Wolverine Watchers

Citizen-Based Multi-Species Forest Carnivore Monitoring in the Bitterroot National Forest

Five-year Project Report

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Executive Summary

Wolverine Watchers (WW) was a citizen-science monitoring project that collected data using wildlife cameras and baited hair snare stations. The project targeted wolverines and fishers on the northern half of the Bitterroot National Forest (BNF) in the Sapphire and Bitterroot mountain ranges. The project collected data in winter 2015 through winter 2019.

- WW volunteers ran up to 28 data collection stations each year from December to April, with trained station leaders that led their teams to gather data from cameras and hair snares. WW logged thousands of volunteer hours and engaged approximately 150 volunteers each winter and nearly 500 volunteers over five years.
- WW collected over 50,000 photos of 39 mammal and bird species and submitted hundreds of hair samples to enable genetic identification of species and individual target species (wolverines and fishers).
- Each year WW identified individual wolverines either by genetics analysis, photographic analysis, or both. The number of individuals identified each year is considered the minimum individuals alive per year or minimum known population per year in the study area.
- Over the five seasons, WW identified 14 unique wolverines via photo data and 13 unique wolverines via genetic data. Ten individuals were matched with photo and genetic data, 4 solely with photos, and 3 wolverines with unique genotypes were not matched via photograph with sufficient certainty.
- Between the USFS's similar project on the southern half of the forest and our effort, 24 wolverines (7 females, 17 males) were identified in the BNF and added to the USFS National Genomics Center for Wildlife and Fish Conservation database.
- WW documented a lactating female wolverine and collected footage of her with three kit; this data is the first documented wolverine reproduction in the area.
- Several wolverines visited more than one station in one season and appeared across seasons. A few wolverines seemed to follow each other; several sites had two different wolverines visit the same station within 12 hours of each other. Several stations had more than one wolverine visit the location across the season, with up to three individuals hitting a site, though never at the same time.
- The Bitterroot Mountains contain extensive wolverine habitat that is well-protected and secure, as it is public land in the National Forest system and much of the Bitterroot range is protected as Wilderness. The Sapphire Mountain range is also public land within the National Forest system. It had fewer wolverine detections. There were fewer WW sites in the Sapphires and the range contains less likely/modeled wolverine habitat.
- Wolverine-targeted stations were placed near, but not necessarily within, Inman et al. (2013)-modeled wolverine habitat, as winter conditions limited volunteer access. Therefore, most wolverine detections were outside of but near modeled wolverine habitat.
- Fishers were detected at three sites across the five years. No lynx were detected.
- Martens were detected at nearly every site. Both American marten (*Martes americana*) and Pacific marten (*Martes caurina*) were documented, sometimes at the same sites. *M. caurina* was documented at more sites.
- The information gathered can inform biologists, conservationists, and managers about wolverine occurrence and assist in informing various conservation measures, management, and policy decisions.

Acknowledgements

This project was started by Kylie Paul while working at Defenders of Wildlife and she continued to co-lead it through a job with MPG Ranch and into a job at another entity. Russ Talmo co-led the project with Defenders and played an essential role from its inception.

A major thank you to Defenders of Wildlife, MPG Ranch, and Patagonia Environmental Grants for their generous financial, equipment, and administrative support over the years.

Staff on the Bitterroot National Forest were essential and supportive partners; Dave Lockman, Chip Fisher, and Gil Gale helped make the project possible. Partnering with the USFS and the National Genomics Lab made the project financially feasible.

Above all, we thank the hundreds of volunteers who made this project what it was; without you, this project could not have occurred and we'd know that much less about wolverines, fishers, martens, and all the other critters in this part of the Forest. The station leaders and numerous others stepped up and provided immense volunteer effort – thank you! Each year we had interns and others who spent many hours in front of computers to help process the photo data. A big thanks to each of them as well.

Thanks to the multiple entities that helped connect us with these volunteers in the first place by sharing the first year's volunteer invitation to their grassroots memberships: Montana Wilderness Association, Montana Backcountry Alliance, Friends of the Bitterroot, Bitterroot Audubon, and the Selway-Bitterroot Frank Church Association.

And of course, thanks to to the critters who have given us all such a thrill in our path to better understand them. We hope you enjoyed the meals. Go *Gulo*!

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Project Background and Objectives

In 2012-2013, USFS wildlife biologists initiated a multi-species monitoring project on the southern portion of the BNF. The national conservation group Defenders of Wildlife (Defenders) had a regional program focusing on the conservation of forest carnivores including wolverines, fishers, and lynx. In 2014-2015 Defenders started Wolverine Watchers to document those species on the northern end of the BNF (Figure 2) to complement the ongoing monitoring conducted by the USFS on the southern portion (Figure 6). Protocols and data collection methods were selected to match as closely as possible those of the BNF's and other similar projects in the region.

The objectives of the project were:

- To contribute data to increase the research, management and conservation communities' understanding of the distribution and activities of wolverine and fishers;
- To collect and share data to inform management decisions on the BNF;
- To increase the public's awareness and support of these species; and
- To demonstrate the ability of citizen science to contribute valuable, cost-effective data.

The project fit into the approach taken by a monitoring initiative developed by the Forest Service Rocky Mountain Research Station and the National Forest System (Golding et al. 2018). That project is run by Jessie Golding of the Rocky Mountain Research Station to monitor wolverines, fishers, and lynx in the individual Forests within the Northern Region (Region 1) and Intermountain Region (Region 4). That initiative uses tiered questions:

- Is a species present?
- If yes, then: Are multiple individuals of a single sex present?
- If yes, then: Are there multiple individuals, including both sexes present?

We aimed to contribute to the initiative and address those questions within our study area and added the question:

- Is there a reproducing population present?

The project continued through winter 2020, but those data are not included in this report as the project effort was significantly reduced in size and number of stations. The project essentially concluded in 2020. While there is no plan as yet, there is potential this project could re-initiate in the future.

Project Area

Wolverines, fishers, and Canada lynx are rare species in the Rocky Mountains. Their management and conservation is challenged by a lack of data regarding distribution, population, and behaviors. It can be costly and difficult to gather data because these species live in remote areas and in low densities.

The Bitterroot National Forest (BNF) is one of the few national forests in the Rockies that contains valuable habitat for both wolverines (Schwartz et al. 2009, Copeland et al. 2010, Inman et al. 2013), fishers (Vinkey 2003, Vinkey et al. 2006, Olson et al. 2014) and possibly lynx.

There have been scattered occurrence records of wolverines, fishers, and lynx in the BNF across time. Habitat modeling predicts primary and maternal wolverine habitat in the mid-to-upper elevation areas in the Bitterroot Mountains (Inman et al. 2013). This habitat is present, but more scattered and restricted in the Sapphire Mountains. In addition to providing a large core area of suitable habitat, the Bitterroot Range has been predicted as the central artery for wolverine gene flow in the Rocky Mountains, connecting wolverines at the southern extent of their current range to more robust populations in northwest Montana and Canada (Cegelski et al. 2006, Schwartz et al. 2009).

Modeled fisher habitat predicts some habitat on the BNF, mostly within lower-elevation creek drainages (Olson et al. 2014). The Bitterroot Divide area in west-central Montana has been considered a stronghold for fishers of native lineage that form a population with fishers in Idaho (Schwartz 2007). However, fishers seem to have a scattered occurrence on the BNF, and records are mostly in the west side canyons.

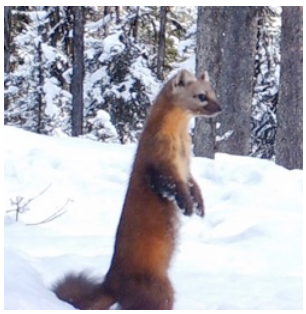
The BNF is currently classified as secondary, unoccupied lynx habitat by the U.S. Fish and Wildlife Service (USFS 2007). Transient individuals have been detected on the BNF in the past but there is not a resident population.

Methods

We used a multispecies bait station methodology that was used frequently and proven effective at detecting our target species by numerous projects and agencies (Robinson et al. 2017). The protocol used a bait pole tree with wire gun brushes to collect hairs of animals that climb the tree to access the bait (Figure 1). Attractants used were ungulate carcass pieces and a carnivore attractant scent lure. A wildlife camera on a nearby tree captured motion-activated images at the station. Stations were set up in December, visited on average every 4 weeks to re-bait, switch camera cards, and collect genetic material. Stations were removed in April.

We recruited volunteers to conduct station visits. Using citizen science to conduct this project created a unique public education and engagement opportunity. It also provided a cheap labor force that fit our small budget. Other similar projects had used volunteers (e.g. Friends of Scotchman Peaks). We organized volunteers into teams and we trained self-designated station leaders to manage each team. Each team ran their own station.

