Wolverine Population Assessment in Glacier national Park

Comprehensive Summary Update

January, 2008

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Executive Summary

The Glacier National Park Wolverine Research Project has completed its fifth and final year of study. Research pursued two primary objectives: 1) live-trap, radio-instrument and monitor wolverine to describe their distribution and reproductive status, and 2) locate natal and maternal dens, and rendezvous sites, and characterize associated landscape features. Secondary objectives included the investigation of wolverine demographics, the relationship between reproduction and winter recreation, and a description of wolverine home ranges, movement, and habitat use. Twenty-eight wolverines (13 males, 15 females) were captured and 27 instrumented, providing over 30,000 relocations. We documented 23 reproductive sites for 6 adult females. Dens occurred beneath deep snow most commonly on upper slopes of sparse timber structurally tied to downed woody debris, rock caves, and boulder talus. Seven kits were captured and instrumented at den sites. Monitoring of kits and mothers through their first summer provided 30 maternal care (rendezvous) sites occurring primarily in boulder talus and cliff areas. Kits became independent of their mother by mid to late September, at 6-7 months-of-age. Kit survival to adulthood was low as evidenced by 5 of 7 kits dying during their first year. In cases where the cause of death could be determined, mortality was attributed to predation (1), shooting (1), and fall from a cliff (1). Two adults died during the study period; one female killed in an avalanche, and one male from predation. Three subadults were killed during the study: a male was legally trapped and killed outside GNP as a disperser, a second subadult male was killed by construction activity on the Going-to-the-Sun Road in GNP, and a subadult female appeared to have been gored to death, presumably by a mountain goat. GPS collars provided data on rates of movement, habitat use, activity, and social interactions. Wolverines followed traditional routes moving over 150 km/week at a rate of approximately 4 km/hr with long-distance movements (commonly exceeding 10 km) interspersed with localization periods at foraging and/or resting sites of up to 60 hrs. Travel routes commonly intercepted uninhabited dwellings and developed areas within the park, and included snowbound roads and trails. Two young wolverines dispersed from GNP during the study period. One subadult male traveled approximately 100 miles to the Northwest Peaks Natural Area in northwestern Montana in 2004. A subadult female moved 55 miles south into the Swan Range in early 2007. Wolverine home ranges averaged 521 km^2 for males and 139 km^2 for females. Scat (n=142) and prey remain (n=55) samples are being analyzed to provide food habits data. DNA profiling indicates limited population structuring with a few established resident males contributing to most of the reproduction. Based on habitat distribution and spatial use, GNP appears to support a stable-to-increasing population of between 40 and 45 individuals.

The findings presented herein are preliminary results, provided to meet commitments to granting agencies and organizations and update project contributors and supporters. Report prepared in January, 2008.

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We extend our deepest appreciation to Glacier National Park for inviting us to study this incredible animal, to the Glacier National Park Fund whose enthusiasm and support kept the project afloat, and to the dozens of contributors and volunteers who gave so much to insure our success.

Preface

The Glacier National Park Wolverine Ecology Study began in the fall of 2002 with the primary objective of investigating wolverine reproductive ecology. Prior to this research, reproductive dens of only 2 female wolverines had ever been located in the contiguous U.S. Increasing interest in winter recreation had necessitated consideration of disturbance issues that agencies were not adequately prepared to address given, at the time, that our familiarity with even the most general wolverine ecology was limited to information provided by only two US-based field studies. While the Glacier National Park wolverine project was initiated to further our understanding of the wolverine's ecological role within the park, it grew into an opportunity to extend knowledge well beyond administrative boundaries as a result of dedicated field personnel, continued agency interest, and support from private NGOs and individuals. Over the course of 5 years we instrumented 27 individual wolverines which occupied nearly half of Glacier National Park. This provided an unprecedented opportunity to study the lives, the relationships, and the habitat associations of one of the rarest and most elusive carnivores on the planet. Without question, the gift of wolverine insight provided by the first animal captured in the study, male M1, has been beyond measure. M1 was given the name "Piegan" in honor of the Blackfeet Nation. Piegan benevolently traveled over a thousand miles through Glacier National Park festooned with a GPS collar recording his movements at 5 minute intervals, ultimately providing over 18,000 GPS locations. Through these data we observed his remarkable winter ascents over Grinnell Point and the Continental Divide, his attentiveness to his females and kits at winter den sites, and his crafty avoidance of our traps. Through 5 years, Piegan sired nearly a dozen kits as his genetic roots extended across Glacier National Park and beyond, providing the core for our understanding the wolverine of Glacier National Park.

The Glacier Wolverine Project ended with this fall's field season. Over the following months we will be analyzing data to produce a comprehensive final report and peer-reviewed research papers.

Jeff Copeland
Rick Yates

We dedicate this to the memory of Grace Kirshner

The rugged mountains and subalpine meadows of Glacier National Park typify wolverine habitat in the western United States.

Capture and Monitoring

Capture of wolverines in Glacier National Park (GNP) began in January 2003 and occurred only during winter months to avoid conflicts with bears. Twenty-one wolverines were captured over 5 trapping seasons using 12 log box traps (Figure 1). Most traps (9) were located east of the Continental Divide (Figure 2). In addition, seven juveniles were caught by hand at reproductive dens. Twenty-seven individuals were marked using VHF implant transmitters and 13 of those also carried a GPS or ARGOS satellite collar for at least 2 weeks.

Throughout the study, we relied on conventional VHF telemetry to routinely locate individual animals. Most telemetry data were gathered by ground-tracking methods whenever possible. Fixed-wing telemetry fights were kept to a minimum due to GNP management concerns regarding aircraft disturbance to park visitors. Aerial telemetry mostly occurred in months of reproductive denning (Feb. - May) and were essential for locating females at den sites. Additional monthly flights were necessary to monitor survival, general distribution, and dispersal of study animals (Figure 3).

Figure 1. Wolverine trap in Glacier National Park

Survivorship

An in-depth analysis of survivorship is best accomplished with long-term datasets that account for natural variability in survival over time. For instance, 4 years of monitoring central Idaho wolverines found a level of mortality in adult females that was much higher than could be expected to maintain a population over the long term. In GNP, we experienced an unusually high incidence of mortality in young individuals, where 5 of 7 wolverines marked as juveniles did not survive to adulthood. We expect this represents an unusually high incidence of mortality in juveniles.

Preliminary survivorship analysis indicates that the probability of a juvenile wolverine in GNP surviving past its 1st year is about 58%, while a subadult has a 53% likelihood of surviving to adulthood. Once a GNP wolverine reaches adulthood, its probability of surviving through any given year is about 96%. That value drops to 85% when we consider the probability of survival throughout our 4 year study period. These values, along with a fecundity rate of about 29% (proportion of female kits/female/year) indicates that the GNP wolverine population is likely increasing by about 5% per year.

