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

2021 Summary Report

Prepared by:

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This project could not happen without the help and support of hundreds of people. It is a community effort.

Countless people contributed to the project, both at the "front line" and behind the scenes. Thank you all!

1. CONTEXT

Report. This report contains an overview of the project, the main achievements, progress to date, preliminary results, and the highlights and challenges in 2021. Compared to the first 3 field-work heavy years, this year was comparatively quiet, focused on photo and hair sample processing, with a small field portion. As would be expected, our activities in 2021 were still impacted by the worldwide Covid-19 pandemic.

What is a wolverine? Wolverine are the largest land-living members of the weasel family, approximately as big as a mid-sized dog. Wolverines are circumboreal and found worldwide in the Northern Hemisphere. They live in the cold and often snowy landscapes of the northern tundra, boreal forests, and further south in alpine regions. Wolverines are carnivores and only eat meat. They are quite flexible in their diet. In some areas, they mostly scavenge on ungulates killed by other large carnivores such as wolves. In other areas, they mostly hunt, everything from voles to squirrels to beavers, porcupines, and caribou. One of the striking things about wolverines is that they are fiercely territorial, and their territories are huge! Females will defend territories of between 50 to 500 square kilometers from other females. Males' territories are defended from other males, and usually comprise those of several females. Thus, male territories are very large, up to 2000 square kilometers! To keep the neighbours out and find food in those barren landscapes, wolverines are constantly on the move.

Wolverine Conservation. Wolverine are listed as a species of 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. Scientists have learned a lot about wolverines in the last decade. A very recent review paper for which Mirjam is a co-author, summarizes these findings and is available at https://doi.org/10.1016/j.gecco.2022.e02019.

More specific to our project, 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 https://doi.org/10.1002/ecs2.2611 (Heinemeyer et al. 2019).
b. Competition from carnivores that readily adapt to human-influenced landscapes, such as coyotes, may contribute to the decline of wolverines in areas with high levels of industrial disturbances (https://naturealberta.ca/wolverines-and-coyotes/) (Chow-Fraser et al. 2022).
c. The Trans-Canada Highway is a barrier to female dispersal www.wolverinewatch.org/s/Banff-Wolverine-Fragmentation.png (Sawaya et al. 2019).
d. 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 www.wolverinewatch.org/s/Mowat_WolverineHarvest_Infographic_V04_02.png (Mowat et al. 2020).

e. Recent levels of trapping in the Kootenay Region were unsustainable (Mowat et al. 2020). Since 2020, wolverine trapping is no longer permitted in the Kootenay Region, for the time being.

f. Within a 9,000 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 www.wolverinewatch.org/s/barrueto-et-al-2020-low-wolverine-density-in-a-protected-area-CJZ.pdf (Barrueto et al. 2020).

g. Within a 7,000 km^2 study area 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).

h. 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 from Parks Canada Agency, Dr. Aerin Jacob from 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.

A curious Canada lynx investigating a sampling station.

Partnership: Over time, the research project grew, and is now conducted through a partnership including 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.

Study Design. Our study takes place in the Columbia Mountains (Upper Columbia and North Thompson watersheds) and the Central Canadian Rocky Mountains (Fig. 1). The sampling area covers approximately 50,000km^2. We divided the sampling into two blocks, *BYK* (Banff, Yoho, Kootenay Region) and *NCR* (North Columbia Region). The data for BYK was mostly collected by Anne Forshner (Parks Canada Agency). The data for NCR was collected by Mirjam Barrueto (with the support of all partner organizations, including Parks Canada - see previous section).