We selected station locations based on feasible winter access for volunteers, probable/modeled habitat for fisher and/or wolverine (Inman et al. 2013, Olson et al. 2014), and previous sighting records of these species. Higher elevation sites targeted wolverines, and lower elevation drainages were selected for fishers. Several stations did not contain high-quality habitat for either species but were included to involve more volunteer teams and to examine whether those sites may still document target species.


Wildlife cameras used included: Reconyx PC800 Hyperfire Professional IR, Reconyx HC500 Hyperfire Semi-Covert IR, Bushnell Trophy Cam, Browning Special Ops, and Browning Strike Force. We attempted to match camera settings across camera brands and models as best as possible, with an emphasis to take as many photos and with as high sensitivity as possible without filling cards too quickly. Lithium batteries were used due to their capabilities in colder temperatures.

Gun brushes that contained visible genetic material (pieces of fur) were collected, individually packaged and labeled in paper envelopes. Samples were kept dry until submission to the USFS' National Genomics Center for Wildlife and Fish Conservation at the end of each season. The lab identified species from each sample they examined and took extra steps to identify the individual and sex of the animal if it was a wolverine (or fisher or lynx, if found). We later obtained results from the lab.

Each season a trained student-intern from the University of Montana sorted and analyzed photos from each station check and recorded data, following a specific analysis and photo storage protocol. The author provided quality control and performed further data analyses.

Wolverines have unique ventral pelage markings that are persistent over time and that can be determined from photographs. These markings can be used to identify individuals. We developed a photo library of wolverines and the author identified and named individuals through visual comparative analysis.

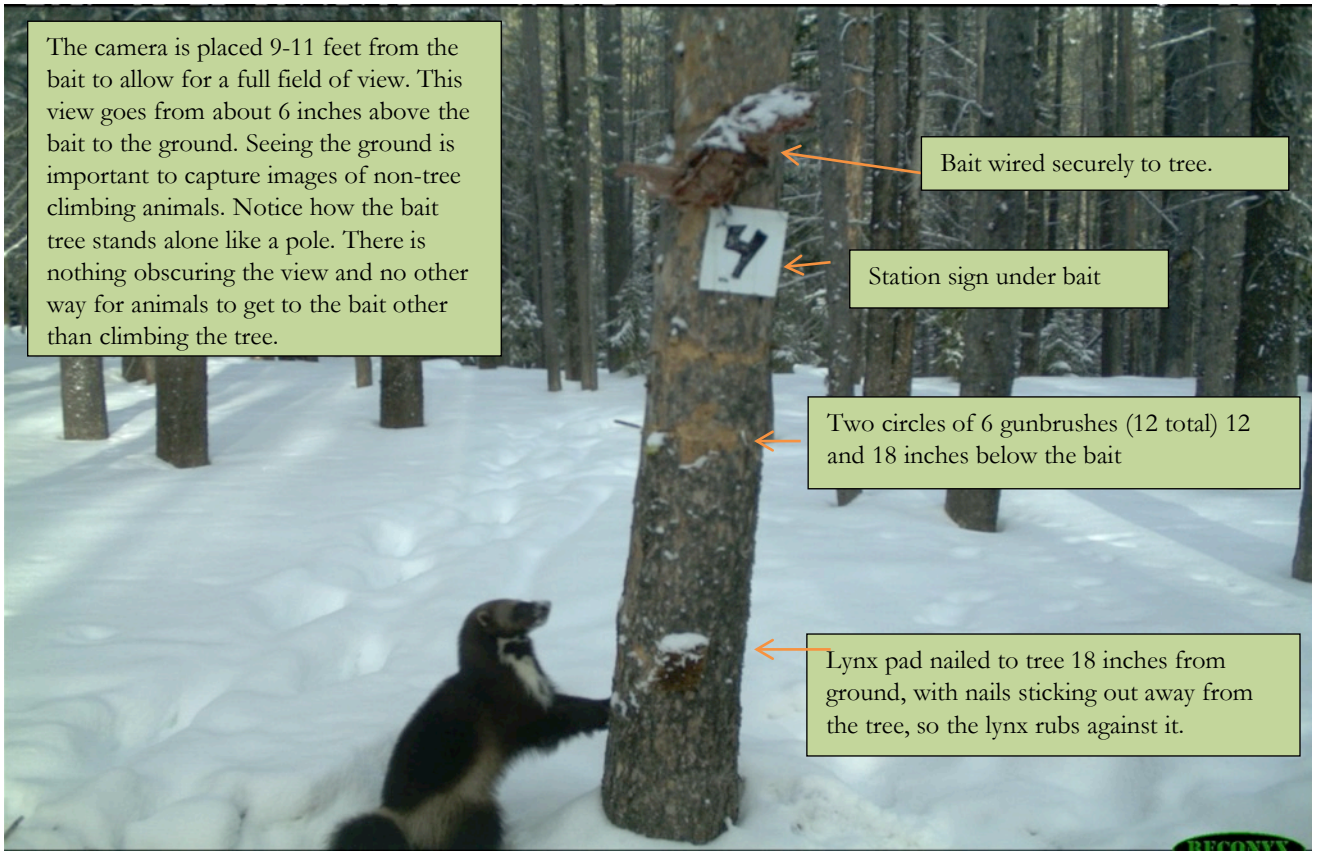


Figure 1. Example of bait station site

Results and Discussion

Results and discussions are described below and are split by topic in the following order:

> Methods; Volunteers; Photographic Analysis; Genetic Analysis; Wolverine Genetic Analysis; Wolverine BNF; Wolverine Photographic Analysis; Wolverine Behaviors; Wolverine Reproduction; Wolverine Habitat; Fisher; Marten; Conclusion; References

Canada lynx are not separately discussed. Lynx were not documented in this project via photograph nor via genetic analyses. Documenting their presence was possible and was attempted in our methodology, but it was not expected. They have occurred on the BNF in the past, but they were likely transient individuals and the BNF is considered unoccupied.

Methods-Related Results and Discussion

WW managed 23 to 28 stations each year (Table 1). Station locations were repeated across seasons, but there were locations that were not used every year or were used only one season. If stations were dropped it was typically due to difficulty of winter access for volunteers, or they were used for one season to provide a site for additional volunteers. A total of 37 unique stations were used across the project period.

Monitoring sites ranged in elevation from 3,773 to 7,900 feet. Most were on the Bitterroot Mountains and approximately a third were in the Sapphire Mountains (Figure 2).

Volunteers visited the sites three to eight times each season, depending on the team. Stations were deployed an average of 112 (range: 64 to 168) camera trap nights across the five seasons (Table 1).

Trap nights represent a maximum count of the camera functioning period, as not all cameras functioned equally across the season. There were occasional technical difficulties with the cameras that included SD card failures, camera malfunctions, user error, and battery failures generally due to extreme temperatures. The non-functioning nights were not consistently documented and thus were not analyzed or considered in other analyses. It is likely that some stations had wolverine or fisher visits that were therefore not documented. Differences in effort level in different seasons, such as number of stations or number of traps nights, may account for some differences in results across seasons.

Table 1. Average and total number of trap nights each season

Year	Number of unique stations	Average trap nights per station	Total trap nights
2015	23	90	2,074
2016	23	113	2,596
2017	22	110	2,429
2018	27	120	3,263
2019	28	126	3,520
Total	**37**	**112**	**13,882**