By the numbers

28 - Number of individual wolverines captured

169 - Number of times wolverine were captured

34,375 - Number of GPS locations collected 2005-2007

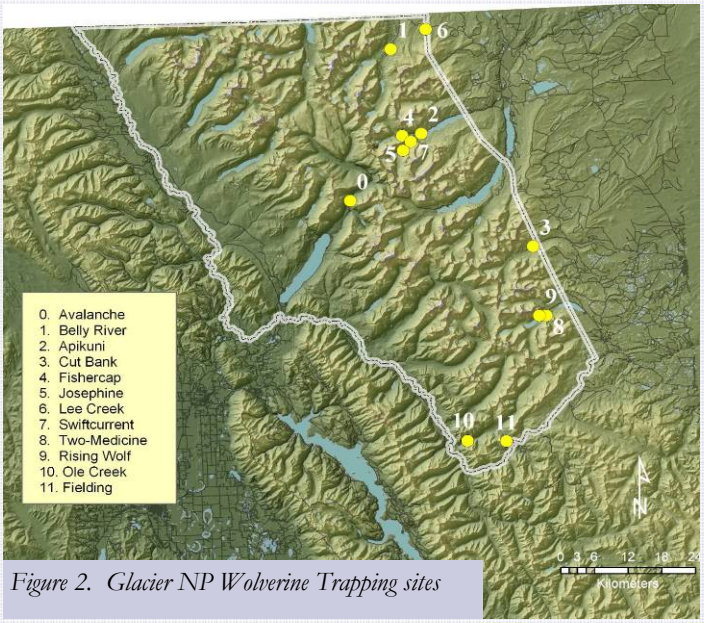


Figure 2. Glacier NP Wolverine Trapping sites

Mortality

During the study, 10 wolverine mortalities were documented (4 juveniles, 4 subadults, and 2 adults). Subadult male M8 was legally trapped in December 2004 on the Kootenai National Forest. Two male kits (M9 & M10), born in 2004, died during their first year. One was legally shot by a trapper outside the park boundary, and the second died of unknown cause at approximately 9-10 months of age. A 2005 male kit (M18) was killed by an unknown predator at 8 months of age. The second 2005 male kit (M19) died (as a subadult) of unknown cause in 2006. A 3-year-old adult female (F5) died in an avalanche in April 2005. In September 2006, female kit F21 died in a fall. Subadult female F24 was killed by a puncture wound in April 2007, which appeared to have been inflicted by a mountain goat. Adult male (M16) was killed by an unknown predator in July or August 2007, and was found dead near the remains of a Bighorn Sheep carcass. A fourth subadult (a male), not captured during the study, was killed

on the Going-to-the-Sun Road by road reconstruction activity in October 2007.

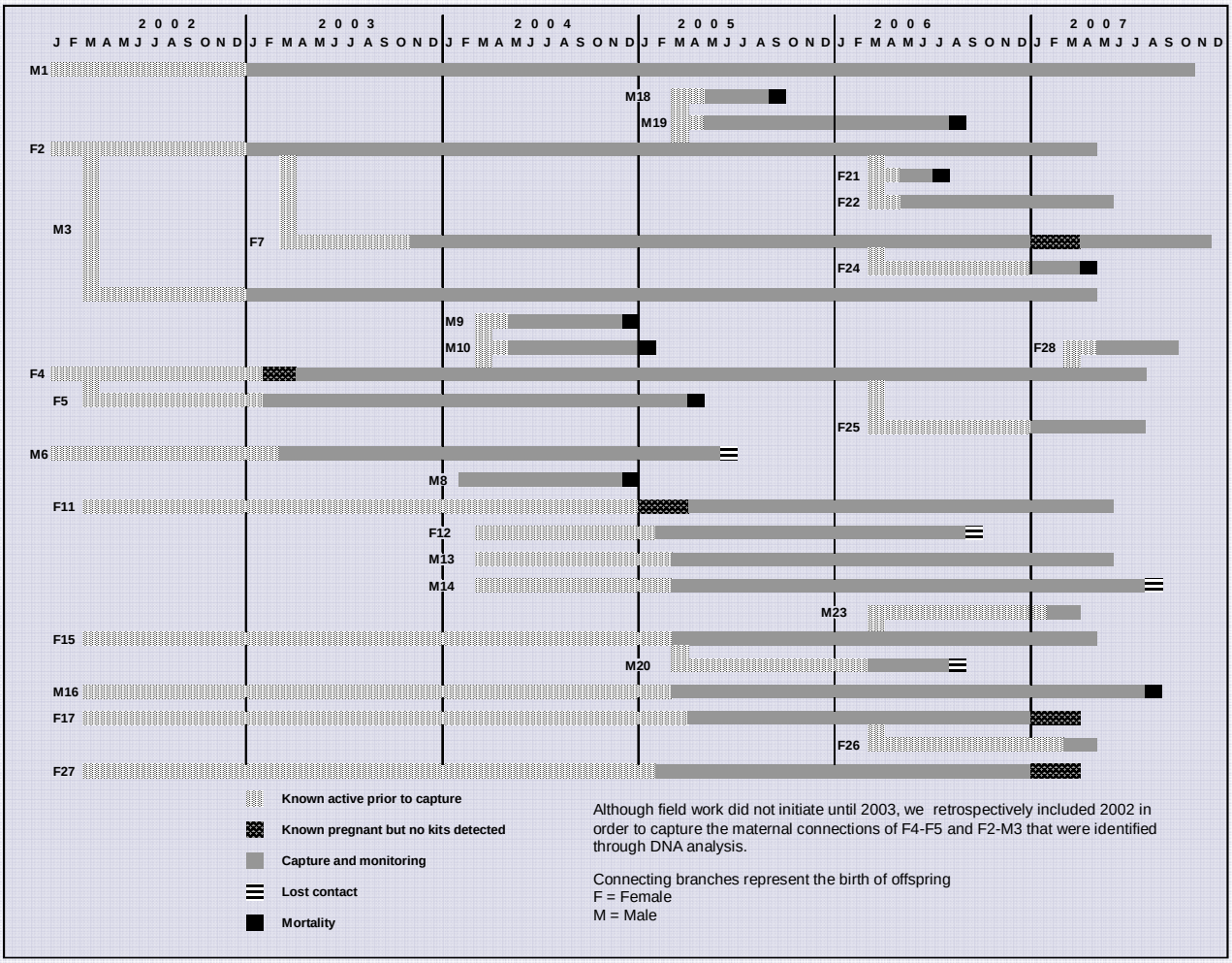
Dispersal

Two dispersals of wolverine study animals have been documented to date. Yearling male (M8) left Glacier park about a week after its initial capture in February 2004. He moved from the Many Glacier Valley to the southern Whitefish Range in early March where we closely monitoring his movements until he disappeared in early April. In late July, U.S. Fish and Wildlife Service researchers conducting a grizzly bear flight in the northern portion of the Kootenai National Forest detected M8's telemetry signal near American Creek. They continued to monitor M8 near the Northwest Peaks Natural Area until

This six-year time-table of wolverine relatedness, survival, and reproduction provides a rarely obtained dataset representing several individuals and generations across half the lifetime of a wolverine. Longer term studies, at multiple study sites, are necessary for understanding the natural variation that is inherent in wild populations.