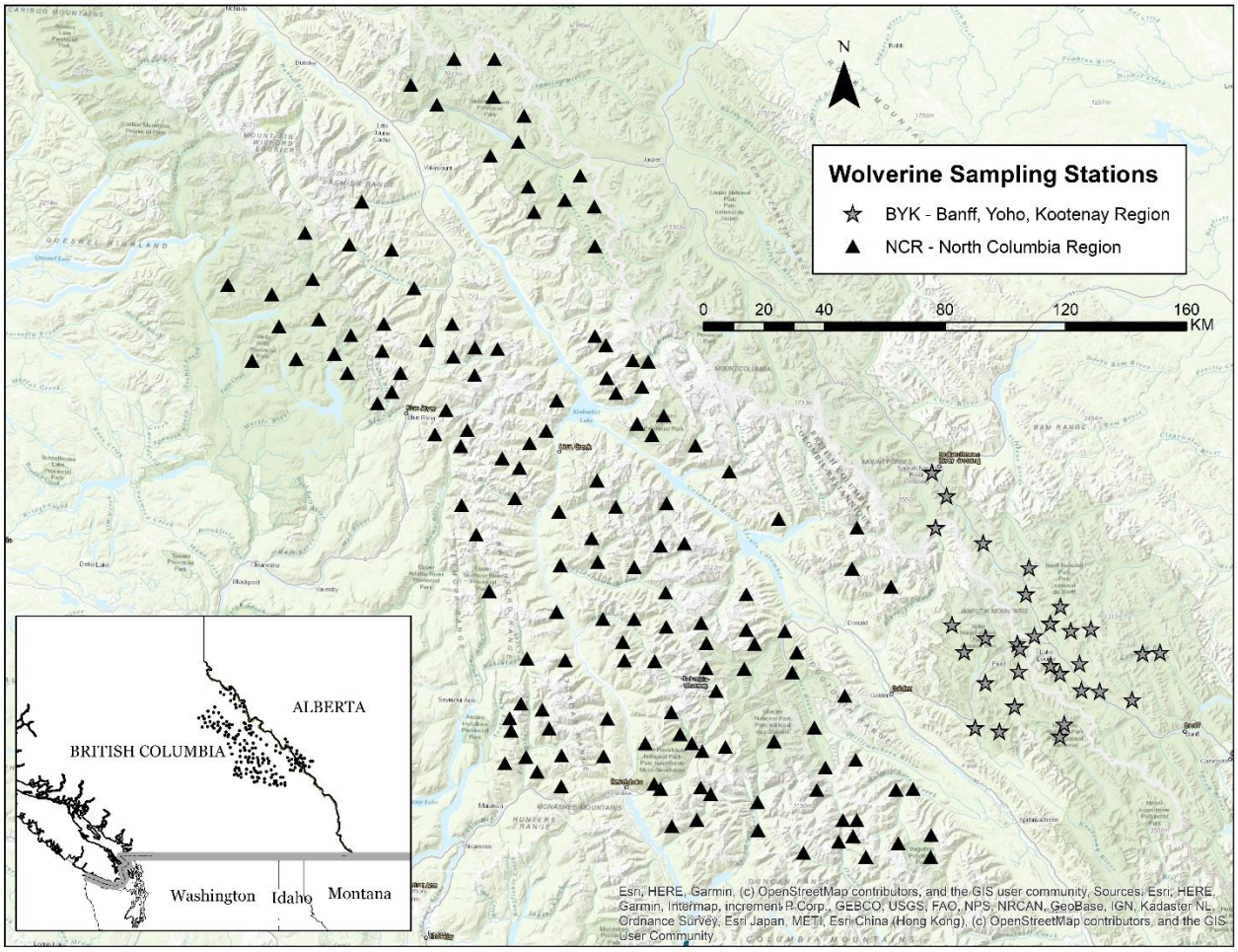


Figure 1 Map of the study area, outlining the two sampling blocks *BYK* (Banff, Yoho, Kootenay) and *NCR* (North Columbia).

Now that data collection is complete, we 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. We will also assess 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 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 the reproductive status of female wolverines.

Sampling Design. We surveyed wolverine occurrence using a clustered sampling design, consistent with previous wolverine research, to enable future data pooling and large-scale analyses. In 2018, we established and 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 in data gaps (Fig. 6). You will find more details in Section 3.

Figure 2 Individuals like this female are identified by their unique chest and gular patches.

A lactating female wolverine.

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 to determine their demographic class and breeding status. The stations also passively collect hair samples for genetic analyses, and to validate photo-derived sex and individual ID (Fig. 2).

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 passively 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.

2. A SHORT SECTION ON METHODS

Image Classification. We classify all images taken by all *Camera 1's*, in 3 steps.

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 IDs 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 $^+$ (Fig. 3) to aid in identifying individual wolverines (den Hartog & Reijns, 2016) (Fig. 2). Annotations of chest pattern morphology resulted in suggested matches for individual wolverines via a pattern recognition algorithm. Suggestions were reviewed for matches and confirmed by the analysts. Where available, genetic results were used to confirm individual IDs, in an iterative process

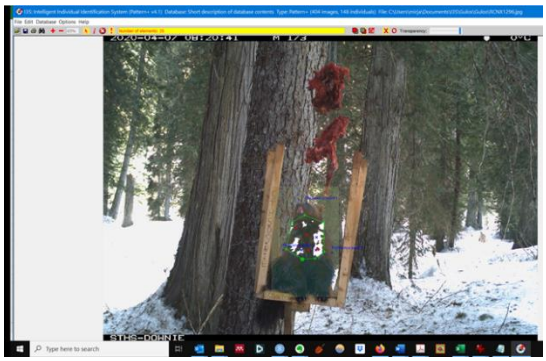


Figure 3 Interface of the program I3S.