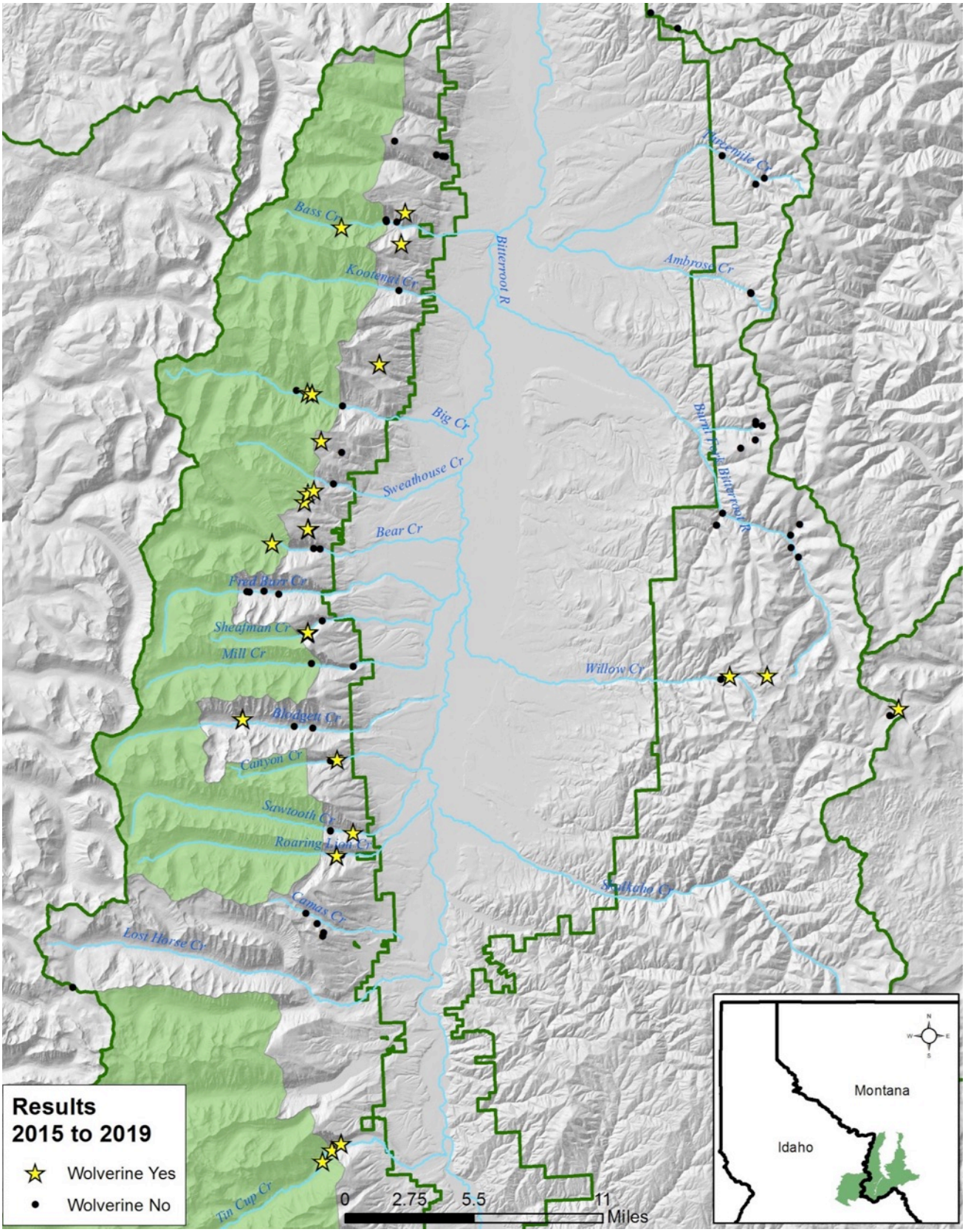


Figure 2. Monitoring station locations across 5 seasons for WW mesocarnivore monitoring project, including those with wolverine detections. Green line indicates Bitterroot National Forest, green fill indicates Designated Wilderness. Locations across seasons changed slightly at some stations.

Volunteers Results and Discussion

An average of 150 volunteers signed up for Wolverine Watchers each season, and nearly 500 people participated or signed up across the seasons. Volunteers were split into teams based on preference for rigor and distance of site, site location, groups of friends, and other factors. Team sizes ranged from 2-15 people, though generally 2-6 people attended a given station check. Volunteers contributed thousands of hours in hundreds of visits each year. Most volunteers participated in more than one season, many of them engaging in all five seasons.

We had success allowing a range of volunteer commitment levels. The station leaders were required to attend a training, organize and go out on almost every station visit, and ensure data and datasheets were submitted after each visit. Station team members attended most of the times, and station visitors could attend just once if desired. This stratified participation approach allowed volunteers to tailor their level of involvement and more volunteers to be involved, while still maintaining consistent protocols. We developed this approach in the first year when confronted by higher volunteer interest than anticipated, and it addressed the high number of volunteers and the mixed ability and commitment level. Many station leaders and team members participated each year the program ran, with valuable experience and familiarity lending itself to more efficient site monitoring.

The energy around these volunteers was palpable and it was inspirational to channel it into enthusiastic data collection efforts. Season kickoff and end of season parties aided in connecting, training, educating, and creating a community.

Uploading and sorting through over 50,000 photos and data entry was performed by a volunteer University intern each season. This was a valuable time-saver for the project managers.

Citizen science worked well with this project. The straightforward protocol of collecting gun brushes, hanging new bait, and changing camera cards led to fairly consistent effort across a large number of data collection stations. This was a fantastic tool for gathering data otherwise not possible to obtain due to small budgets and no option for additional hired staff. The educational benefits are rewarding. Provided there is sufficient capacity to manage volunteer training, questions, and to go out to several stations each season to address possible problems, citizen science is a useful approach for projects like this.





Photograph Analysis Results and Discussion

While the study targeted wolverines and fishers, the multispecies bait station methodology documented many other species. Via photographs across the five seasons we documented 39 wildlife species, including 20 mammal and 19 bird species.

Many species climbed the trees and consumed bait, including birds, black bear, bobcat, deer mouse, fisher, flying squirrel, marten, mountain lion, red fox, red squirrel, weasel, and wolverine. Other species did not climb the bait station tree but were captured on camera at the site, including deer, elk, moose, snowshoe hare, striped skunk, and wolf. It appears those species incidentally walked past the site, or were curious about the bait or stink lure but did not or could not climb to reach it.

Martens and a variety of bird species were visitors at most of the stations each season (Table 2). Red squirrels, snowshoe hares, bobcats, flying squirrels, red foxes, moose, and deer mice were also consistently photographed at many of the stations. Long bouts of climbing and removing bait were recorded of individual martens, red foxes, and mountain lions.

With the study design, we could examine the number of different species counted at a location, or the species richness of that location. The species richness we documented via photograph at each station varied between station and year (Table 3). The number of mammal species per site ranged widely, from no species documented at a few sites to a site with nine mammal species recorded.

We could not measure species diversity, a measure of evenness of distribution of difference species, population sizes, or absence, with this study design. This means we cannot examine whether a species did not occur in an area nor why; we can only determine that we did not document it there.







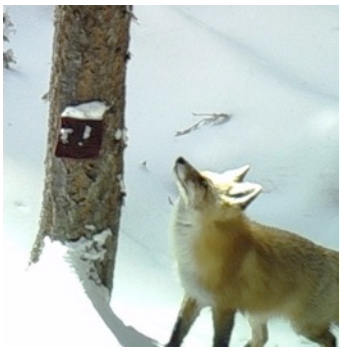



Table 2. Number of stations that species were documented via photographs each season

Species via photographs	Percent of stations observed, by year				
	2015	**2016**	**2017**	**2018**	**2019**
Bird species	43%	65%	91%	93%	86%
Black bear	0%	9%	0%	4%	7%
Bobcat	22%	22%	14%	44%	29%
Canada lynx	**0%**	**0%**	**0%**	**0%**	**0%**
Deer	9%	0%	9%	11%	14%
Deer mouse	9%	13%	18%	30%	18%
Elk	0%	0%	0%	7%	4%
Fisher	**0%**	**0%**	**5%**	**7%**	**4%**
Flying squirrel	17%	13%	23%	22%	36%
Marten	87%	78%	86%	89%	79%
Moose	13%	26%	14%	19%	14%
Mountain lion	4%	13%	18%	11%	14%
Red fox	9%	26%	32%	48%	43%
Red squirrel	30%	52%	59%	48%	46%
Snowshoe hare	17%	22%	45%	44%	29%
Striped skunk	0%	9%	9%	7%	0%
Weasel/Ermine	4%	0%	5%	11%	11%
Wolf	17%	4%	0%	0%	14%
Wolverine	**17%**	**35%**	**50%**	**52%**	**36%**
Total # of stations run each season	**23**	**23**	**22**	**27**	**28**

Table 3. Number of mammal species documented via photograph at each station each season. N/A indicates the site was not used that year.