DR. DAN SAVAGE HOLDING A KIT CAPTURED IN MAY, 2007

Figure 3. Time periods of study animal monitoring and maternal relatedness



he was legally taken by a trapper in December 2004. He had traveled over 200 kilometers from GNP, as measured by straight-line distance. Subadult female F26 was captured in the Two Medicine Valley in February 2007. She left GNP by March and was found on a survey flight in August, 55 miles south of her last location. Her movement south from GNP to the Flathead National Forest took her through portions of the Great Bear Wilderness and across Hungry Horse Reservoir. However, this location may not represent her final dispersal point. During the study four other subadult wolverines, likely dispersers, (1 female, 3 males: F12, M14, M20, and M23) disappeared from GNP.

Wolverine Reproductive Ecology

Reproductive rates

Female wolverine reach sexual maturity as yearlings but generally don't produce their first litter until they are 3 years old. Litter sizes are normally 2-3 kits with sex ratios generally approaching 50:50. Studies conducted on trapper-killed wolverine carcasses report pregnancy rates ranging from 70-90% in adult (>2 years old) females. Most field ecology studies report the number of kits/female at weaning age (9-10 weeks-of-age) as less than 1 suggesting that less than half of reproductively mature females are taking kits from conception to weaning.

From 2002 - 2007 we documented 19 pregnancies by GNP wolverines for a pregnancy rate of 68%. Females produced 21 kits, or 0.75 kits/female/year. Kits remained with their mothers until mid-late September of their first year (6-7 months of age). After separation, kits generally remained within their father's home range, but were also documented moving into an adjacent female's home range.

Denning

Females select den sites at locations where deep snow (2-3 meters) persists until time of weaning in early May. Dens are occupied by late February and occur under snow, at ground level, in natural cavities that form beneath downed trees or boulders. A female may use multiple den sites prior to weaning, which may be due to disturbance or unfavorable conditions resulting from cold or moisture. The den in which kits are born is termed the "natal den." Dens used subsequently, but prior to weaning, are called "maternal dens." Once the kits wean, they travel with their mother for up to 4 months. During this time, females may leave kits at "rendezvous sites" while she forages and/or mates.

Natal and maternal dens are very similar in structure, most often associated with down and dead whitebark pine or subalpine fir. Dens in GNP commonly occurred at or just below treeline.

Entrance to natal den. Note tracks leading to hole under cliff.

We documented 14 natal and maternal dens for 3 GNP females, along with over 30 rendezvous sites. All of these sites were visited, mapped, and measured. We documented an additional 10 den sites associated with 3 other females, which were not confirmed or visited by field personnel due to their inaccessibility.

Genetics

DNA analysis will help clarify our understanding of relatedness within the GNP study population, but more importantly it will allow us to gauge how the GNP population contributes to the overall genetic fitness of the broader northern Rocky Mountain population. Genetic fitness is generally measured in terms of the degree of genetic variation, or allele frequency, within a population. This degree of allelic frequency provides a metric of genetic fitness termed "effective population size" (N_e), which is a measure of the portion of the population that is actually contributing

to the transfer of genes from generation to generation. Populations that are small tend to lose genetic variability through inbreeding, leaving populations less adaptable to random environmental changes. Wolverine populations are vulnerable to inbreeding depression due to their naturally low population densities.

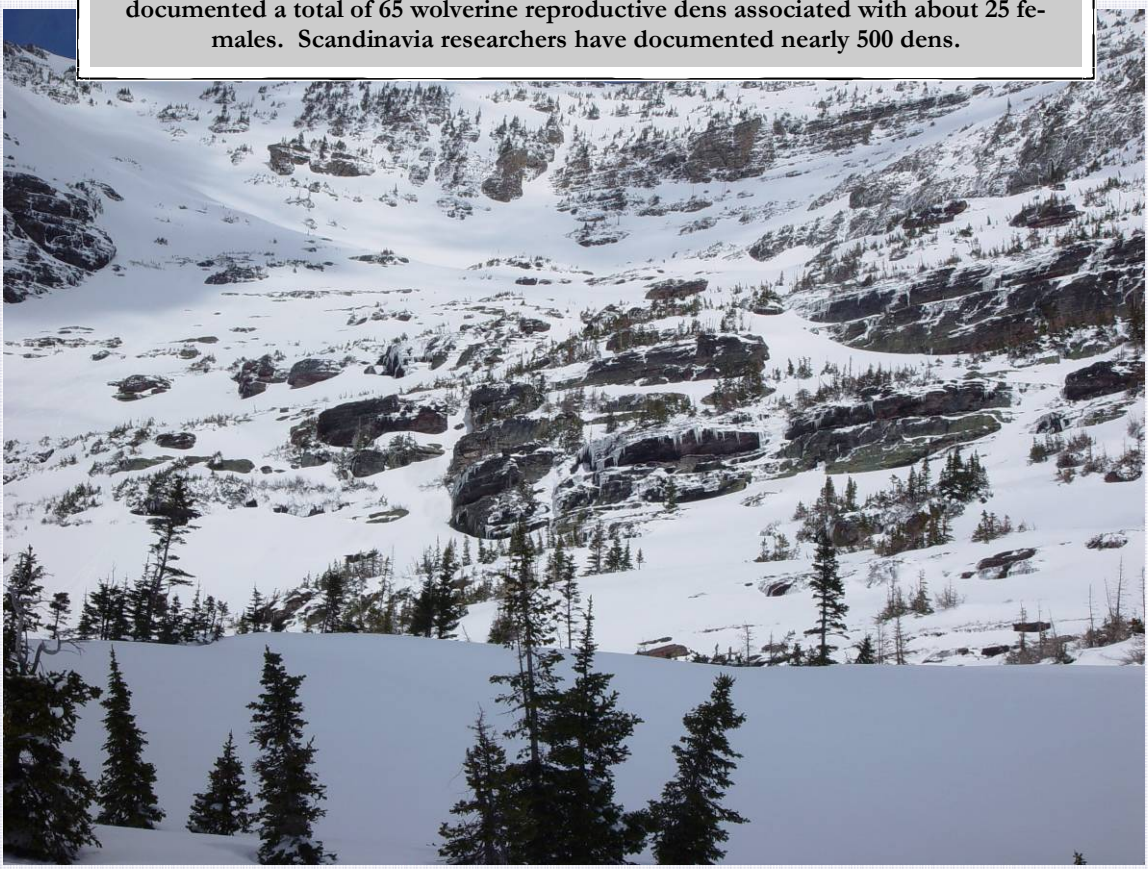
Conservation biologists have worked under a rule of genetic variation termed the "50/500 rule", which states that an N_e of $\geq$ 50 is necessary to ensure short-term survival and minimize the risks of inbreeding, and an $N_e \geq 500$ to ensure long-term survival through the ability to adapt to environmental change. Recent genetic analyses at the Rocky Mountain Research Station Wildlife Genetics Lab suggest $N_e = 18$ for GNP wolverine and only 39 for the entire northern Rocky Mountain population. These numbers are reminders of the naturally low population densities at which wolverine persist, underscore the essentialness of viable connective corridors, and emphasize the importance of GNP as a wolverine refuge and source population to the surrounding region.