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 (Fig. 4). CameraBase, in conjunction with Irfanview, also facilitates side-by-side comparison of individual wolverines. Extensive error checking is completed before using the resulting data for spatial capture-recapture modelling.

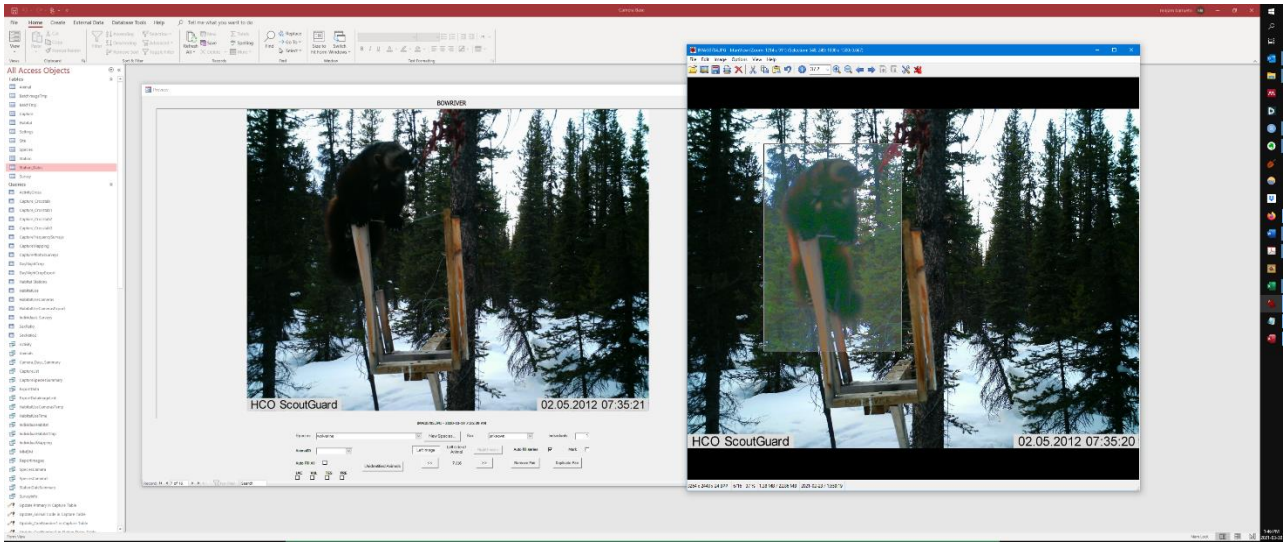


Figure 4 Interface of the program *CameraBase.*

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 the methods are available by request.

3. ACTIVITIES BY YEAR

3.1. Year 4 (2021)

Data Collection. In 2021 we monitored 18 stations: 8 in BYK and 10 in NCR. We collected >103,000 photos in BYK, and >33,000 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, Canada lynx, moose, coyote, black bears, and deer.

In 2021 in NCR and in BYK, only a few people were involved in field work because of pandemic restrictions and a much smaller field program. In all cases, one of the project staff was leading site visits, often assisted by one or more helpers - Parks Canada staff and volunteers. The summer visits during the very smoky fire season were quite something.

Field work can get surprisingly challenging once the snow has melted!

Genetic Analysis – Round 2. In fall 2021, 160 additional hair samples (128 from 2018 – 2020; 32 from 2021) were sent to WGI, for a second round of DNA extraction and microsatellite scoring. Lab work was complete on February 24, 2022.

Photo Classification. Throughout 2021, most of Mirjam's focus continued to be on classifying the > 1 million (!) photos to specify species, and if wolverine, identify which individual was present in each photo. There were more photos than originally anticipated, and thus more work to complete! Classification of all 2018 to 2020 photos was completed by Dec 30, 2021. In parallel, the photos were matched with the genetic results, to obtain a cross-referenced, integrated data set. After the second round of genetic analysis, 64% of all detected individuals have both a reliable photo and a genetic ID. 36% have only a reliable photo ID.

Photo-Processing and Classification Protocol. The field methods we used to collect wolverine data had been developed previously by other researchers (Magoun et al. 2011). However, we had to come up with our own protocol to sort, process and systematically classify the photos. Mirjam worked with Allison Fisher at Parks Canada Agency to document these processes step by step, using the methods developed in 2020 with UCalgary student Trevor Thompson. The resulting protocol, once complete, may be used internally by Parks Canada for potential future wolverine surveys and will also be made available to external researchers.

Moose are very curious animals. Many visit our sampling stations repeatedly, sniffing it all out.