Station Location	2015	2016	2017	2018	2019
Ambrose Creek	2	3	8	0	1
Bass Creek	4	3	4	4	6
Bear Creek	1	4	3	4	3
Bear Creek 2	2	N/A	N/A	N/A	N/A
Bear Creek Overlook	7	4	4	3	1
Big Creek	1	3	5	5	5
Big Creek 2	N/A	N/A	N/A	4	1
Blodgett Creek	1	4	5	7	7
Burnt Fork	5	2	3	N/A	N/A
Burnt Fork 2	N/A	3	N/A	N/A	N/A
Camas Creek	1	1	2	1	N/A
Canyon Creek	N/A	1	4	8	4
Fred Burr	3	1	3	7	4
Fred Burr 2	1	N/A	N/A	N/A	N/A
Gash Point	2	3	2	5	6
Glen Lake	2	3	2	N/A	N/A
Gold Creek	N/A	4	4	3	4
Kootenai Creek	1	N/A	N/A	N/A	N/A
Lappi Lake	N/A	N/A	N/A	2	N/A
Little St Joe	N/A	N/A	N/A	5	3
Lost Horse	2	N/A	N/A	N/A	N/A
Mill Creek	1	N/A	N/A	N/A	5
Palisade Mountain	N/A	N/A	3	4	5
Roaring Lion	1	3	N/A	2	4
Sawmill Creek	0	0	4	3	4
Sawtooth Creek	N/A	5	N/A	4	4
Sheafman Creek	4	6	5	3	2
Skalkaho Pass	N/A	2	2	4	5
St Mary's Peak	7	4	5	6	3
Sweathouse Creek	1	N/A	N/A	N/A	N/A
Sweeney Ridge	N/A	2	4	3	3
Threemile Creek	3	1	3	N/A	N/A
Tin Cup Creek	N/A	N/A	3	9	6
Tin Cup 2	N/A	N/A	N/A	5	2
Willow Creek	3	7	4	5	2
MPG-A	N/A	N/A	N/A	7	6
MPG-B	N/A	N/A	N/A	6	5

Genetic Analysis Results and Discussion

The combination of using both camera traps and genetic analysis afforded us more detection and identification tools and allowed a basic comparison in methods. Compared to photographic analysis information, fewer species were documented via genetic analysis. While numerous species appeared on camera at the stations, many that were photographed did not climb the bait tree and therefore did not leave genetic material on the gun brushes. Our findings corroborate other studies that detected fewer species with DNA than cameras (Fisher and Bradbury 2014; Robinson et al. 2017).

Marten, wolverine, and bobcat were documented via genetic analysis at the most stations (Table 4). They are the species most likely to climb a tree for bait and leave sufficient hair on the gun brushes for analysis.

Deer and elk were often identified in genetic analysis each season. This was due to the use of roadkill and hunter harvest remains as bait; though the ungulate carcass pieces were skinned, genetic material dripped or fell onto the gun brushes.

Table 4. Percent of stations that species were documented via genetic analysis each season

Species via Genetics	Number of stations per year				
	2015	2016	2017	2018	2019
Black bear	0%	9%	0%	0%	0%
Bobcat	13%	9%	23%	19%	11%
Canada lynx	0%	0%	0%	0%	0%
Deer mouse	9%	9%	0%	0%	0%
Fisher	0%	0%	0%	0%	4%
Flying squirrel	0%	0%	5%	0%	0%
Marten	87%	78%	73%	78%	75%
Moose	0%	4%	0%	0%	0%
Mountain lion	0%	4%	0%	4%	0%
Red fox	0%	0%	0%	4%	7%
Red squirrel	13%	9%	0%	7%	0%
Striped skunk	0%	4%	0%	0%	0%
Weasel/Ermine	0%	0%	0%	4%	0%
Wolf/canine	0%	4%	0%	0%	0%
Wolverine	17%	26%	27%	26%	21%
Total number of species	5	10	4	7	5
Total # of stations run each season	**23**	**23**	**22**	**27**	**28**

Wolverine Results and Discussion

Wolverines were detected and individual wolverines were identified both via camera and via genetic analysis (Table 5). Each year we identified individuals either by genetics analysis, photographic analysis, or both. The number of individuals identified is considered the minimum individuals alive per year or the minimum known population per year in the study area (McKelvey and Pearson 2001).

The number of stations that detected wolverines via photograph within a season ranged from four stations to 14 stations and totaled 19 stations across the five seasons (Table 5). Via genetic analysis, the number of stations that documented wolverines within a season ranged from three to seven and totaled 12 stations across the five seasons. Each year, wolverines were detected via genetic analysis at fewer stations than via photographs. Explanations for this could include: some individual wolverines tended not to climb the bait trees and thus did not leave hair, some gun brushes may have been already filled with hair from other species such as marten, the genetic material could have degraded due to weather, and so on.

Via genetic analysis alone, we documented 13 individual wolverines (Tables 5 and 7). Sex of an individual can be determined via genetic analysis. Of the 13 individuals identified via genetic analysis, we documented four females and nine males.

Table 5. Number of stations that detected wolverines via photographs and via genetics, and number of wolverines via cameras only and via genetics only, each season.

	2015	2016	2017	2018	2019	Total
Stations						
Number of stations with wolverines via camera	4	7	11	14	10	**19**
Number of stations with wolverines via genetics	3	6	6	7	6	**12**
Wolverines						
Number of wolverines estimated via camera	2	6	7	8	6	**14**
Number of wolverines via genetics	2	4	4	7	4	**13**

Wolverine Results and Discussion – Bitterroot National Forest Study

As mentioned prior, the USFS conducted similar data-collection efforts on the southern portion of the BNF in the same period. Their study running more than seven years was executed by two full-time staff who monitored 20 to 60 stations each year (Table 6).

Table 6. Number of stations run by WW and by USFS

Year	Number of stations	
	WW	USFS
2013	n/a	34
2014	n/a	60
2015	23	27
2016	23	32
2017	22	34
2018	27	35
2019	28	20

From 2013 to 2019, the USFS documented 16 individual wolverines at numerous stations (Table 7, also Figure 6 later in document). Between the two studies, *24 wolverines* have been identified and added to the National Genomics Center for Wildlife and Fish Conservation's database (Table 7).

The USFS documented three females and 13 males. The WW study found four females and nine males. In general, male home ranges are several times larger than female home ranges (Magoun 1985, Copeland 1996, Persson et al. 2010), which corresponds with their polygamous mating system where one male breeds with several females (Hedmark et al. 2007). The relatively lower number of females compared to males documented in our studies could be reflective of the more limited home ranges that female wolverines maintain, as fewer females may have had territories that overlapped with our sites. Alternatively, it could be that the data collection sites were further from female denning habitat than male primary habitat.

Of the 13 individual wolverines from the WW study and the 16 that the USFS genetically documented in their study area, five individuals (M11, M13, M14, M16, M17) were documented in both. Those overlapping individuals occurred in the area where WW and USFS stations were nearest each other.

This report does not attempt to further report or analyze the USFS's results. However, there is a wealth of knowledge to be gained from further analyzing both the USFS and WW's data. Examinations of the differing proportions of modeled primary and maternal denning wolverine habitat in the northern versus southern portion of the Forest (Figure 6), locations of the wolverine detections in both areas, and the sex of detected wolverines, could be of interest.

Table 7. Number and ID of wolverines identified via genetic analysis each season from Wolverine Watchers (WW) and from Bitterroot National Forest (USFS) efforts

Year	Number and genetic ID: WW		Number and genetic ID: USFS	
2013	N/A		**1**	(M1)
2014	N/A		**2**	(F2, M3)
2015	**2**	(F5, M6)	**3**	(F2, M3, M4)
2016	**4**	(F10, M9, M11, M12)	**4**	(F7, M1, M3, M8)
2017	**4**	(F10, F15, M12, M14)	**4**	(F2, M11, M13, M14)
2018	**7**	(F15, F19, M11, M12, M13, M16, M17)	**7**	(F2, M1, M11, M14, M16, M17, M18)
2019	**4**	(F15, M12, M14, M24)	**6**	(F2, F23, M1, M20, M21, M22)
Total	**13 individuals (4 ♀ , 9 ♂)**		**16 individuals (3 ♀ , 13 ♂)**	
	Total unique individuals: 24 (7 ♀ , 17 ♂)			

Wolverine Results and Discussion – Photographic Analysis

Wolverines have unique ventral pelage markings on their neck and chest that are persistent over time. They may also have white markings on their toes, feet, or legs. These can be examined to identify individual wolverines via photographic analysis (Magoun et al. 2011, Baughan 2015, Baughan and Davis 2020). Other research efforts have used primarily front-facing frame mounts. While we used those frame mounts in 2018 and 2019 (see wolverine reproduction section), we were able to readily identify individual wolverines on the majority of wolverine visits, using photographs from the tree sets with side views of wolverines.

We developed a photo library of wolverines and identified and named individuals through visual comparative analysis (Figures 3 and 4). Using this visual analysis from photographs, we documented 14 individual wolverines (Figures 3 and 4, Tables 5 and 8).

Table 8. Wolverine individuals documented as identified via photographs, each season.