Genetic-based analysis of wolverine relatedness, along with continuous monitoring of study animals, allowed us to extend our time table of parent-offspring and sibling relationships back to the year 2002 (Figure 3).

Site of parturition in natal den. Note chewing on sides of log and bed of wood chips.

This contributed to our understanding of reproductive parameters and survivability as well. Future analyses will assess the congruence between genetic relatedness, spatial distribution, and social interaction.

The discoveries of reproductive dens in Glacier National Park doubled our sample of known wolverine dens in the contiguous US. Researchers across North America have documented a total of 65 wolverine reproductive dens associated with about 25 females. Scandinavia researchers have documented nearly 500 dens.



Typical wolverine denning habitat in Glacier National Park. Downed trees, cliffs, and boulders provide natural cavities under a deep blanket of snow, which provides protection from predators and insulating warmth for the kits.

Wolverine Spatial Use and Sociality

Recent technological advances in GPS technology currently provide lighter weight and more power-efficient transmitters enabling researchers to consider GPS study of small carnivores such as wolverine. This study played an important role in the development of that technology. We worked directly with manufacturers in the creation of smaller, more ergonomic collar systems, and improved designs to avoid potential collar-related injuries. However, a GPS collar, suitable for wolverine, that reliably acquires high frequency location data for an entire year is still unavailable due to battery limitations. Our study's high wolverine recapture rate and a GPS collar design that allowed on-site battery replacement and data download, enabled us to acquire short duration, high fix-frequency data. These data, in turn, will allow us to investigate wolverine movement at various temporal and spatial scales during winter months, which will provide a better understanding of both the capacity of wolverine movement and the ecological constraints of those movements across the landscape.

Home Range

Home ranges of wolverines in GNP are considerably smaller than home ranges documented in other studies; an indication that GNP provides a rich and diverse habitat for wolverine (Figure 4. Table 1). Adult home range size for males and females averages 521 and 139 km² respectively. Still, population estimates for Glacier National Park are expected to indicate only 40-50 individuals.

Currently, it appears that 3 wolverines are established residents of the Many Glacier Valley. M1 is the resident male associated with resident females F2 and F4. Male M3 and female F15, residents of the Belly River area, make occasional forays into Many Glacier, most likely stimulated by the availability of food at our traps. Females F11 and F7 remain mostly west of the Continental Divide with F7 making occasional forays to Logan Pass, while F11 remains primarily in the Livingston Range centered around Vulture Peak in the upper Logging Creek area. Several individuals associated with the Two Medicine area have not had their spatial juxtaposition well defined due to a lack of telemetry locations. Adult male M16 may have been the resident male for the south-eastern portion of the park, yet he appeared to center his activity in the St. Mary Valley. He died in early 2007. Female F17 is a Two Medicine resident adult that may have been associated with M16, but has most recently been mated with M13, an adult male that ranges between Logan Pass and Mount Rockwell.

Table 1. Minimum convex polygon (100%) home range sizes for adult wolverines in Glacier National Park, 2007.[a]

Animal ID	Current Age/Sex	N (locations)	Home Range (km^2)
M1	Adult male	171	438
F2	Adult female	204	167
M3	Adult male	152	749
F4	Adult female	205	207
F5	Adult female	123	121
M6	Adult male	33	312
F7	Adult female	38	140
F11	Adult female	22	80
M13	Adult male	11	587
F15	Adult female	33	72
F17	Adult female	11	150

[a]Home range analyses include only VHF telemetry relocations across all years.

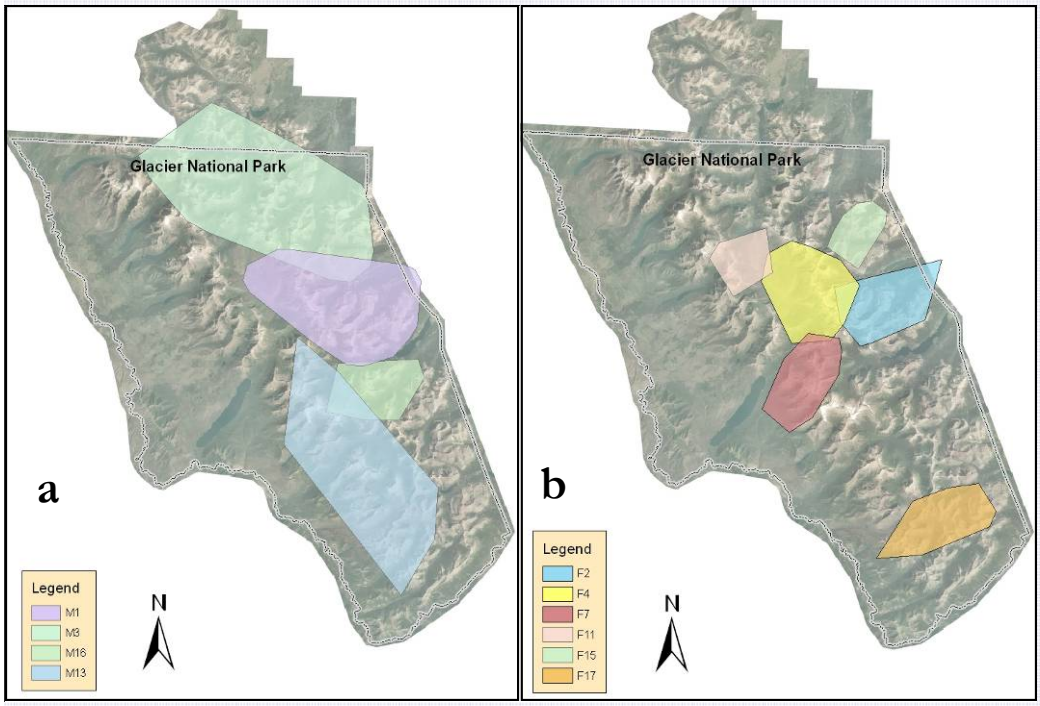


Figure 4. Home ranges of male (a) and female (b) wolverines in Glacier National Park

Social interactions

Understanding the intraspecific relationships in wolverine populations may provide important insight into spatial and social population structure. Anecdotal accounts of interactions among wolverines continue to increase as research techniques improve our ability to more closely monitor individuals over time. Evidence of sociality, documented in central Idaho wolverines, was strongly reinforced in GNP. We documented over 60 instances in

