banff, Yoho and Kootenay national parks, wolverine occurred at low densities of approximately 3 wolverines/1,000 $km^2$ in 2011-2013 (Barrueto et al. 2020).

f. Within a 7000 $km^2$ study are in the Columbia Mountains (Big Bend Country of the Columbia River), wolverines occurred at densities of approximately 6 wolverines/1,000 $km^2$ in 1997 – 2004 (Lofroth and Krebs 2007).

g. Protected areas may function as source populations for surrounding unprotected areas, with young individuals from protected areas dispersing to unprotected areas where fewer wolverines are born (Heim et al. 2017; Barrueto et al. 2020).

**Beginnings of This Project.** The study was initially conceived by Mirjam Barrueto, Dr. Audrey Magoun, Dave Butler (CMH) and Ian Thomm (then ED of Helicat) and came to life in early 2017 during a pilot project carried out with support from K3 Cat Ski, Mike Wiegele Heli Ski, and Selkirk Snowcat Skiing. Mirjam then started her PhD research in September 2017 at the University of Calgary with supervisor Dr. Marco Musiani, in collaboration with Anne Forshner with Parks Canada Agency, Dr. Aerin Jacob with Yellowstone to Yukon, and more informally, K3 Catski and Mike Wiegele Heli Skiing. The main goal is to better understand the ecology and connectivity of female wolverines in the North Columbia Region and Central Canadian Rocky Mountains:

**Research Objectives.**

1. To determine the regional density and distribution of wolverines.
2. To evaluate and compare top-down and bottom-up effects of human activities on wolverine density, distribution, particularly that of breeding females, while accounting for variability in natural habitat characteristics.
3. To estimate regional population structure, connectivity, and source-sink mechanisms.
4. To determine how infrastructure such as highways and hydro-reservoirs impact female dispersal and gene flow that can lead to fragmented populations.
5. To communicate among interested parties and decision-makers.
6. To test and establish multi-method non-invasive research techniques for monitoring wolverine across large spatial and temporal scales.

**Partnership:** Over time, the research project grew, and is now conducted through a partnership including the Department of Biological Sciences at the University of Calgary; Parks Canada Agency (Banff, Yoho, Kootenay, Glacier and Mt Revelstoke National Parks), Yellowstone to Yukon Conservation Initiative, BC Parks and several members of the helicopter and cat skiing industry in British Columbia (especially Mike Wiegele Heli Skiing, Selkirk Tangiers Heli Skiing, K3 Cat Ski, Mustang Powder). Other agencies and companies have contributed data, funding and in kind-support. Strong partnerships are needed for this kind of landscape study, not only for financial reasons, but also to ensure effective sharing of knowledge and information that may otherwise not be available to researchers and other partners.

**Study Design.** Our study is focused on the Columbia Mountains (Upper Columbia and North Thompson watersheds) and the Central Canadian Rocky Mountains (Figure 1 and 2). Working across 50,000 $km^2$ area in British Columbia and Alberta, it will evaluate and compare the effects of human activities on wolverine density and distribution, particularly breeding females, while accounting for variability in natural habitat characteristics; and estimate regional population connectivity and gene flow.

The study area has a range of habitat conditions and human activities, including winter recreation, forestry, trapping, and resource roads. We will compare how these factors affect wolverine density using spatially explicit capture-recapture models, and we will assess regional gene flow patterns and population structuring using landscape genetic methods. The project will result in greater understanding of interacting forms of human activity and their impact on rare species of conservation concern and inform future conservation strategies. It is the first landscape-scale, non-invasive capture-recapture study that identifies reproductive status of females.

**Sampling Design.** The sampling areas captured characteristic variability in human disturbance rates and types and trapping. We surveyed wolverine occurrence using a clustered sampling design, consistent with previous wolverine research to enable data pooling and large-scale analyses. In 2018, we established & monitored the first 80 sampling stations. In 2019, the number of sampling stations was expanded. In 2020, some sampling stations were moved to new areas to fill data gaps (Figure 1 & 4).

**Sampling Sites.** We use non-invasive methods, developed originally by Audrey Magoun (Magoun et al. 2011) to collect photos to detect, identify and sex individual wolverines and determine their demographic class breeding status, and to passively collect hair samples for genetic analyses and to validate sex and individual ID (Figure 1). Stations are baited and consist of wooden structures ("run poles") attached to a tree, on which wolverines climb, exposing their chest and abdomen to the camera. Each station has two cameras. *Camera 1* takes white-flash photos of chest and abdomen. *Camera 2* takes infrared overview photos to document visits by wolverines that do not result in climbing of the run pole, and visits by other species. Stations are equipped to collect hair for DNA analysis. Once sites are set, two or three visits are conducted approximately one month apart to collect hair samples, photographs, and rebait the station.

Figure 1 Individuals like this female are identified by their unique chest and gular patch.

## 2. A SHORT SECTION ON METHODS

**Image Classification.** We classify all images taken by all *Camera 1's*, in 3 steps. To date, Step 1 and 2 are complete, and Step 3 is in progress.

*Step 1 – Classify to Species Level*: Camera-trap image processing was completed to species level, where possible, using software program Timelapse 2 (Greenberg, 2020; Greenberg & Godin, 2015). Animals in low-quality view were classified to the lowest taxonomic level possible or labelled unidentifiable. Extensive error-checking was conducted before proceeding to the next step.