Year	# of wolverines	Names of identified wolverines
2015	2	Left-Hook, Few-Marks
2016	6	Back-Spot, Big-Chunk, Chin-Strap, Island-Chain, Left-Hook, Two-Dot
2017	7	Back-Spot, Chin-Strap, Few-Marks, Left-Hook, Lefty-White-Toes, Powder-Paws, Thin-Stripe
2018	8	Back-Spot, Island-Chain, Left-Hook, Lefty-White-Toes, Pearl, Powder-Paws, Swoosh, Thin-Stripe
2019	6	Back-Spot, Lefty-White-Toes, Thin-Stripe, Powder-Paws, Righty, Sixby
Total likely individuals 14		

We combined our photographic and genetic identification results. After accumulation of genetic and photograph data across several seasons, we were able to confidently link photographic identification and genetic identification for ten individual wolverines (Figure 3). This was possible in situations where a wolverine was identified with confidence based on rigorous photograph analysis and a hair sample was clearly linked to that individual at that location and data collection visit.

There were several individual wolverines that were clearly identifiable based on photographic identification and for which their DNA signatures were documented such that genetic analyses were not needed to distinguish those individuals. However, using both photographic and genetic identification is encouraged, as instances when cameras may not function can still allow for wolverine identification via hair collection, and because new or unidentified wolverines arrived at different sites across seasons and therefore the photographic library and linking with DNA signatures continued to be needed.

There were several wolverines that were identified via photograph but were not identified from genetic analysis (Figure 4). Conversely, there were a few wolverines (F19, M6, and M13) with unique genotypes that were not then identified via photograph with sufficient certainty.

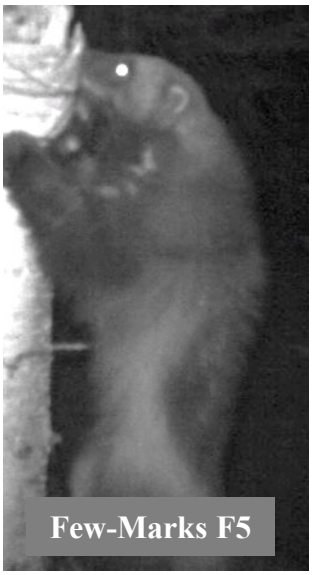


Figure 3. Wolverines identified via photographs by Wolverine Watchers and identified individually via genetics. Includes their 'given' WW name and their individual genetic identification/DNA signature.

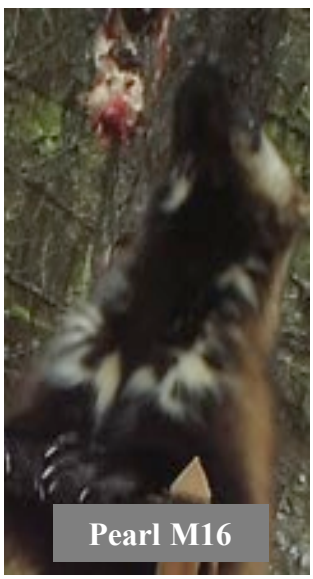


Figure 4. Wolverines identified via photographs by Wolverine Watchers but that were not clearly paired with DNA signature

There are several points to note with this approach of identification using photographs at the tree sets:

The individual wolverine estimate is a minimum number. There were several wolverine visits each season that did not allow for identification of individual due to the wolverine's behavior (i.e., walked by quickly without climbing tree) or low quality of photo. Instances with only a few photographs taken were the most difficult to identify individuals, and those visits tended to be 'unidentified individuals.' Therefore, there could be a few more individual wolverines than we were able to identify.

Identifying individual wolverines from photographs at tree sets is used best with a multi-year project. Photographs of both the left and right sides of the individual were needed and were able to be collected sometimes at the first sighting of an individual or sometimes required more than one visit. As the photo library became larger with more visits from more individuals, it became easier to discern individuals; more photographs and more visits helped clarify individual wolverines as their identifying features were made visible. With some wolverines, their identification was clear on the first glance, while others required a compilation and comparison over several site visits. More photographs allowed for a better chance at identification, so camera settings that allowed for multiple shots were useful.

Cameras must be set sufficiently close to the station for the photographs to clearly show markings. Our cameras were set nine to 11 feet from the stations.

For consistency, the same person should do the photograph analysis for individual wolverine identification across all seasons.

Stations where more than one wolverine visited during a data collection check period had the potential to be more challenging to link DNA signature to photograph identification.

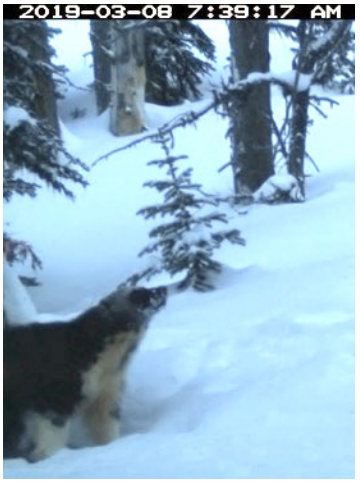
Identification was easiest for individuals with obvious markings like white toes or legs.

Wolverine Results and Discussion – Behaviors

It is fascinating and frustrating to attempt to piece together wolverine behavior based on observations at static monitoring stations across seasons. There are some inferences that can start to be considered by examining individual occurrence across seasons and across various sites within a season (Table 9) and combining that with the scientific literature on wolverines. Several wolverines appeared across seasons (Tables 8 and 9). Several wolverines visited more than one station in a season (Table 9). Two males, Left-Hook and Back-Spot, were documented four of five seasons. Other individuals were documented for one or two seasons.

Most research has found wolverines are territorial, with a low level of overlap between same-sex adults (Magoun 1985, Copeland 1996, Persson et al. 2010, Inman et al. 2012). Ranges of young males can overlap with resident adult male home ranges (Magoun 1985). Several WW sites had more than one (up to three) individual wolverine visit the location across the season (Figure 7), though never at the same time (except a female with her three kits). There were instances of same-sex individuals at the same station across the season, but without genetic analysis determining relatedness, there was not a way to discern whether the same-sex occurrences at a site were related individuals, whether they were more unusual examples of male-male territory overlap, or whether they were non-territorial dispersers passing through.

A few wolverines appeared to follow each other, as several sites had two different wolverines within 12 hours. These typically were male and female individuals. We assumed they were breeding pairs, as breeding pairs have overlapping territories (Copeland 1996, Dawson et al. 2010, Persson 2010, Inman et al. 2012). In one site, we were confident that a male and female (Powder Paws and Lefty-White-Toes, below) were a breeding pair as they were the only documented adults in the area and that a third young individual (Righty) was their subadult kit. Lefty-White-Toes and Powder-Paws were documented the three seasons that the higher-elevation portion of the Sapphires were monitored.



Two males in our project, Left-Hook and Back-Spot, traveled broadly and occurred for several seasons (Table 9). We assumed they were resident, dominant males, as they appeared to be adults, they were documented for several years, and they covered large areas, presumably patrolling their territories.

Table 9. Stations that detected individually identified wolverines via photographic analysis/cameras, by season. N/A indicates the station did not exist that year. N indicates it existed but did not detect wolverines. Unknown indicates a wolverine that was not able to be identified as any known wolverine.

Location	Elevation (ft)	2015	2016	2017	2018	2019
Bear Creek	4933	None	Left Hook, Chin-Strap, Big Chunk, Unknown	Back-Spot, Chin-Strap	Back-Spot	Sixby
Bear Creek Overlook	6230	Left-Hook	Chin-Strap	Chin-Strap	Back-Spot, Unknown	None
Big Creek	4352	None	None	Unknown	None	None
Big Creek 2	4352	N/A	N/A	N/A	Back-Spot	None
Blodgett Creek	5450	None	Chin-Strap, Left-Hook, Unknown	Left-Hook	Left-Hook, Back-Spot	Unknown
Canyon Creek	5115	N/A	None	Left-Hook	None	None
Gash Point	6102	Left-Hook, Unknown	Island Chain	Back-Spot	Back-Spot	Back-Spot
Glen Lake	7113	Few-Marks	None	None	N/A	N/A
Lappi Lake	3773	N/A	N/A	N/A	Back-Spot	N/A
Little St Joes	6420	N/A	N/A	N/A	Island-Chain	Back-Spot
Palisade Mountain	7720	N/A	N/A	Lefty-White-Toes, Powder Paws	Lefty-White-Toes, Powder Paws	Lefty-White-Toes, Powder Paws, Righty
Roaring Lion	4663	None	Left-Hook, Two-Dot	N/A	None	Unknown
Sawtooth Creek	4461	N/A	Left-Hook, Two-Dot	N/A	None	None
Sheafman Creek	6070	None	None	Back-Spot	Back-Spot	None
Skalkaho Pass	7900	N/A	None	Lefty-White-Toes, Powder Paws	Lefty-White-Toes, Powder Paws	Lefty-White-Toes
St Mary Peak	6354	Few-Marks	Back-Spot	Back-Spot	Back-Spot	Back-Spot
Tin Cup Creek	4370	N/A	N/A	Thin-Stripe, Unknown	Left-Hook, Pearl, Unknown	Thin-Stripe
Tin Cup 2	4321	N/A	N/A	N/A	Pearl, Swoosh, Thin-Stripe	None
Willow Creek	6110	None	None	None	Powder Paws	Righty
Total stations with wolverines		4	7	11	14	10

Wolverine Results and Discussion – Behaviors, cont'd

Most wolverine visits occurred in January, February, and March (Table 10). December had fewer deployed stations than other months, which could explain the lower visitation rate. April had fewer visits though most stations were still deployed. We found high value in keeping the stations up through April, however, as several stations did not have any wolverine visits until that month.