Research Article – 10-Year Population Trend. In December 2021, we submitted the first paper resulting from this project, to undergo peer-review at a scientific journal. The working title is "*Trapping, recreation, and a ten-year decline of a partially protected wolverine population*". Here is a short description of the paper:

Protected areas play an important role in species' conservation. High rates of human-caused mortality outside reserve borders and increasing popularity of protected areas for recreation can impact the species they aim to preserve.

We conducted targeted, non-invasive wolverine surveys in >14,000 km^2 protected and adjacent non-protected lands in Alberta and British Columbia between 2011 and 2020 (Fig. 5). Concurrently, we carried out broad-scale camera surveys designed to monitor large mammals, including wolverine. Wolverine harvest occurred in the unprotected areas. Outdoor recreation was popular and increasing and occurred throughout our study area, and parts of otherwise suitable wolverine habitat were near intensely used human developments, quantifiable using night light intensity. Using the spatial capture-recapture (SCR) framework, we combined SCR data sets with occupancy data and developed novel integrated Bayesian spatially explicit population models.

Our objectives were to a) assess 10-year wolverine population trends, b) estimate harvest mortality rates, and c) identify the levels at which non-motorized recreational activities and human development footprint had impacts on wolverine habitat selection and detection probability.

We anticipate (or rather, we hope) that the paper will be published and publicly available mid to late 2022.

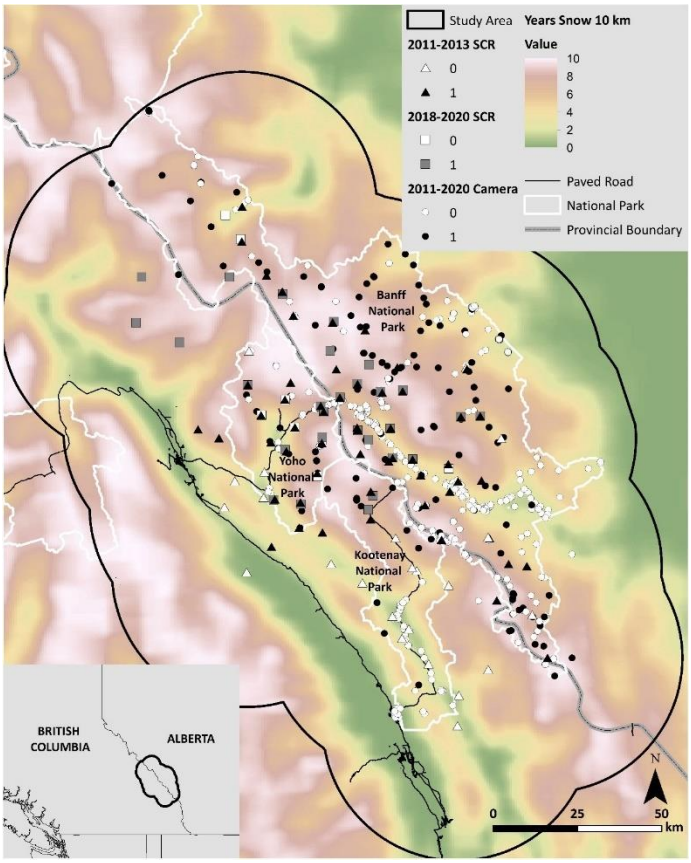


Figure 5 The study area, outlined in black, for a 10-year wolverine population trend study, conducted between 2011 and 2020 in the Canadian Rocky Mountains in southern Canada. Grey and black symbols mean that wolverines were detected at least once. White means that no wolverines were detected. Sampling sites for the three field studies are depicted with triangles ("2011 – 2013 SCR"), squares ("2018-2020 SCR"), and circles ("2011-2020 Camera"). Colors indicate the number of years out of 10 a pixel had complete spring snow cover between 2010 and 2020, using a 10 km moving average. National parks are outlined in white, and paved roads as thin black lines.

3.2. Year 3 (2020)

Data Collection. In 2020 we monitored 127 stations (Fig. 6): 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 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.

A wolverine taking a nap. Investigating sampling stations seems to be a tiring activity.

Genetic Analysis – Round 1. In summer 2020, we submitted 2442 hair and tissue samples to an external lab, Wildlife Genetics International (WGI) in 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. In the summer, fall and winter of 2020, Mirjam, helped by Trevor Thompson, an undergraduate student at the University of Calgary, developed a protocol and began carrying out classification of the > 1 million photos to specify species, and if wolverine, identify which individual was present in each photo.

A wolverine (left) and a lynx (right) at a sampling station. Because of the scent lure, many species are attracted.