*Step 2 – Build Individual Wolverine Library*. In a first pass, wolverines were assigned individual ID based on their fur pattern, using the human brain and the image viewing software Irfanview, Version 4.57 (www.irfanview.com). We then used the pattern recognition software, $I^3S$ Pattern $^+$ to aid in identifying individual wolverines (den Hartog & Reijns, 2016) (Figure 2). Annotation of chest pattern morphology resulted in suggested matches for individual wolverines via pattern recognition algorithm. Suggestions were reviewed for matches and confirmed by the analysts. Where available, genetic results were used to confirm individual IDs.

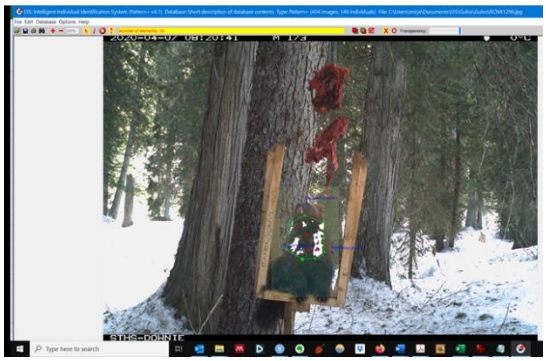


Figure 2 Interface of the program I3S.

*Step 3 – Classify to Individual Wolverine Level*: We use a customized version of the open-access software CameraBase (Tobler, 2007), which was written in Microsoft Access 2010, to tag all wolverine photos with the ID of the individual(s) present on the photos (Figure 3). CameraBase, in conjunction with Irfanview, also facilitates side-by-side comparison of individual wolverines. Extensive error checking will be completed before using the resulting data for spatial capture-recapture modelling.

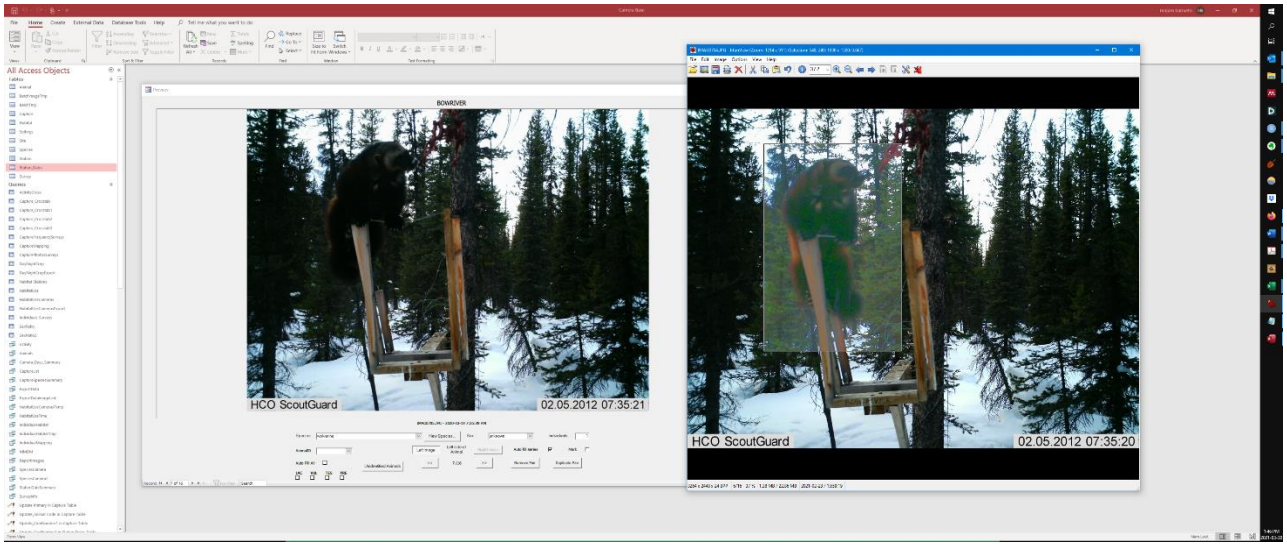



Figure 3 Interface of the program *CameraBase.*

**Statistical Analysis.** Wolverine numbers and distribution will be determined by analyzing the photographs and hair samples. We will use spatial capture re-capture, population, and landscape genetic models to answer our research questions. More details on methods available by request.

## 3. PRELIMINARY RESULTS

### 3.1. Year 1 (2018)

In 2018 we set up and made 3 repeat visits to 58 stations in the North Columbia Region (NCR) and 22 in Banff, Yoho and Kootenay national parks (BYK). We collected 186,000 photos from the remote cameras. We collected 350 hair samples, many from wolverines. Out of 78 sites, 63 sites (80.8%) were visited by wolverines at least once. Based on photos we detected 35 individual wolverines in the NCR and 11 individuals in BYK.

In 2018 in NCR, we made 177 site visits during 37 field days. In BYK, 62 site visits were conducted on 48 workdays. In most cases, one of four project staff were leading site visits, usually assisted by two or more helpers: helicopter and cat ski guides and staff, Parks Canada staff, helicopter pilots, and volunteers. For both NCR and BYK combined, the field work was conducted in approximately 675 people workdays, involving over 46 individuals.