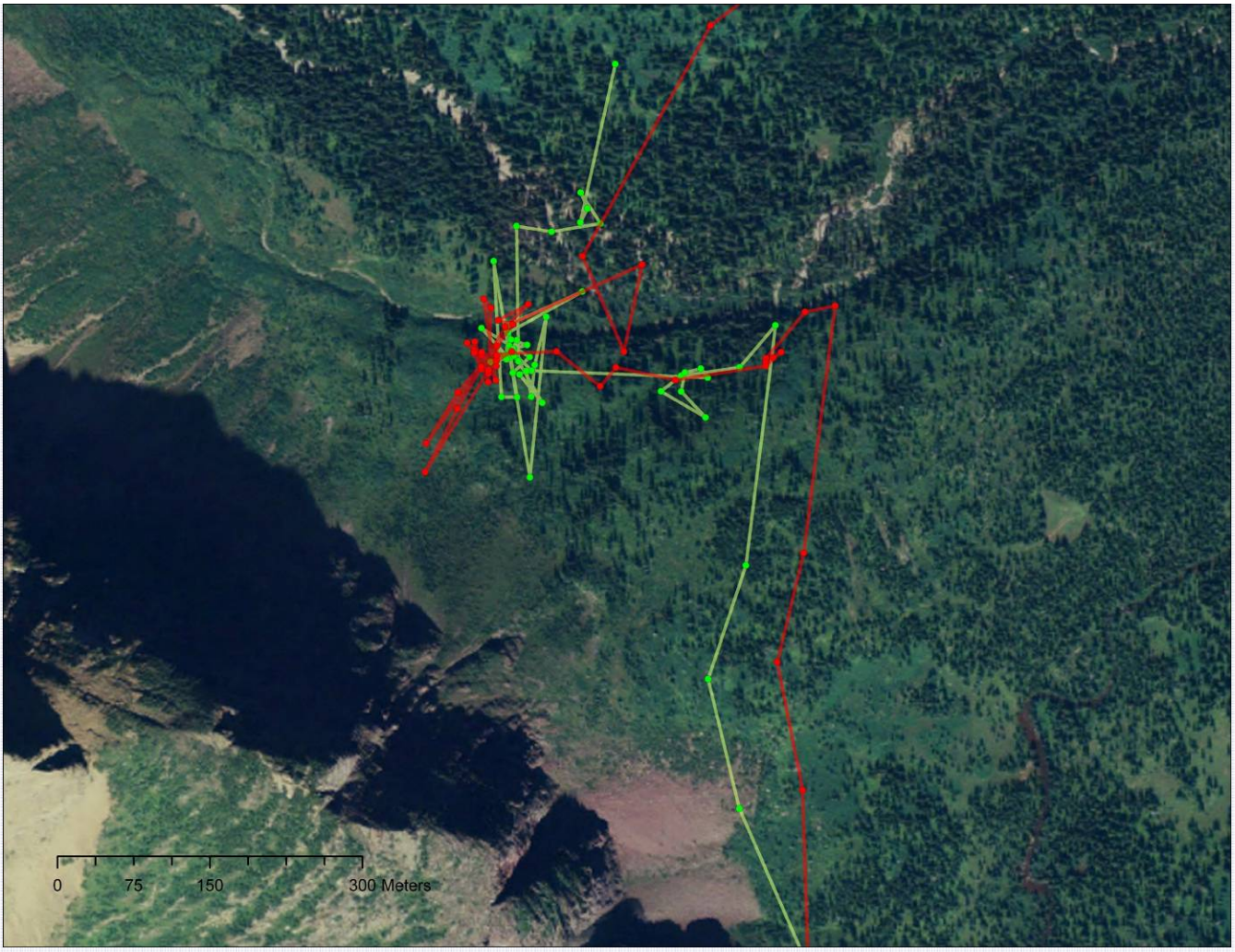


Figure 5. GPS data showing pairing of Belly River male M3 (red line) and his juvenile offspring, M23 (green line). Both individuals met at the outlet of Helen Lake, then traveled north where they stopped for several hours. They left together although M23's GPS collar quit shortly. This sort of social interaction between a resident male and subordinate male is extremely unusual for any carnivore species outside of the most social of the carnivores. It suggests a much more highly developed sociality than previously thought and indicates the possibility of male parental care in wolverine.

which GNP wolverines were found together or near one-another, not including pairings between adult males and females during the mating season. Seventeen of these instances occurred between Many Glacier male M1 and his offspring.

It is not uncommon for GNP visitors to see two wolverines together. Most often these are probably siblings that remain together through the summer months while under the supervision of their mother. Female F7 frequents the Logan Pass area where she and her offspring are commonly seen near Hidden Lake during the summer. Female F4 and her kits are occasionally seen along the Highline Trail hunting ground squirrels and marmots. Occasionally, father-offspring pairings occur once the juveniles separate from each other and their mother (after September). If juveniles remain in their natal areas, at some point they will make contact with their father. This pairing may benefit the offspring as the adult male shares knowledge of travel paths and forage sites (Figure 5).

Fine-scale GPS monitoring in GNP also provided an opportunity to intensively track multiple individuals, and thereby monitor movements and distribution in time and space. Our GPS data, which is currently under analysis, provided evidence of 2 instances in which a resident male visited, and most likely entered the den of a reproductive female (Figure 6). Such interactions in solitary carnivores are remarkable and significant to understanding how wolverine social structure might respond to management activities. For instance, juvenile survivorship that is strongly tied to an extended parental care period which includes participation by the offspring's father, may be altered by a harvest strategy that targets adult males. For a low population density species, such as the wolverine, this knowledge could be critical to population persistence in areas where the species is already rare.