3.3. Year 2 (2019)

In 2019 we monitored 152 stations (Fig. 6): 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.

3.4. Year 1 (2018)

In 2018 we monitored 58 stations (Fig. 6) 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 and 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.

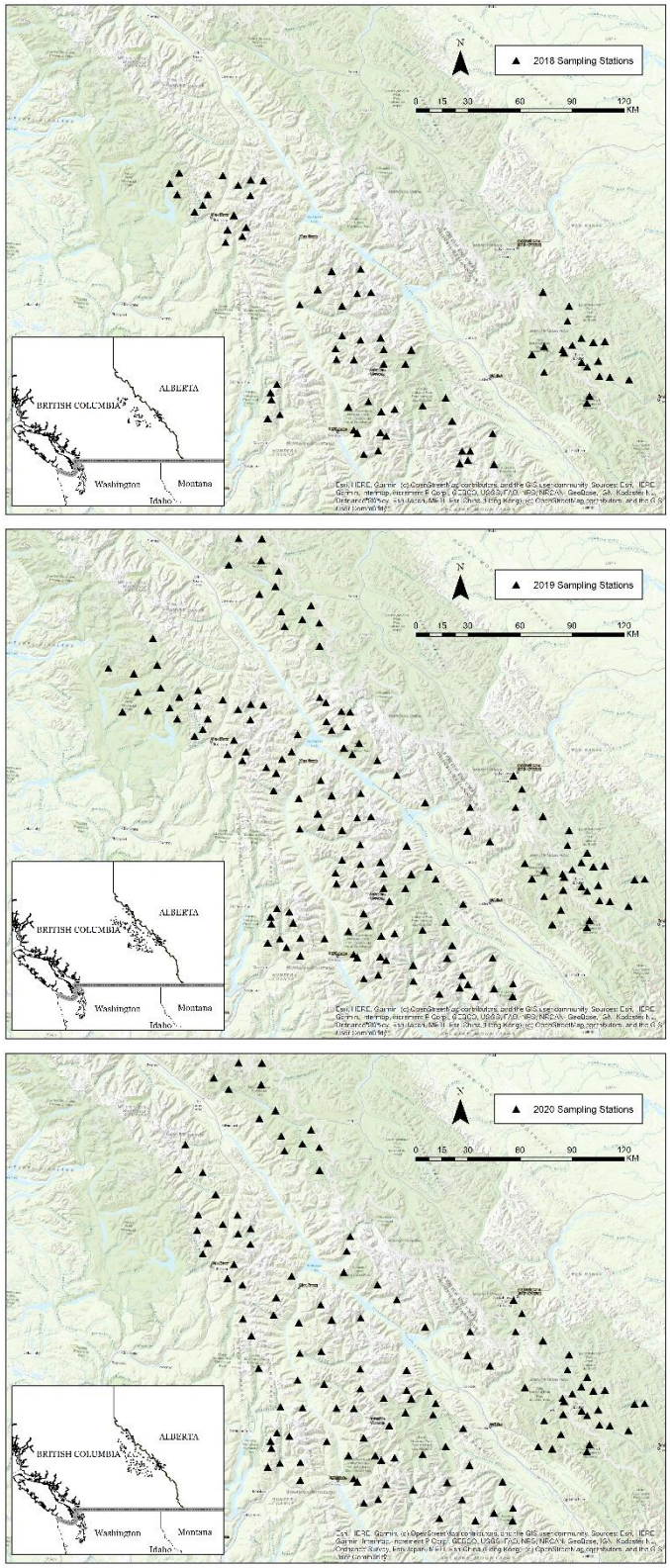


Figure 6 The sampling stations that were deployed in each year: 2018 (top), 2019 (middle), 2020 (bottom).

4. PRELIMINARY RESULTS

Wolverine Detections

In order to accurately estimate density of the wolverine population, in other words, to determine how many wolverine there are in the study area, we will be developing statistical models that account for all 3 years of data and the underlying attributes of the habitat.

The spatial capture-recapture data we collected is extensive, as each photograph of an individual could be used as a recapture data point! Table 1 shows the total number of detections of individual wolverine. During DNA-based capture-recapture studies, which is how we did wolverine studies previously, one cannot usually know on which day a hair sample was deposited, which makes such data much less granular. In our study, however, cameras collected data continuously and we have a time stamp for each visit. This paints a much more detailed picture of individual whereabouts.

In total, we ended up with 129,093 photos featuring a wolverine! Fig. 7 shows the 439 detections, by round (a "round" or "occasion" lasted approximately 1 month), for the 128 individuals we detected in 2019. A preliminary density map (Fig. 8) displays the uneven distribution of wolverines.