### 3.2. Year 2 (2019)

In 2019 we monitored 152 stations: 30 in BYK and 122 in NCR. We collected >99,700 photos in BYK, and >631,600 photos in NCR. We collected 226 (BYK) and 964 (NCR) hair samples, many from wolverines. Out of 152 sites, 134 sites (88.2%) were visited by wolverines in at least one of the two years. Other species detected on cameras include pine marten, red and flying squirrels, bird species, coyote, wolf, red fox, Canada lynx, mountain caribou, mountain goat, black and grizzly bears.

In 2019 in NCR, we made 481 site visits during 92 field days. In BYK, 100 site visits were conducted on 86 workdays. As in 2018, many people were involved in the field work. In most cases, one of four project staff were leading site visits, usually assisted by two or more helpers: helicopter and cat ski guides and staff, Parks Canada staff, helicopter pilots, and volunteers. Over 45 people helped with fieldwork in NCR, at least 16 people helped in BYK with setup, and more during re-visits.

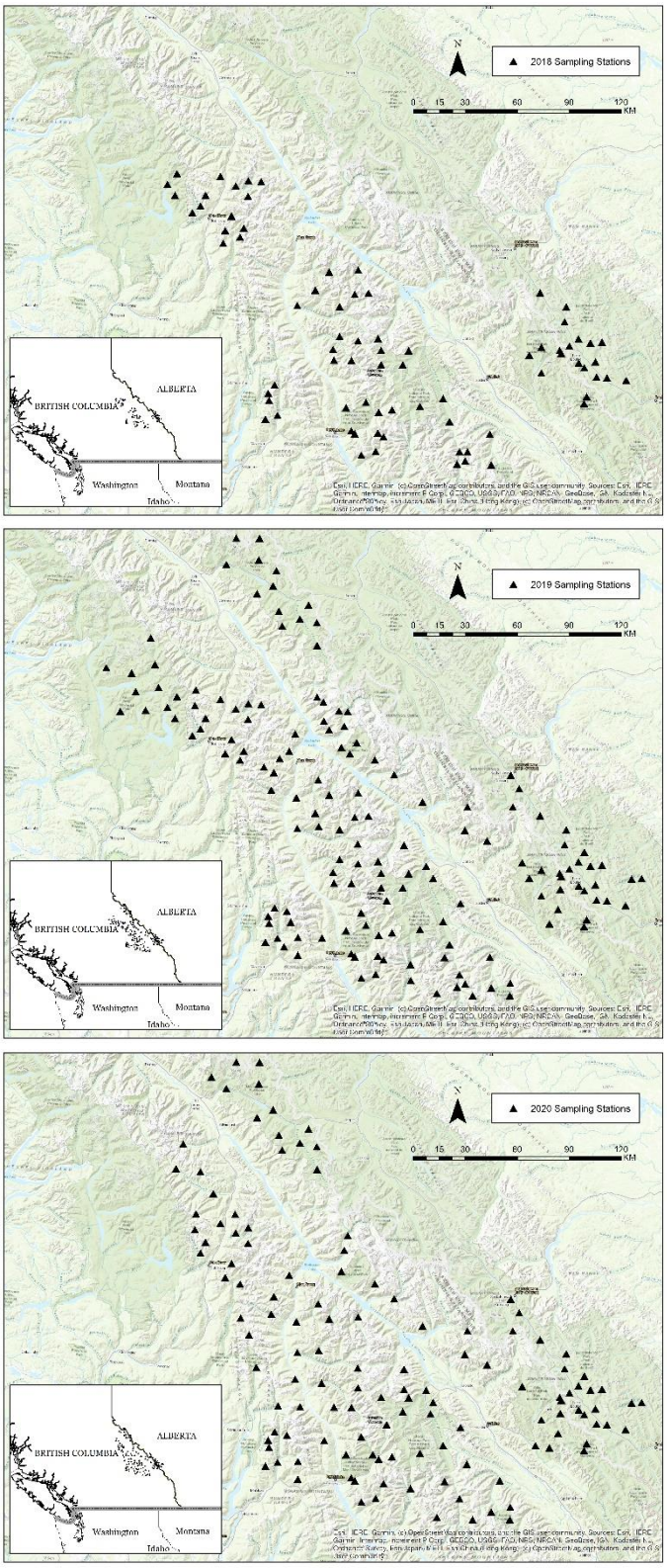



Figure 4 Maps with sampling stations monitored each year. From top to bottom: 2018, 2019, 2020

### 3.3. Year 3 (2020)

**Data Collection.** In 2020 we monitored 127 stations: 28 in BYK and 99 in NCR. We collected >161,000 photos in BYK, and >463,000 photos in NCR. We collected >100 (BYK) and >560 (NCR) hair samples, many from wolverines. Other species detected on cameras include pine marten, red and flying squirrels, several bird species, Canada lynx, mountain caribou, elk, mule and whitetail deer, moose, black and grizzly bears.

In 2020 in NCR and in BYK, fewer people were involved in the field work than in previous years, because of pandemic restrictions. In all cases, one of the project staff was leading site visits, usually assisted by one or more helpers: helicopter and cat ski guides and staff, Parks Canada staff, helicopter pilots, and volunteers.