Wolverines displayed crepuscular activities, as they visited stations most often in the morning and evening (Figure 5).

Length of time spent at a station was highly variable. Some visits by individuals spent significant periods (maximum at one visit was 148 minutes) at the site, working to remove and consume the bait. Other visits were simply a wolverine walking through, sniffing or marking the bait tree but not climbing it.

Table 10. Number of wolverine visits at stations per month via photos and percent of stations deployed per month, 2015-2019

Month	Number of wolverine visits (total 217)	Average percent of stations deployed
December	10 (5%)	48%
January	63 (29%)	98%
February	51 (24%)	100%
March	62 (29%)	100%
April	31 (14%)	86%

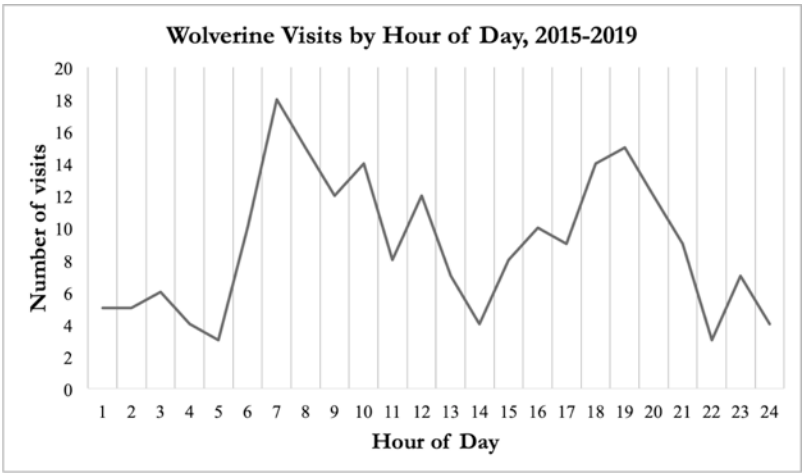


Figure 5. Number of wolverine visits at stations per hour of the day, 2015-2019

Wolverine Results and Discussion – Reproduction

From the first several seasons' results showing repeated wolverine visits, it was clear wolverines occurred and were residents on the BNF. We then sought to document wolverine reproduction.

To do so, in the 2018 and 2019 seasons we used a wooden frame mount system (below) to encourage wolverines into upright, bipedal positions to display unique markings, genitals, and signs of reproduction (Magoun et al. 2011, Baughan 2015, Baughan and Davis 2020). The detection of visible signs of lactation in female wolverines is important as this data provides some of the most reliable, non-invasive information on reproductive success. If the same female wolverine is repeatedly photographed in an active lactation state over several months, then it can be inferred that her kits are alive up to a certain point in time. The tree sets we used in the previous seasons and for most stations in 2018 and 2019 are effective for documenting species and for identification of individual wolverines by photographic analysis, but they are not able to provide information on sex or reproductive evidence.

We selected five stations that had previous and consistent wolverine sightings over the past seasons. We replaced the tree sets with frame mounts at those locations.

As was the case with tree sets, we had mixed success of wolverines using the frame mounts, where some individuals chose not to climb the tree and/or frame mount. The frame mounts were similar in their success at capturing genetic material compared with the tree sets.

Wolverine Results and Discussion – Reproduction, cont'd

The wooden frame mounts proved successful for our goal, as we documented evidence of lactation in a female (Lefty-White-Toes) at one station in the Sapphire Mountains in late March 2018 (below). We had previously documented only two adults total in the Sapphires, including the female. After seeing her evident nipples/teats, we kept a (non-baited) station deployed there past the typical field season in hopes of documenting wolverine offspring (kits).

This was successful, as she returned with three kits in early June (below). They spent 10 minutes at the station, chewing on bones from the previous season, sniffing the frame, grooming themselves, and making vocalizations. This is the first time reproduction has been documented in the BNF. We used video settings and obtained some of the best available kit footage captured from wildlife game cameras. It provides evidence that the Sapphire Mountains and BNF have a resident wolverine population.

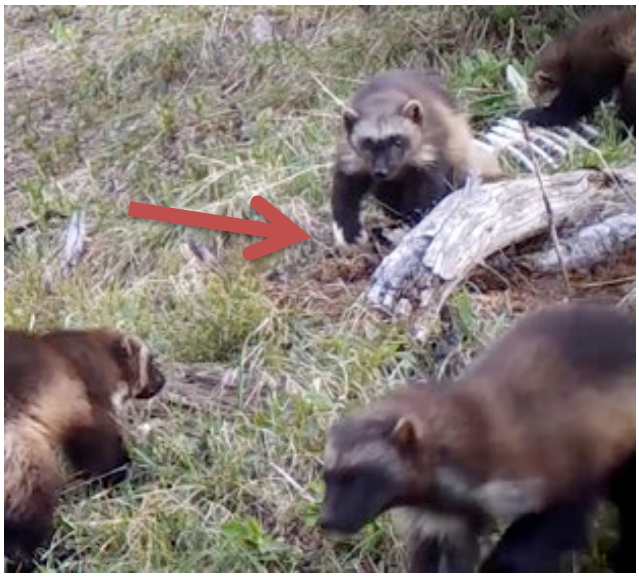
We attempted to get further footage that summer and early fall by adding more cameras in the area with scent lures in the cameras view but did not document further wolverines during that time. We did not seek permission to place bait during that summer/fall period, so these stations were not baited.

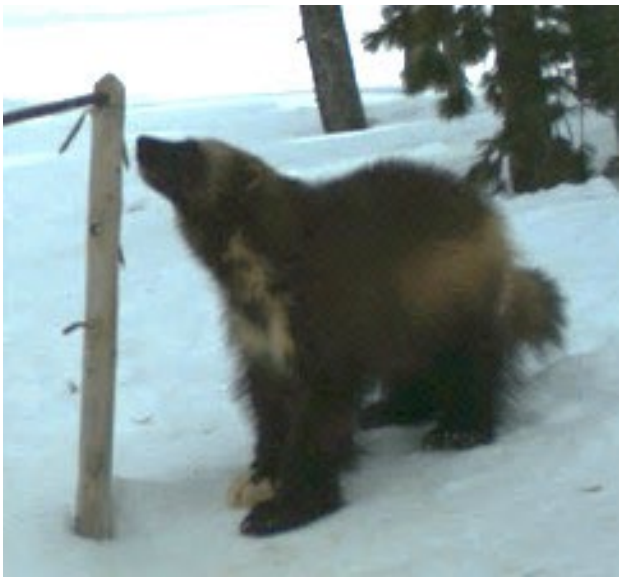
Wolverine Results and Discussion – Reproduction, cont'd

One of Lefty-White-Toes' kits had a unique right white foot pattern; we named it Righty. That individual kit was documented on its own the following winter season, which marked the first wolverine with an age we could confirm.

Juvenile wolverines tend to remain in their parents' territories into their second year and continue to travel with their parents at times during that period. This occurred here, as Righty generally seemed to follow a day behind Powder-Paws (male/father) or Lefty-White-Toes (female/mother).

Righty was last seen in the study area in April 2019. Righty then seems to have forayed about 20 miles north, as what appears on video imagery to be the same individual was captured on a wildlife camera on a private property in the northern Sapphires in July 2019. This distance could have been a typical movement or a dispersal-related movement; subadults dispersing from the home range of their mothers have been found to travel hundreds of kilometers (Magoun 1985, Copeland 1996, Flagstad et al. 2004, Inman et al. 2012). This private property has over 100 wildlife cameras running for many years and has only documented wolverines twice.