In our case, using daily detections would double the detection data compared to detections summarized by round (Table 2). However, statistical models using daily data take much longer

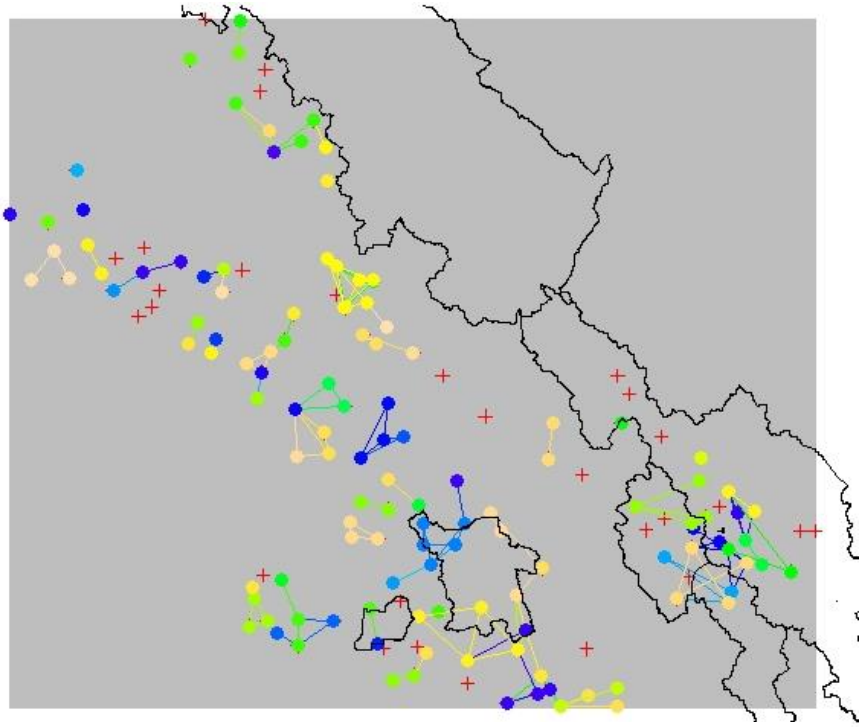


Figure 7 This map displays individual detections (128 animals) at sampling stations, in 2019. Individuals are color-coded, but colours are not unique and may be re-used for different individuals. If several same-coloured dots are connected, that means it's the same individual. The black lines in the figure outline the national parks, and the red crosses are sites where no wolverine were detected in 2019.

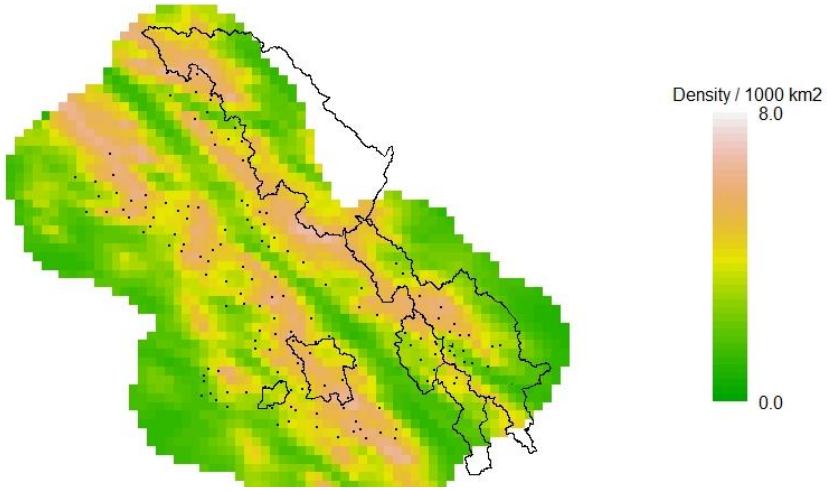


Figure 8 A map of a preliminary wolverine population density surface calculated from our 2019 data, with "spring snow" as a density covariate. The presence of spring snow had a positive effect on wolverine density. Hence, the "greener" pixels (with low density of wolverines) also have very little to no spring snow cover. There are very likely other models which would fit the data better, and which would result in a somewhat different density map, but we have not completed the work yet to identify those models.

to run, which is a consideration as computer power is finite. We will therefore most likely use different data summary options (e.g., daily, weekly, biweekly, monthly) for our different analysis goals, to find the optimal data structure for each goal.

Table 1 Number of individual wolverines detected across the study area between 2018 and 2021, for females, males, and individuals of unknown sex ("UNK").