**Genetic Results.** In summer 2020, we submitted 2442 hair and tissue samples to an external lab, Wildlife Genetics International (WGI), Nelson, BC. From those samples, 30% (n = 748) were selected for DNA extraction. The lab successfully extracted DNA from 40% (n=299) of those samples. Based on 8 microsatellite markers, the lab assigned the 299 good samples to 162 individual wolverines (98 females, 64 males). 16 individuals had already been detected in previous studies. The lab then selected the best performing sample from each of the 146 new individuals. It analyzed them at 12 additional microsatellite markers to extend their genotypes to the standard set of 20 markers that has been used for population genetics work in previous projects from the region.

In addition to our samples, FLNRORD contributed tissue samples and genetic analyses from 35 trapper-harvested wolverines from our study area. These additional data are expected to increase precision of density and survival estimates and may add to our understanding of dispersal movements.

**Photo Classification.** Since summer 2020, Mirjam, helped by Trevor Thompson, an undergraduate student at the University of Calgary, have been carrying out classification of the > 1Mio photos, to specify which species, and if wolverine, which individual, was present on each photo. Summary results are detailed in the next section.

Table 1 Number of individuals detected across NCR and BYK, for females, males, and individuals of unknown sex ('UNK"). * the number of individuals that were confirmed by camera only is preliminary.

| | CAMERA ONLY* | CAMERA & DNA | CAMERA NO DNA | CAMERA TRY MORE DNA |
|---|---|---|---|---|
| FEMALE | 95 | 76 | 7 | 12 |
| MALE | 65 | 52 | 6 | 7 |
| UNK | 59 | 0 | 45 | 14 |
| **TOTAL** | **219** | **128** | **58** | **33** |

Table 2 Number of individuals with genetic ID from samples of harvested animals, and one road killed wolverine. One harvested animal was detected in our study before its death; 3 harvested animals were detected in previous studies.

| | TOTAL | RECAPTURES | |
|---|---|---|---|
| | | THIS STUDY | PREVIOUS STUDIES |
| HARVEST | 32 | 1 | 3 |
| ROADKILL | 1 | 0 | 0 |

### 3.4. Preliminary numbers in NCR and BYK

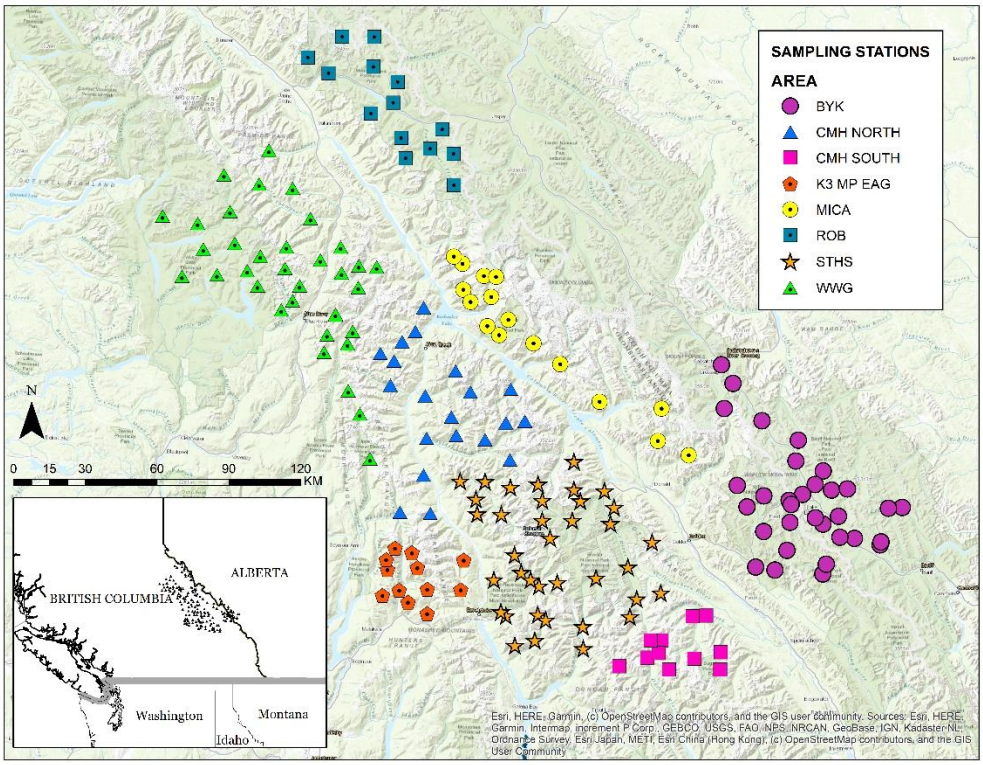



Figure 5 Overview map of all sampling stations used in the study. BYK sites (purple circle) were monitored and serviced by Anne Forshner/Parks Canada Agency. All other stations were serviced and monitored by Mirjam Barrueto (University of Calgary).

Sampling stations were monitored for 1, 2 or 3 years between 2018 and 2020, and are displayed by Area. Areas were defined based on logistical and access considerations, not ecological reasons.

Based on photographs, we detected up to 199 individuals: 56 males, 86 females, and 57 of undetermined sex. 46 females appeared to be breeding (lactation evident) in at least one of the years. All numbers and breeding status are preliminary as data analysis is ongoing.