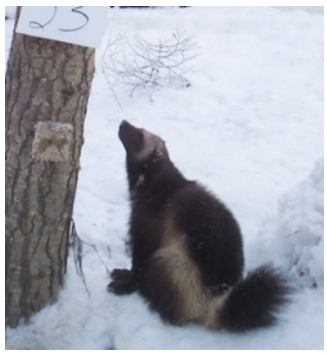


Wolverine Results and Discussion - Habitat

Wolverines were documented at 19 stations over the five seasons (Table 9). Elevation at sites with wolverine detections averaged 5,864 feet across all wolverine detections in the five seasons. The lowest elevation with a detection was 3,773 feet and highest was 7,900 feet.

Of the 37 total stations used, only six were within Wilderness (Figure 2, earlier in document). Five of those had wolverine detections. No stations were placed in Wilderness due to permit restrictions in the first year. The following year permits allowed Wilderness placements, and WW placed stations in Wilderness. This allowed deeper access into wolverine habitat in those locations.

While stations placed to target wolverines were placed within likely wolverine habitat, most of them were very near but not within the specific polygons of modeled wolverine habitat (Inman et al. 2013). To allow feasible access during winter months by volunteers, stations were positioned somewhat near existing trails. Therefore, most wolverine detections were not within modeled wolverine habitat (Figure 6), but most of the stations that had been selected to target wolverine did indeed detect wolverines. While most wolverine detections were not within the model, they were very near it, often in lower-elevation drainages between mountains that contained modeled habitat. Those lower drainages offered overall security and habitat and given wolverines' ability to detect food sources and travel vast distances, it was not surprising to document wolverines in those areas. Additionally, seasonal shifts in elevation have been observed for wolverines, moving to lower elevations in winter to follow food sources such as fall hunting season carrion and higher elevations in summer for cooler temperatures (Hornocker and Hash 1981, Copeland 1996). A couple stations, particularly Camas Creek and Sweeney Ridge, were expected to but did not detect wolverines.



The number of wolverines detected with both the WW effort and the USFS effort falls within the wolverine population estimate for the Bitterroot Mountain range (Inman 2013). The BNF contains high-quality wolverine habitat sufficient to maintain a significant wolverine population.

In the Bitterroot Mountain range, there is extensive wolverine habitat that is well-protected and secure, as it is public land in the National Forest system, and much is protected as Wilderness. This supports other studies and models that indicate this region is an important and sizeable piece of core habitat for wolverines (Copeland et al. 2010; Inman et al. 2013). The Bitterroot Range is assumed to act as a connectivity zone between this area and populations in northwest Montana and Canada (Cegelski et al. 2006; Schwartz et al. 2009).

The Sapphire Mountain range is protected as public land within the National Forest system, though it has fewer wolverine detections; only two adult wolverines (and three kits) were documented in the Sapphire Mountains. Our survey effort was lower on the Sapphire portion, and modeled wolverine habitat is also less extensive there (Figure 6).

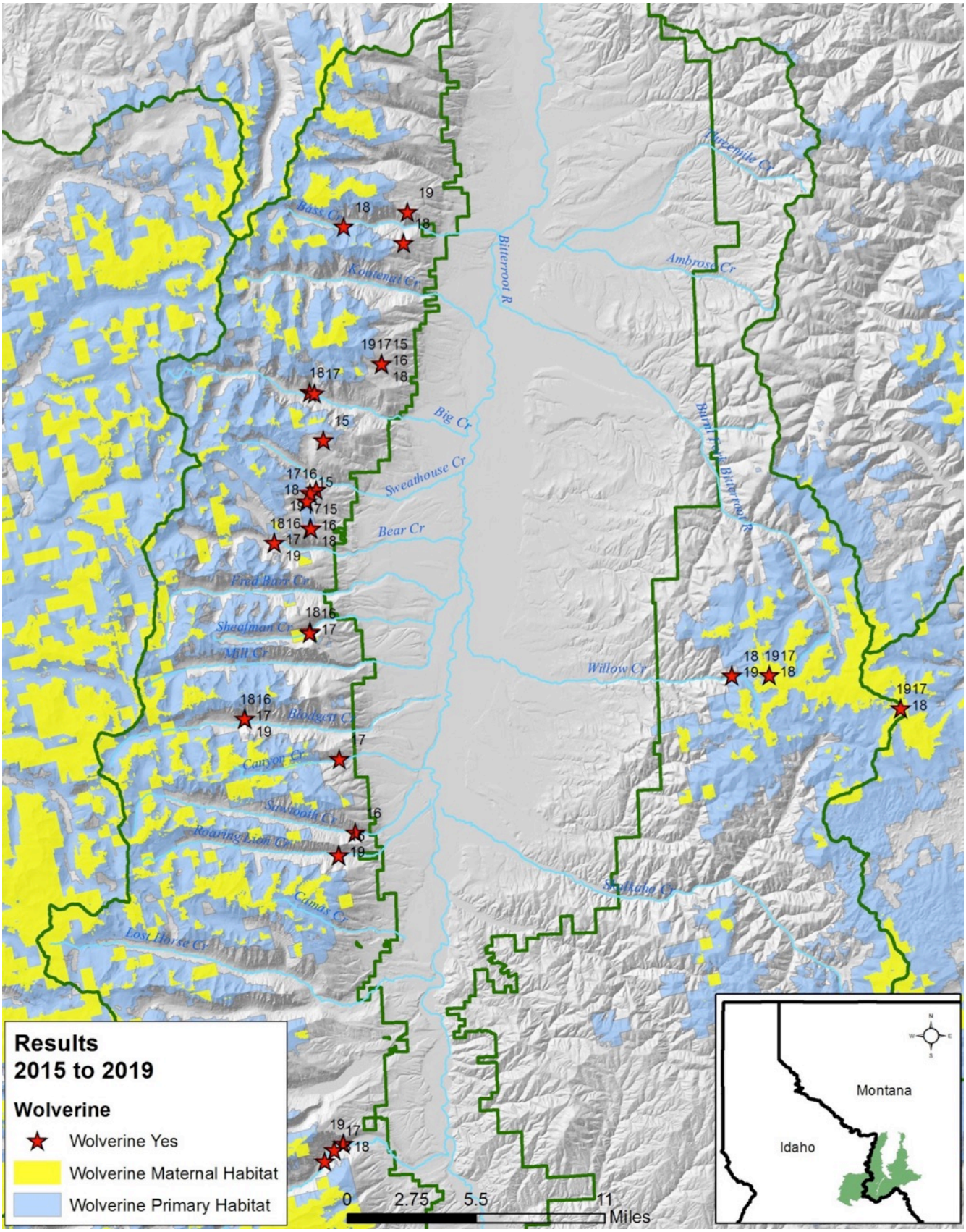


Figure 6. Locations of wolverine detections across the 5 seasons by WW mesocarnivore monitoring project, with modeled wolverine primary and maternal habitat (Inman et al. 2013). In some locations, there was more than one station nearby due to other efforts (i.e. 2018 FWP fisher study), appearing as clusters of stars.