	TOTAL	CAMERA & DNA	CAMERA NO DNA
FEMALE	103	84	19
MALE	70	60	10
UNK	53	-	53
TOTAL	**226**	**144**	**82**

Table 2 Wolverine detections 2018 - 2020. The first column reflects the number of photographs with a wolverine on it, for the North Columbia Region (NCR) and the Banff, Yoho, Kootenay Region (BYK). The second column is the number of individual detections when summarized by day. The third column is the number of detections summarized by sampling round (approx. 1 month). Depending on the analysis conducted, any one of these metrics may be more suitable.

	By photo & individual & sampling site	By day & individual & sampling site	By round & individual & sampling site
NCR	114,268	1610	805
BYK	14,825	251	122
NCR + BYK	129,093	1861	927

5. FUNDING

In 2021, funding for all work carried out in the NCR part of the study area, including field work, DNA analysis, data analysis and student stipend, came from the University of Calgary, Yellowstone to Yukon Conservation Initiative, NSERC, Earth Rangers, and several private donors.

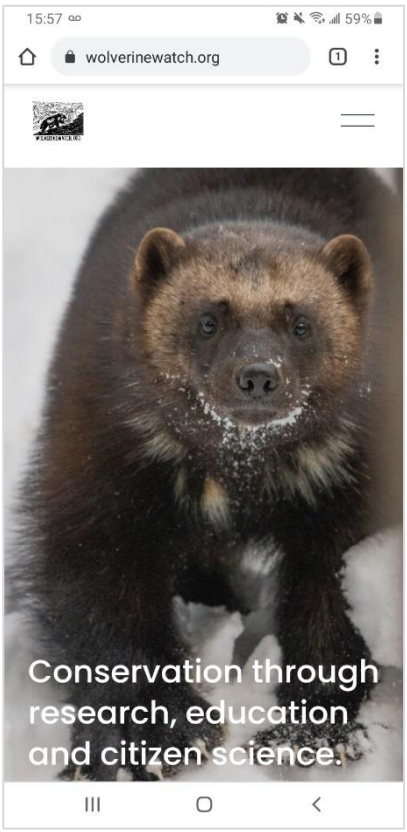
In 2021 Parks Canada Agency covered the costs of all research carried out in the BYK part of the study area. This included and contractor time, materials, bait, DNA analysis, and a contribution to Mirjam's stipend. Parks Canada Agency staff and contractors carried out all field work in BYK.

In the smoky summer of 2021, we temporarily removed some of the cameras that were too close to active wildfires.

6. OUTREACH AND EDUCATION

This year was comparatively quiet with regards to outreach. The focus was on photo processing, data analysis, and writing. Unfortunately, we did not hold an annual partner meeting in 2021, primarily due to pandemic considerations. We look forward to resuming the partner meetings in 2022.

As in previous years, our target audience is broad, including furbearer conservation officers and other resource managers, the heli and cat ski industry, winter recreationalists, the trapping community, First Nations, and members of the public that are 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.



Screen shot of the website on mobile.

6.1. Main outreach activities and events

1. Participated in a Wolverine Conservation Planning Session (October 2021) with Canadian and US wolverine researchers and managers. Held virtually. Purpose: 1) To 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.
2. Continued work on developing guidelines for recreational and industry activities near wolverine den sites, in collaboration by B. Harrower, A. Kortello, D. Hausleitner.
3. Our wolverine research is referenced on Species at Risk webpages for Yoho and Kootenay National Parks.
4. Posters (Fig. 9) that were developed as part of the Wildlife Wise initiative (www.y2y.net/wildlifewise) were distributed throughout the region again.

6.2. Leadership training - Wilburforce Leaders in Conservation Science

In spring 2021, Mirjam had the incredible fortune to be accepted into the year long *Wilburforce Leaders in Conservation Science* program. More info on this excellent program: www.compasssciccomm.org/wilburforce-leaders-in-conservation-science/

Figure 9 To increase sighting reports through our website, these posters were distributed at trailheads in wolverine habitat, from the South Coast to the Kootenays.