We divided the NCR sites into 7 areas, and the breakdown of wolverines by area (Figure 3) is as follows:

1. **Mount Robson (ROB)**: 5 males, 10 females (6 lactating), 8 of unidentified sex.
2. **Mica Heliskiing & Blackwater Range (MICA)**: 5 males, 6 females (4 lactating), 1 of unidentified sex
3. **Selkirk Tangiers Heli Skiing & Glacier & Mt Revelstoke National Parks (STHS)**: 16 males, 25 females (10 lactating), 7 of unidentified sex.
4. **Mike Wiegele Helicopter Skiing & Wells Gray Provincial Park (WWG)**: 17 males, 16 females (7 lactating), 18 of unidentified sex.
5. **K3 Cat Ski & Mustang Powder Cat Skiing & Eagle Pass/Boulder Mtn (K3 & MP & EAG)**: 4 males, 5 females (4 lactating), 6 of unidentified sex.
6. **CMH North**: 9 males, 19 females (8 lactating), 11 of unidentified sex.
7. **CMH South**: 0 males (2 males already counted in STHS), 6 females (2 lactating), 6 of unidentified sex.
8. **Banff, Yoho, Kootenay (BYK)**: 9 males, 8 females (6 lactating), 2 of unidentified sex.

Table 3 A summary of wolverine detections in the NCR and BYK. Individuals identified by genetic fingerprinting, by photographs (*numbers preliminary; include the individuals identified by genetic fingerprinting/DNA), and the number of

individuals recaptured from previous studies (by genetic fingerprinting). The density estimates for BYK are estimated using the R package *openCR*.

| NCR | TOTAL | FEMALE | MALE | UNKNOWN |
|---|---|---|---|---|
| Individuals identified DNA | 113 | 70 | 43 | - |
| Individuals identified photo* | 199 | 87 | 56 | 56 |
| Individuals recaptured from previous studies | 11 | 8 | 3 | - |
| Sites with ≥1 wolverine detection | 90.5% or 133/147 sites | | | |
| BYK | TOTAL | FEMALE | MALE | UNKNOWN |
| Individuals identified DNA | 15 | 6 | 9 | 0 |
| Individuals identified photo | 19 | 8 | 9 | 2 |
| Individuals recaptured from previous studies | 4 | 2 | 2 | 0 |
| Sites with ≥1 wolverine detection | 83.9% or 26/31 sites | | | |
| Preliminary superpopulation density (3-year open SCR model): | 2.9 wolverines/ 1000 km2 | | | |

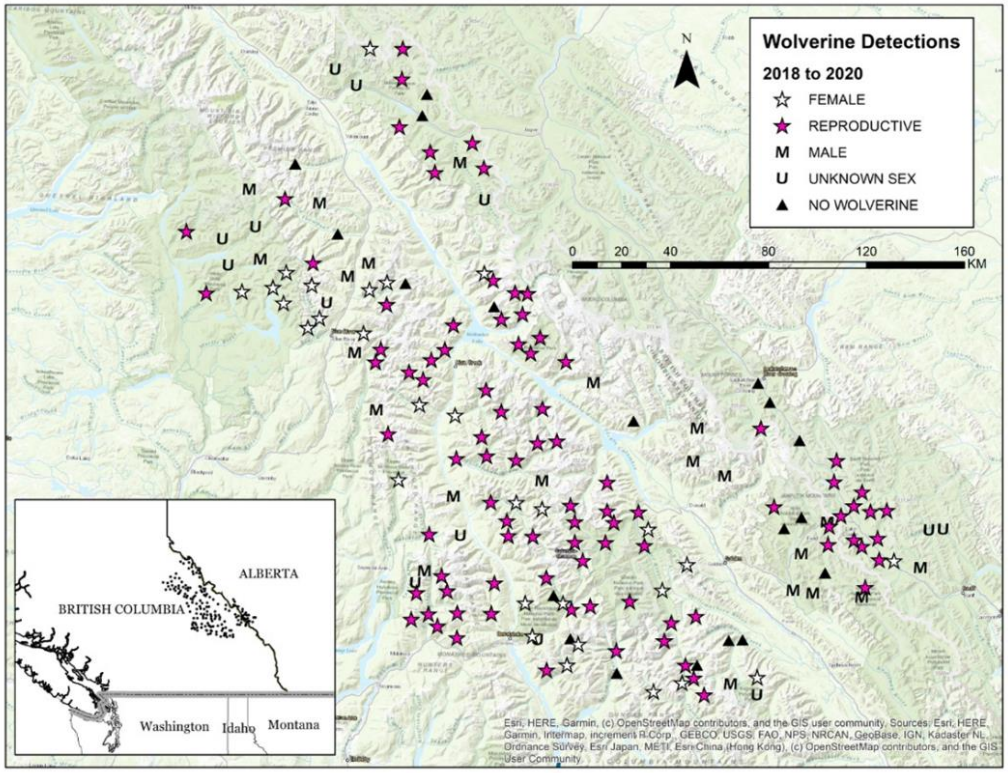



Figure 6 Study area and a summary of the data collected. Sampling stations (n=178) were active for 1 to 3 winters each (2018, 2019, 2020). Stars depict stations where females were detected at least once; in pink are stations where a reproductive female was detected at least once. Sites marked as "M" are sites where males only or males and individuals of unknown sex were detected, but no females were confirmed. Sites marked as "U" are sites where sex of individuals is not yet determined. Black triangles are stations where no wolverines were detected. All data are preliminary.