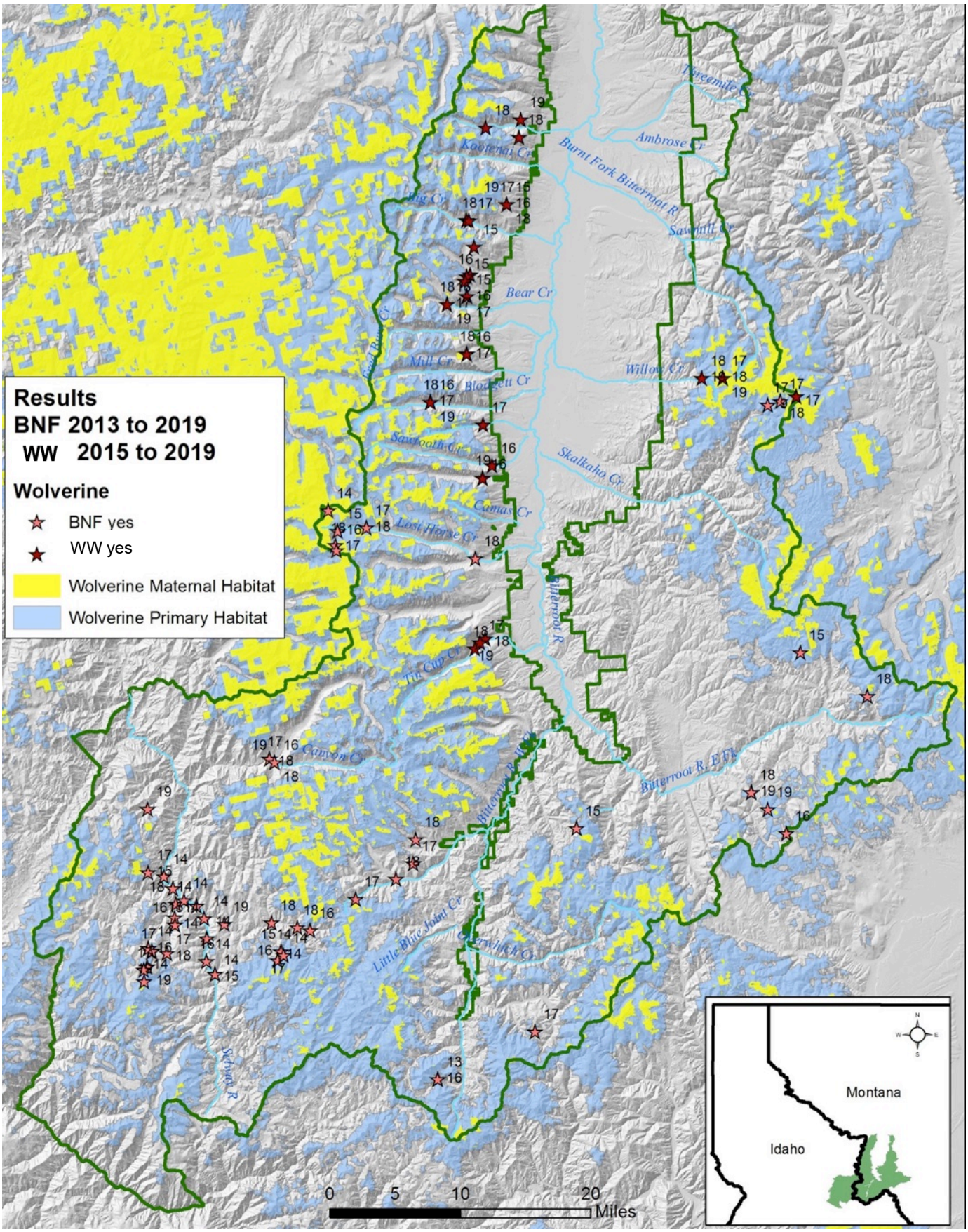


Figure 7. Locations of wolverine detections by both WW monitoring and by USFS monitoring, across seasons, with modeled wolverine primary and maternal habitat (Inman et al. 2013). In some locations, there was more than one station nearby due to other efforts (i.e. 2018 FWP fisher study), appearing as clusters of stars.

Fisher Results and Discussion

WW documented fishers via photographs at one station in 2019, two stations in 2018, one station in 2017, and none prior. We attempted to obtain genetic material from the 2017 fisher during the summer using fisher-specific hair-snare boxes but did not document any further fisher visits. Genetic results from 2018, unfortunately, did not document fisher. In a collaboration with a Montana Fish, Wildlife & Parks fisher study in 2019, one of our stations successfully collected both photographs and genetic material from a fisher.

Fishers are known to be rare in Montana, yet the Bitterroots are considered the stronghold for fisher occurrences in the state (Vinkey 2003). These fishers are a remnant of a native Montana population that persisted in the Selway–Bitterroot Mountains near the Montana–Idaho border despite early 20th century trapping that had extirpated fishers from other parts of Montana and Idaho (Vinkey et al. 2006, Schwartz 2007). There is modeled fisher habitat in the study area and trappers trap a few fishers each year in the BNF. We were surprised we did not document them in more locations. It appears they are rare in the area.

2017 fisher

2018 fishers

2019 fisher

Martens Results and Discussion

Martens were documented at most of the stations both via photographic and genetic analysis. This bait station methodology is a good tool for documenting martens. It appears that martens occur in many parts of the BNF.

Two species of martens, *Martes caurina* (Pacific marten) and *M. americana* (American marten), are recognized in North America and both occur in Montana (Dawson and Cook 2012; Schwartz et al. 2012; Dawson et al. 2017). They cannot be differentiated via physical characteristics. In 2017 the National Genomics lab began differentiating them in our genetic analysis results. They are able to identify both species based on mitochondrial DNA. Hybridization is known to occur between these species in the northern Rocky Mountains, and further genetic testing on these samples could be performed to determine the level of hybridization.

We documented both species in 2017, 2018, and 2019. In 2017, four stations found *M. americana* and 15 had *M. caurina*. In 2018, seven stations found *M. americana* and 20 stations had *M. caurina,* and in 2019, three stations had *M. americana* and 15 had *M. caurina*. For each season, all stations with *M. americana* also had *M. caurina*.

Martens Results and Discussion, cont'd

Several stations collected footage of two or three martens feeding together on the bait at the same time. These are presumably mates or a family group.

We observed instances where a marten's foot became stuck to the gun brushes, likely due to its fur getting caught within the brush hairs. This was discernable particularly with video footage, though could be seen in the photographs as well. This occurred both with the stations using the tree sets and in those using the wooden frame mount system. The martens were not stuck for a long period but did slightly change their behavior at the time as they struggled to free their foot.

As wolverines have pelage markings on their necks and chest, martens also have markings that could be used to help distinguish individuals. These markings presumably persist through the life of the marten. We did not attempt to identify martens but propose that it could be feasible, though likely challenging due to the smaller size of martens which could impede sufficient view of their markings.

Conclusion

To conclude, WW has considered whether and how we have met our project objectives:

Objective 1: To contribute data to increase the research, management and conservation communities' understanding of the distribution and activities of wolverine and fishers

We documented important information about wolverine, fishers, and other species.

We shared our data in a variety of manners.

- The locations of marten, fisher, and wolverine observations were shared each season with the USFS.
- The genetic analyses of wolverines and other species were performed by the USFS National Genomics Center for Wildlife and Fish Conservation. Those data remain in their possession and we encourage them to use it for further analyses.
- WW provided species observation data for each season to the Montana Natural Heritage Program (MTNHP). MTNHP is a program of the Montana State Library's Natural Resource Information System that is operated by the University of Montana. It provides information on Montana's species and habitats, emphasizing those of conservation concern. These data can be used by other researchers and can be viewed (with some key information hidden) by the public.

WW aims to further share our data. If entities or University students or professors are interested in this dataset, WW is keen to continue sharing and examining the extensive information gathered. Further research questions could include methods analyses looking into comparing photo versus genetic analysis, repeatability of photo analysis, and other topics. Additionally, if interested in further information such as the protocol manual and specific details of project protocols, volunteer management, and so on, please contact the author.

Objective 2: To collect and share data to inform management decisions on the BNF and elsewhere

WW's data and results can help inform a wide range of regional management efforts. These data can and already have contributed to analyses in BNF management projects and project planning decisions. At the project planning scale, detection locations can be used when deciding where management actions should occur and can help identify areas of potential use by these species and where improvements to habitat may be appropriate. Additionally, it would be valuable to analyze a combined WW and BNF wolverine dataset more in depth to gain a fuller understanding of the wolverine population. We're taking steps to undertake that analysis.

Objective 3: To increase the public's awareness and support of these species

Over 450 volunteers took part in this project, providing them with an opportunity to collect data and get outdoors in the winter. Through their participation, volunteers became strong supporters of wolverines and other species in the region.

Outreach and education is essential for conservation. WW developed an online presence (Facebook and Vimeo) and published newspaper articles for several years, as well as giving numerous presentations to local and regional groups. In each of these, we had continual, significant interest from the public. With this interest, it is clear that continuing to share the results of this project would be welcome and desired.

Objective 4: To demonstrate the ability of citizen science to contribute valuable, cost-effective data

By using volunteers, this project collected data that otherwise would not have been possible to collect due to capacity limitations. The protocol was simple and easily taught and executed, making it feasible for volunteers to accurately collect data in the field, by far the most time-consuming aspect of this work. The budget, therefore, only needed to cover time for two paid professionals, equipment, and season kickoff and end-of-season volunteer events. Genetic analysis was paid for via our partnership with the USFS. Equipment and volunteer management was performed by two paid professionals (project leaders including the author) for several months each season. Data analysis done by the same WW project leader (the author) each year ensured data analysis was consistent and professional.

We also aimed to address the Region One project questions:

Is the species present?

WW documented presence of wolverines in both the Bitterroot and Sapphire Mountain ranges and fishers in the Bitterroot range but did not document presence of lynx.

If yes, then: Are multiple individuals (including females) present?

WW documented multiple individuals of wolverines, including females, each year. We did not document multiple individuals of fishers.

If yes, then: Is there a reproducing population present?

We documented reproduction of wolverines by capturing images of a lactating female and footage of three kits.

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