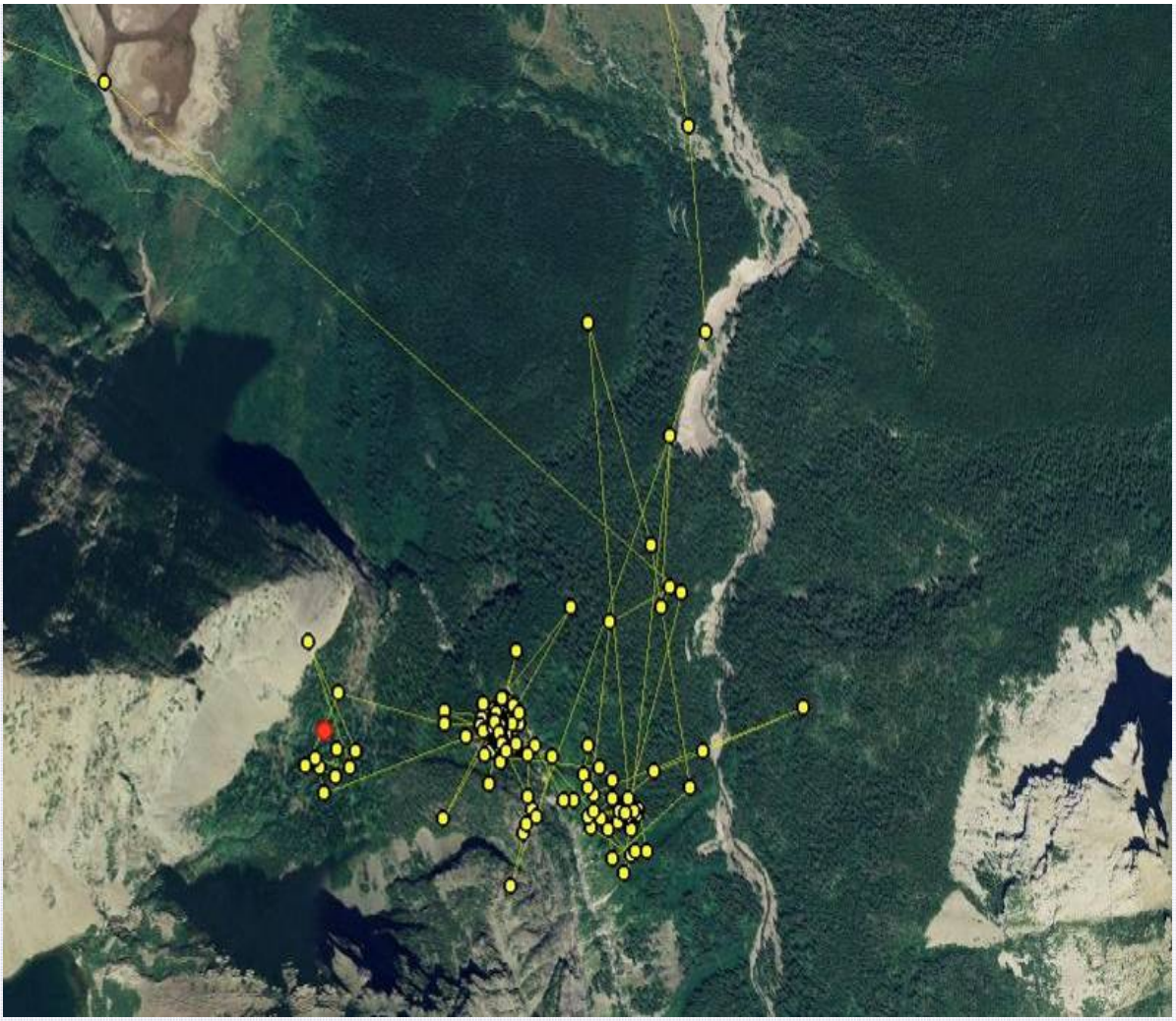


Figure 6. The resident male (green dots) cluster near the female's den (red dot) for several hours. At one point he approached the den and his GPS collar went off the air for 6 hours indicating he had likely went into the den.

Wolverine Movement, Habitat Associations, and Activity

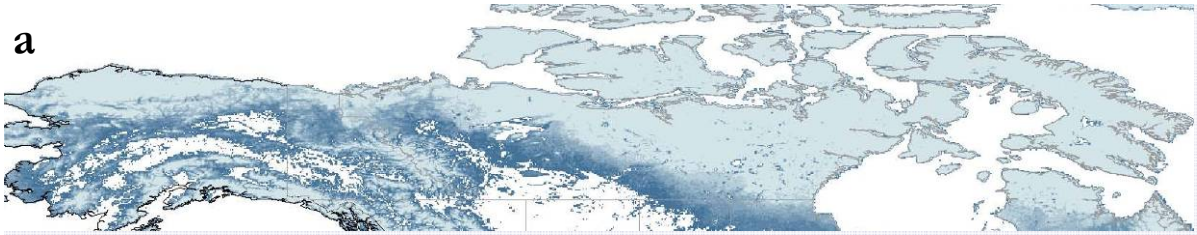
The wolverine's world-wide range is strongly tied to a specific habitat signature; referred to as tundra or taiga at northern latitudes, boreal at mid-latitudes, and subalpine in the south. Wolverine habitat is defined by a tundra-subalpine signature that effectively restricts its range. At northern latitudes, wolverine habitat occurs virtually everywhere, but to the south, the subalpine lifezone necessary for wolverine presence becomes restricted to an elevational band, resulting in a naturally fragmented distribution (Figure 7).

Populations that are further restricted to island habitats are vulnerable to extinction unless they are able to spatially communicate with neighboring populations. Western Montana and GNP typify this insular population structure more so than anywhere else across the wolverine's range. By studying how wolverine move across the landscape and their response to changes in habitat and encounters with human-related features, we can better predict how changes to the landscape might impact the persistence of populations.

To understand how wolverine respond to the landscape, it is necessary to study their movement at varying scales. The GNP study provided a unique opportunity to view fine-scale movement using GPS technology. In addition, our high recapture rate allowed for collection of multiple data sets on the same individuals. These data will provide an unprecedented look at patterns and rates of movement, and how movement relates to habitat features, foraging behavior, and sociality among study animals.

Patterns and rates of movement

The speed at which an animal moves across the landscape is indicative of its interest in a particular habitat. Analyzing fine-scale patterns of movement helps us better understand how individuals space themselves across the landscape and how that relates to food resources. GNP wolverine display a movement pattern that indicates a patchy distribution of food resources; individuals move long distances to food patches and remain there for a period of time. Our GPS



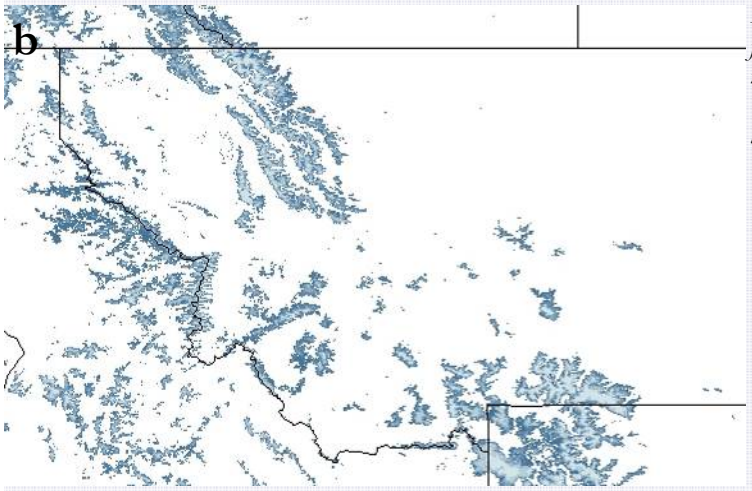


Figure 7. These maps of wolverine distribution in North America , as defined by the distribution of spring snow, illustrate the continuous nature of wolverine habitat at northern latitudes across northern Canada and Alaska (a), opposed to the more fragmented nature of wolverine habitat at southern latitudes in portions of Idaho, Montana, and Wyoming (b).

Avoidance of certain habitat features, topographic characteristics, or human structures documented within an animal's home range at fine-scale may indicate how an individual might be expected to move at larger scale, such as during a dispersal attempt This study's fine-scale GPS data, collected at a rate of 5 minutes/fix attempt, will be used to develop habitat resistance models which will inform us how wolverine relate, and respond to various habitat features. Preliminary analysis of how each 5-minute "step" in the animal's movement is influenced by changes in elevation, and comparing this with the availability of changing elevation across the park, indicates that the wolverine operates as largely a "flat-land" species as it maximizes its efficiency traversing some of the most rugged topography in North America. Glacier park wolverines avoid uphill slopes greater than 5%, and downhill descents greater than about 3% slope as they contour the landscape (Figure 10). This apparent avoidance of steep slopes is confounded by the occasional ascent over such formidable obstacles such as Mt. Cleveland (Figure 11) and Iceberg Notch. Further analysis will refine these results, but we can speculate that traversing might allow the individual to efficiently travel country that provides the highest likelihood of providing food, and in the process conserve energy for necessary ascents over cliffs and peaks.