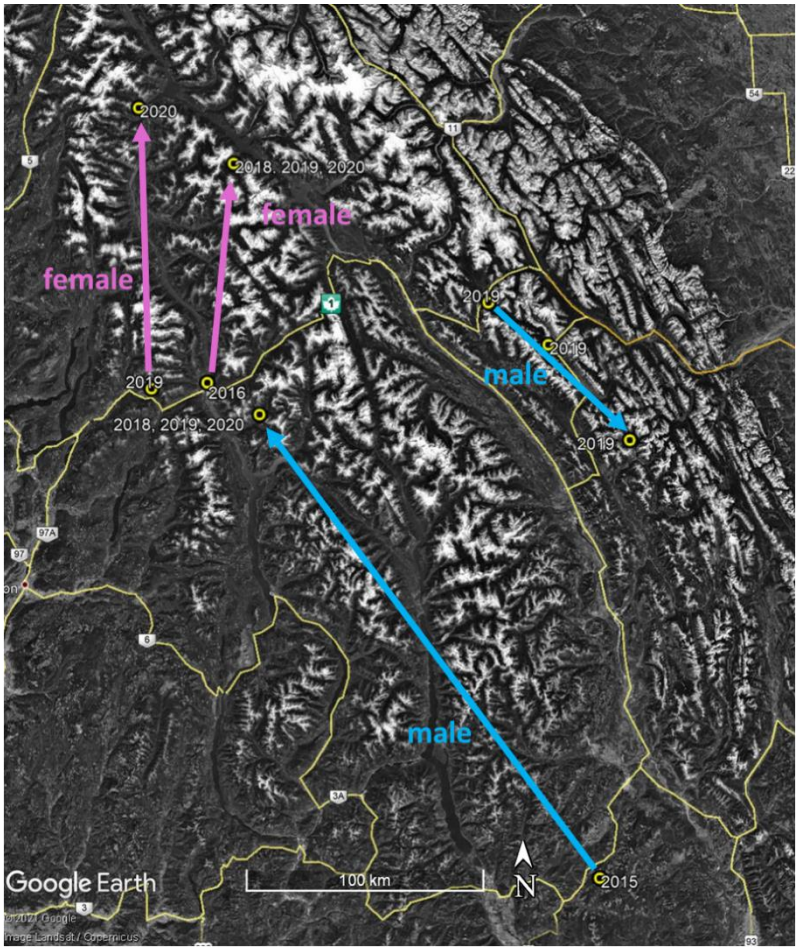



Figure 7 We detected several long-distance movements of individuals between or within years. The longest movement is that of a male between his first detection in 2015 in the southern Purcells, and later detections in 2018, 2019 and 2020 in the Selkirks south east of Revelstoke. These movements may not be parts of dispersal movements, as we cannot (yet) tell where the individual had originated.

### 3.5. Individual Movements

One objective of this project is to investigate potential barriers to dispersal. "Dispersal" means that an animal leaves the area where it is born, to find its own territory somewhere else. Many females do not disperse far, and their movements may be impacted by features such as highways (Sawaya et al. 2019). Our sampling design enables us to detect some individuals in multiple years. We have evidence of movements within years and between years, for example, several long-distance movements are shown in Figure 7. We also collect information on demographic status, where possible, from photographs. We will use the framework of spatial capture-recapture, possibly combined with landscape genetic approaches, to test several hypotheses on (female) dispersal.

### 3.6. Changes in harvest management – Region 4 (Kootenay)

Across Canada, harvest of furbearer species is generally managed by traplines, which are areas that give their holders exclusive trapping rights. In British Columbia, as of January 2020, it was legal for trapline holders to trap in all regions but the Okanagan, Lower Mainland and Vancouver Island. ("2018-2020 Hunting & Trapping Regulations Synopsis" 2018). Because of their low population densities, large home ranges, and slow reproduction, wolverine are vulnerable to overharvest (Lofroth and Ott 2007; Dalerum et al. 2008), and trapping is a conservation concern for wolverines across the country (COSEWIC 2014; BCCDC BC Conservation Data Centre 2017). A recent analysis on trapping rates in the Kootenay Management Region, which includes parts of our study area, showed that recent harvest rates were not sustainable, and the study recommended a reduction in trapping rates (Mowat et al. 2019). In response, and following stakeholder consultations, the provincial government closed

the wolverine trapping season, which had been open from Nov 1 to Dec 31 every year, in Region 4, with the closure taking effect Jan 19, 2020.

Our study had been designed to include information on harvest mortality, taking advantage of more accurate harvest data being collected in Region 4 since 2016. As most of our sampling was complete before the closure of the trapping season, the changes in harvest management in Region 4 will not affect our data analysis. Trapping management in the other parts of our study area remains largely unchanged.

## 4. FUNDING

As in 2019, funding for the NCR and BYK parts of the projects was separate in 2020.