6.3. Website

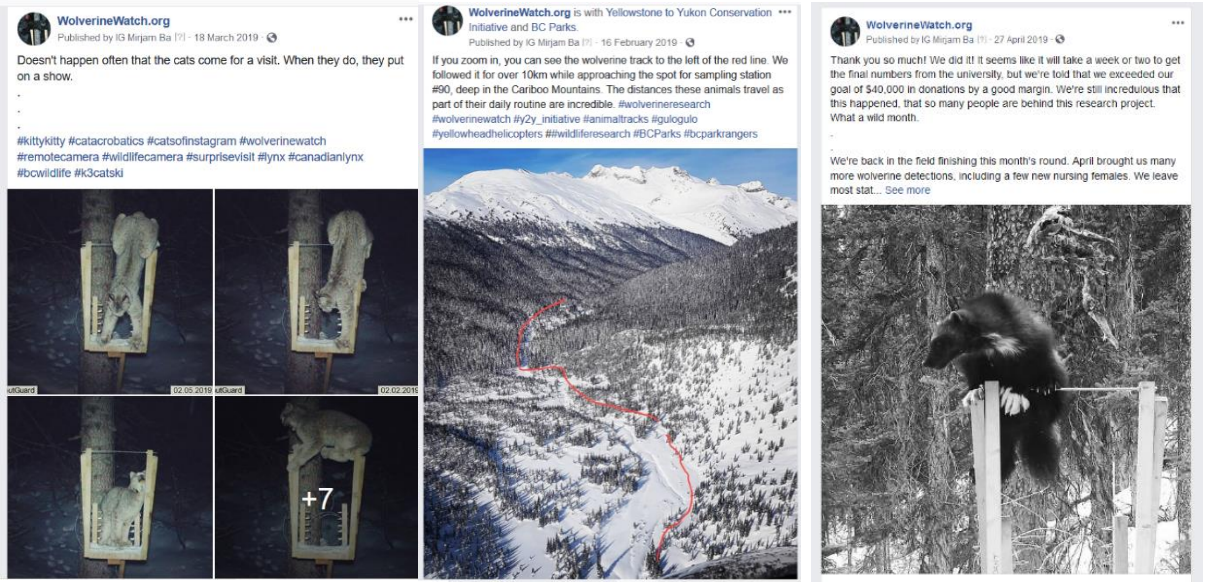
The project continued to maintain an online presence. The website www.wolverinewatch.org has been in use since 2010, when the website was created with seed funding from the Alpine Club of Canada to solicit wolverine sighting reports by the public.

The main purposes of the website are:

- to highlight and provide information on this and other current and past wolverine research projects.
- to collect public wolverine sightings for research on wolverine distribution on BC's South Coast and a female den project in the Kootenay Boundary Region.
- to provide information for people interested in supporting this project, and links to partner organizations and funders.

6.4. Facebook and Instagram

We continued to lightly 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. Posts document the project and some of the highlights and frustrations of conservation research. The Facebook page (www.facebook.com/wolverinewatch) has ~4,800 followers; Instagram (www.instagram.com/wolverine_watch) has ~1,700 followers.



Some sample posts from our social media pages.

7. FINAL THOUGHTS

This past year, the project transitioned from a busy and ambitious field program to a quieter, but equally interesting period of data assembly, analysis, and interpretation. The pandemic continued to leave its mark, but the constraints on in-person meetings were less impactful on this stage of the project. The second round of genetic analysis work at WGI proceeded as planned, for which we are grateful. The photo classification, an enormous task which seemed to be never-ending, was entirely doable remotely from home, with planning and training sessions conducted with University of Calgary researchers, students, and Parks Canada staff via zoom.

In late summer 2021, we teamed up with Parks Canada ecologist Jesse Whittington and carried out a long-planned analysis: We had processed the photos from the Central Rockies first and combined it with previous wolverine data from a 2011-2013 study, and an independent long-term, large-scale camera monitoring data set collected by Parks Canada. This enabled us to complete a 10-year wolverine population trend analysis for the Central Rockies, the first of its kind in Canada, while simultaneously investigating non-motorized recreation's impacts on wolverine habitat selection in the parks. The work on this paper had the added benefit of breaking up the somewhat monotonous task of processing photos. With the data sets complete, we are now at the point of starting with the two main analyses for the project – female density across natural and human factor gradients, and female connectivity and gene flow. We hope to have shareable results towards the end of the year. Good science takes time.

8. FUTURE

2022:

Analysis and writing will continue throughout 2022. In May, Mirjam will make a month-long visit to a research group that specializes in spatial capture-recapture modeling, at the Norwegian University of Life Sciences. This collaboration will greatly increase Mirjam's analytical skillset and ensure that we take advantage of all the information our data contains. Her PhD thesis is anticipated to be completed and defended by the end of 2022, for a total study duration of 5 years.

2023:

Work on this project, including further publishing of and disseminating results, is likely to continue beyond Mirjam's defence, as there are so many questions to answer, and so much data to dig through. Exactly what, when and how are not yet decided, so please reach out if you have ideas or want to contribute.

9. ADDITIONAL INFORMATION and CONTACT 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.

The less "instagram-worthy" aspects of research: A lab desk at Wildlife Genetics International (WGI) in Nelson, BC, where our hair samples were analyzed (left photo). Now that the field work is done, most days are spent at our desks (right photo).

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