Elk remains at a cluster site.

data indicate that movement to and from these patches occurs at a rate of about 4 km/hour indicating that little time is spent hunting or pursuing other interests between patches. GPS points tend to show as clusters at these patches (Figure 8). Project personnel investigated these cluster sites to determine the nature of their use by wolverines. During a 7-day period, a wolverine may stop at a dozen such sites, which represent a variety of activities, such as foraging, interactions with other individuals, or simply periods of rest. An adult male wolverine travels in excess of 150 km during this period and generally follows a movement pattern that will be repeated throughout the year (Figure 9).

The relationship between movement and habitat

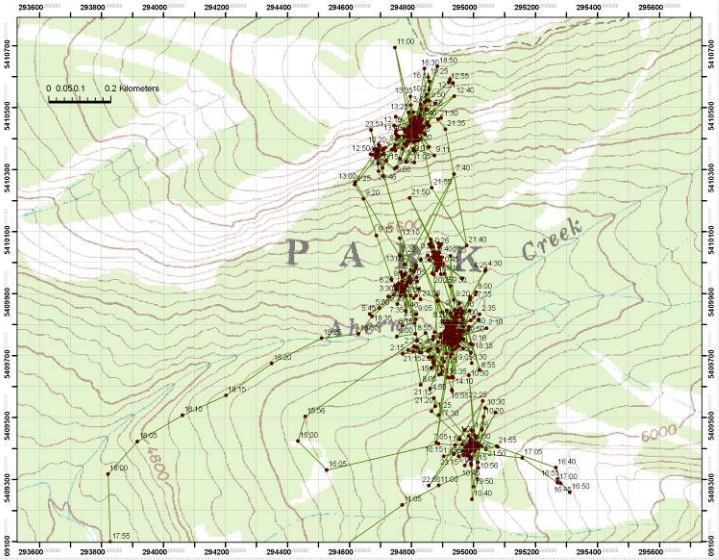


Figure 8. GPS point clusters identify sites of concentrated use. Project personnel investigate these sites to determine the nature of use.

Movement and foraging behavior

We investigated 102 cluster sites derived from GPS data. Animal remains were documented at 41 of these sites. Most sites were visited 7-8 months after the cluster was used by a wolverine; there is a likelihood that animal remains or evidence of foraging had deteriorated or been moved during that interval. We are investigating other ways of determining the nature of a wolverine's presence at a cluster site. One such indicator of use might be the pattern of activity cycling exhib-

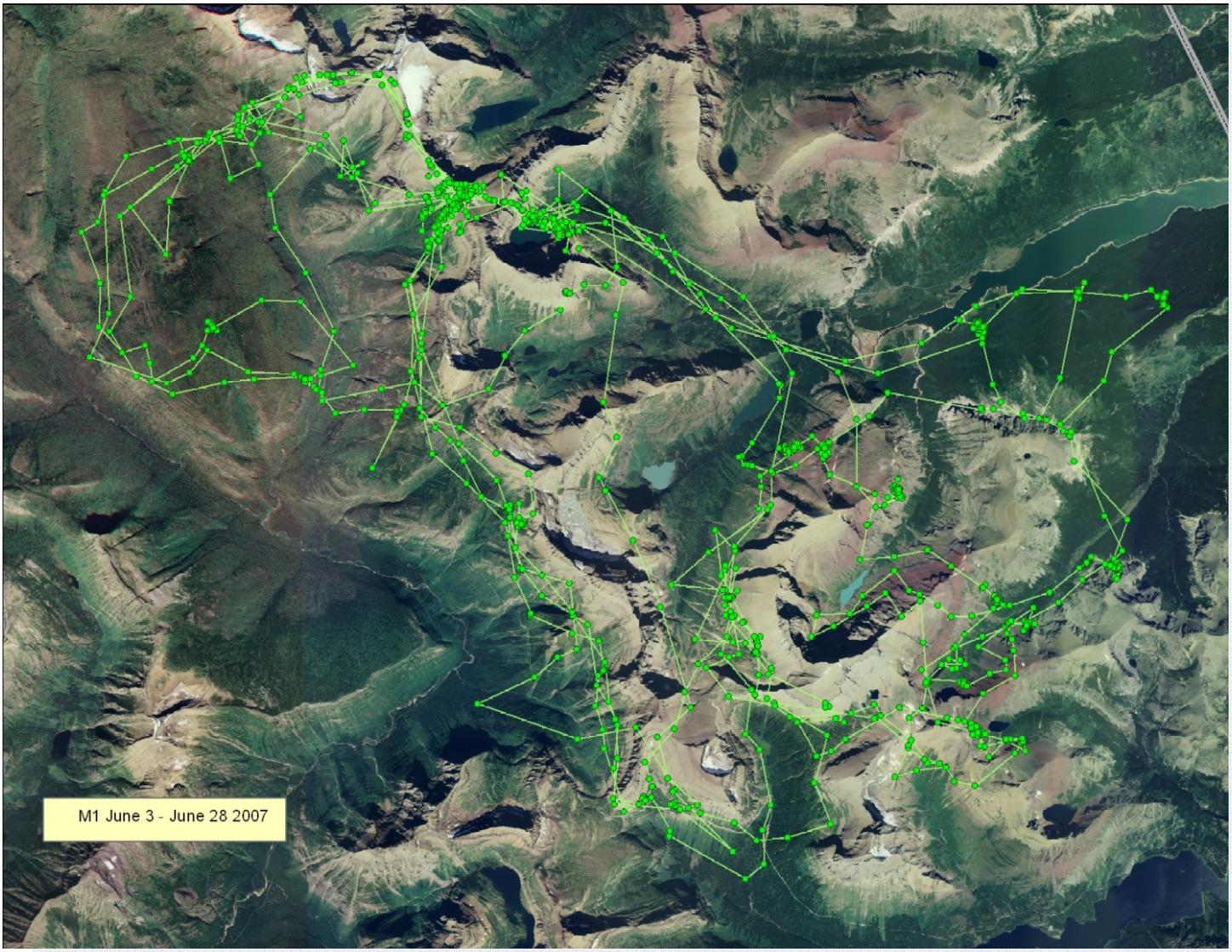


Figure 9. Typical GPS path of adult male wolverine. The movement path between each dot represents a 5 minute movement averaging about 300 meters. A typical adult male will travel approximately 150 km a week. Clusters of points show places where the individual stopped to forage, rest, or interact with other individuals.

ited by wolverines at known foraging sites. GPS collars were equipped with activity sensors that recorded collar vibrations at 5 minute intervals. Wolverines at confirmed foraging sites exhibited a fairly well defined pattern of activity-inactivity that tended to cycle around an approximate 2-hour period (Figure 12). This cycle is noticeably absent from many cluster sites, which may indicate that the animal is simply resting, rather than foraging. The relationship between activity patterns and foraging behavior will be useful in developing energetic models that will, in turn, help us understand the relationship between food availability and spatial needs of the wolverine.

Food habits

Food habits will be described through the analysis of scats, photographic evidence from park visitors, and collection of prey remains at rendezvous, forage, cache, and reproductive den sites. Analysis of 142 scat samples is currently underway. Forage sites (N=56) were documented using VHF telemetry and GPS analysis and visual locations by GNP staff.