For the NCR work, in-kind or cash funding (>$1000) in 2020 came from the University of Calgary, Yellowstone to Yukon Conservation Initiative, Parks Canada Agency, NSERC, Edmonton Community Foundation, Mike Wiegele Helicopter Skiing, BC Parks, Parks Canada Agency, Earth Rangers, Mustang Powder, K3 Cat Ski, and several private donors.

Parks Canada Agency covered the costs of all aspects of research in BYK, including staff and contractor time, materials, bait, helicopter visits, DNA analysis, and a contribution to Mirjam's stipend. Parks Canada Agency staff and contractors carried out all field work in BYK.


## 5. OUTREACH AND EDUCATION

Because of the unexpected changes to life in 2020, we conducted only relatively limited outreach. As in previous years, our target audience is broad, including furbearer conservation officers and other resource managers, heli and cat ski industry people, winter recreationalists (ski, sled), the trapping community, First Nations, and the general public that is interested in wolverine and conservation of mountain landscapes. Public interest in our research project is strong, as demonstrated by participation in our outreach activities and philanthropic donations to our project. We have an established online presence (run by Mirjam, details below) and we have regular interactions with individual trappers and other interested individuals. Overall, we fully understand that conservation is as much about the science as about communication, outreach, education, and ultimately public participation in decision making.

### 5.1. Main outreach activities and events

1. Organized the *Annual Partner Meeting* (May 22, 2020): Held virtually. Purpose: 1) To update project partners on study progress; 2) to describe planned work.

2. Participated in *BC Wolverine Conservation Planning Session* (April 30, 2020). Held virtually. Purpose: 1) To briefly review recent research on wolverines in Western North America; 2) To understand the Province of BC's current plans and intentions for wolverine management and planning in BC; 3) To identify priorities and challenges related to wolverine management and identify potential recommendations.
3. Presentation at the *Wildlife Wise in British Columbia - Virtual workshops* (Dec 9, 2020). https://y2y.net/events/wildlife-wise-in-british-columbia-virtual-workshops/.
4. Continued work on developing guidelines for recreational and industry activities near wolverine den sites. In collaboration by B. Harrower, A. Kortello, D. Hausleitner.
5. Our wolverine research is featured in the Parks Canada Agency 2020 centennial visitor guide for Kootenay National Park .
6. Our wolverine research is also referenced on Species at Risk webpages for Yoho and Kootenay National Parks: www.pc.gc.ca/en/pn-np/bc/yoho/nature/conservation/especes-species;

### 5.2. Social media

***Website*** – Mirjam continued to maintain, manage, and use the private website www.wolverinewatch.org as the project website. "WolverineWatch" has been an informal group of wolverine researchers since 2010, when the website was created with seed funding from the Alpine Club of Canada, to solicit wolverine sighting reports by the public in Banff, Yoho and Kootenay National Parks, as part of a study on wolverines there.

The main purposes of the website now are to highlight and provide information on this and two other current, and one past, wolverine research project led by researchers Anthony Clevenger, Doris Hausleitner, Andrea Kortello and Mirjam Barrueto. It continues to collect public wolverine sightings, provide information for people interested in supporting this project, and to provide links to partner organizations and funders.

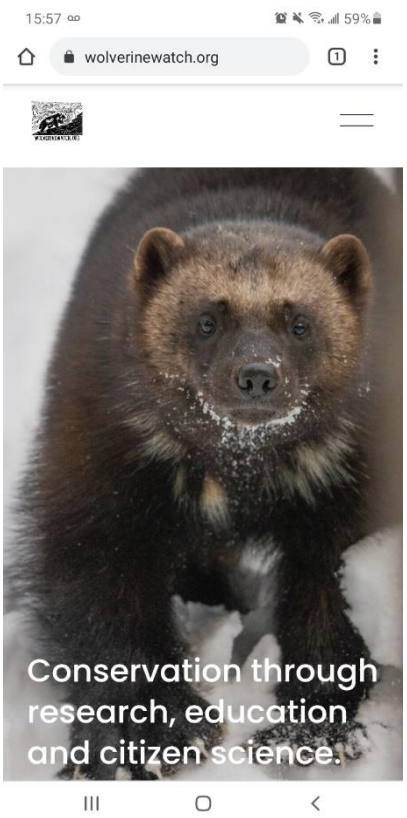
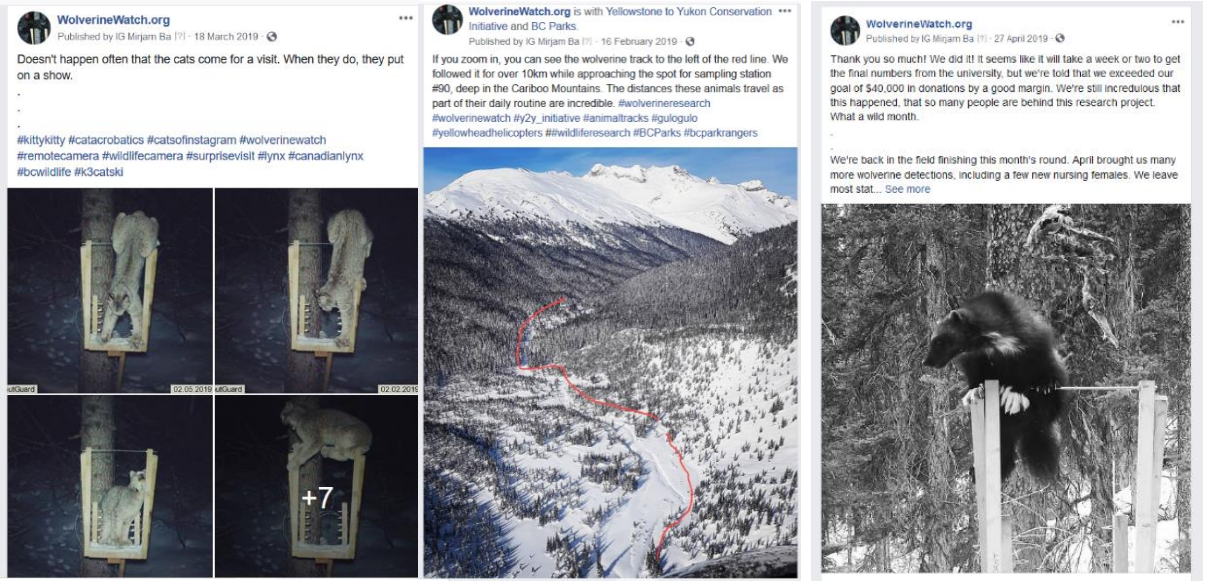



Figure 8 These photos wolverine sightings were submitted to our website, wolverinewatch.org/report-observations. Photos are very helpful to validate sightings.

***Facebook and Instagram*** – Mirjam also continued to use the linked Facebook and Instagram pages of WolverineWatch.org, to inform and raise awareness of wolverine conservation, management, and research in the Canadian Rockies and the Columbia Mountains. She documents the research, shows how data are collected, showcases the landscape surveyed for wolverines, the project partners, and some of the highlights and frustrations of conservation research. The Facebook page (www.facebook.com/wolverinewatch) has ~4000 followers; Instagram (www.instagram.com/wolverine_watch) has ~1500 followers.




## 6. FINAL THOUGHTS

First and foremost, we are grateful for a successful third year of field data collection without injuries, illnesses, or accidents. The greatest lesson learned is, to take nothing for granted, but be prepared for anything. There may be a pandemic.

Because we had great, well-trained, and experienced staff, volunteers, and pilots, we were able to safely complete all sampling, perhaps against all odds. And despite everything that 2020 threw at us, we managed to collect the field data mostly as planned. The several new sampling stations we established in 2020 to fill sampling gaps, were in good locations – all were visited by wolverines.

Committed partners were key again, and we were able to hold the annual partner meeting virtually this year. We are also grateful to the respective land managers, as we were able to garner all necessary permits to complete field work despite the Covid-19 related BC Parks and Parks Canada backcountry closures.

The wolverine naming contest with Earth Rangers (online on earthrangers.com) was a personal outreach highlight for Mirjam – it is rewarding to (virtually) connect with kids.

On the downside, we had hoped that this year would be less stressful than 2019, which was not the case. In NCR, the sudden shut-down ended support from heli-ski partners early, leading to loss of many hours of expected in-kind flight time. Fortunately, several other partners (Yellowstone to Yukon Conservation Initiative, University

of Calgary, Whitetooth Helicopters, Mike Wiegele Heli Skiing) as well as friends and family stepped in to cover for those shortfalls.

For all sampling, Covid-19 restrictions meant however, that from Mid-March onwards there were only very limited opportunities for volunteers and students to take part in field work. In addition, the restrictions meant that for the NCR sampling, there was no full-time technician as had been planned, from mid-March till the end of May. All these changes delayed sample processing and lead to summer field work, which is more time consuming than winter work. As a result, field sampling was not complete until Thanksgiving, and opportunities for hair samples were limited at some stations, because DNA degrades when exposed to the elements for months. Because of these delays in field sampling, data processing (genetic lab-analysis and photo encoding) was/is also delayed – but progressing well now.

Overall, the preliminary data (genetic, photographs) look very promising. In areas that were sampled >1 year, we obtained hair samples for most individuals detected on camera – indicating that with this method, >1 year of sampling would likely lead to better genetic detection probabilities. Most individuals were detected multiple times, and often in more than one location and/or year.

And finally, it is tempting to comment on what appear to be patterns in the wolverine detection data, and to speculate on preliminary results. However, because of the complex nature of the underlying habitat conditions, and with the data set's extensive spatial coverage, large number of individuals, and 3-year sampling duration, it is more prudent to wait until we have conducted rigorous analyses.

## 7. FUTURE

**2021:**

Targeted field work is planned for select areas for 2021 and 2022, e.g. to monitor specific individuals, collect information on dispersing animals, or disassemble sampling stations. We will continue to assemble other spatial data sets and finalize photo analysis. We expect first density and genetic connectivity results in mid to late 2021.

**2022:**

Analysis and writing up of results will continue throughout 2022. The PhD thesis is anticipated to be completed and defended by the end of 2022, for a total project duration of 5 years.

## 8. ADDITIONAL INFORMATION

Further photos, higher resolution maps and information on planned analyses may be available upon request. Inquiries about the NCR study area should be directed to Mirjam Barrueto - mirjam.barrueto (at) ucalgary.ca. Inquiries about the BYK study area should be made to Anne Forshner – anne.forshner (at) canada.ca.

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** *Paper available from author or by request at website provided*


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