Management Implications

Scandinavian wolverine research found a significant relationship between female reproductive output and the availability of food. We suspect that a relatively abundant food resource in Glacier National Park is at largely responsible for the high population densities observed in this study. Healthy populations of mountain goat, mountain sheep, elk, and deer provide winter surpluses in the form of winter carrion, while abundant hoary marmot and ground squirrel populations provide ample hunting opportunity for wolverines in the spring and summer. Any activity that limits the availability and abundance of prey species will adversely impact wolverine. As such, we would encourage continuation of Glacier National Park's policy regarding the removal of carcasses as a deterrent to grizzly bear-human conflicts. Leaving carcasses in place, as is current policy, provides for-

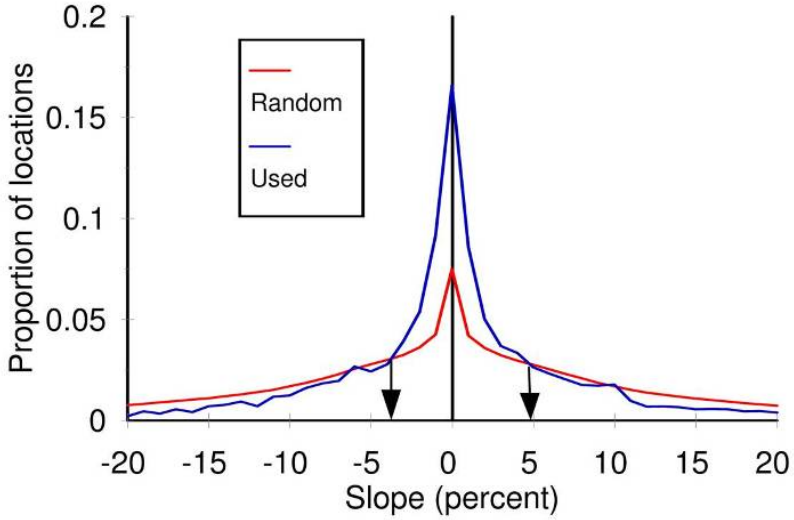


Figure 10. This graphic represents of distribution of choices made by wolverine as to whether the individual moves uphill or downhill as it moves across the landscape. The red line represents choices that could be made, while the blue line represents choices that were made by this particular study animal. Where the lines cross represents the point where avoidance and preference meet. Between –5 and +5% the wolverine is using mild slopes much more than would be expected by random chance. Beyond these points, the individual is using those slopes less than expected, indicating avoidance of steep slopes.

aging opportunity for wolverine and other scavangers.

Concerns over the sensitivity of denning female wolverine to human-related activities such as snowmobiling and backcountry skiing has lead management agencies to restrict winter access into areas used by wolverines as potential denning habitat. Until we develop a better understanding of this relationship, consideration should be given to protecting potential denning habitat during the critical denning months of February through April. As global warming continues to reduce the extent of deep, spring snow necessary to wolverine denning, protection of habitat through the denning period will become increasingly important to wolverine persistence.

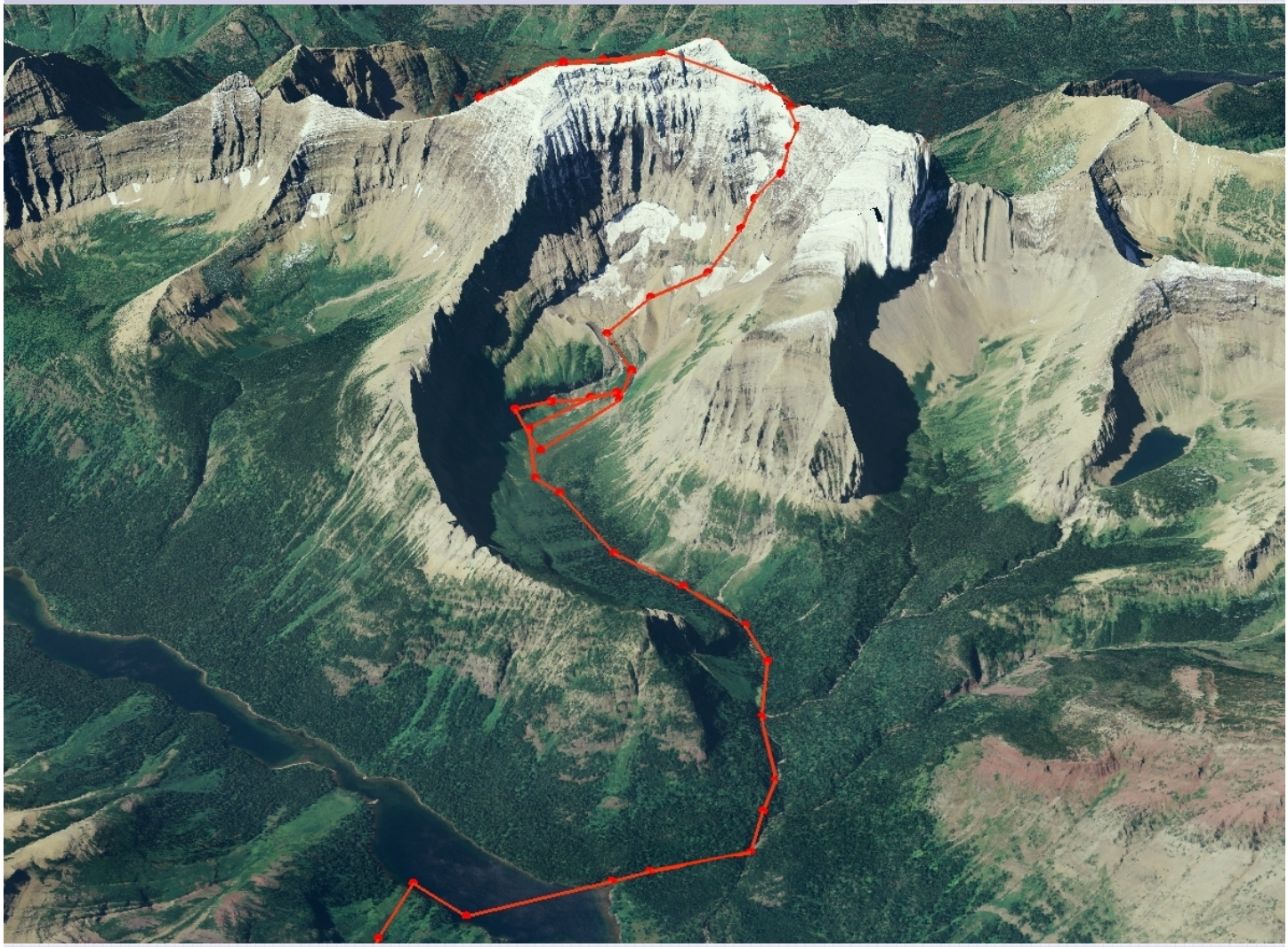


Figure 11. The Belly River resident male, M3, traverses his way to the base of Mt. Cleveland. He ascended to the summer, nearly 5,000 vertical feet, in less than 90 minutes.

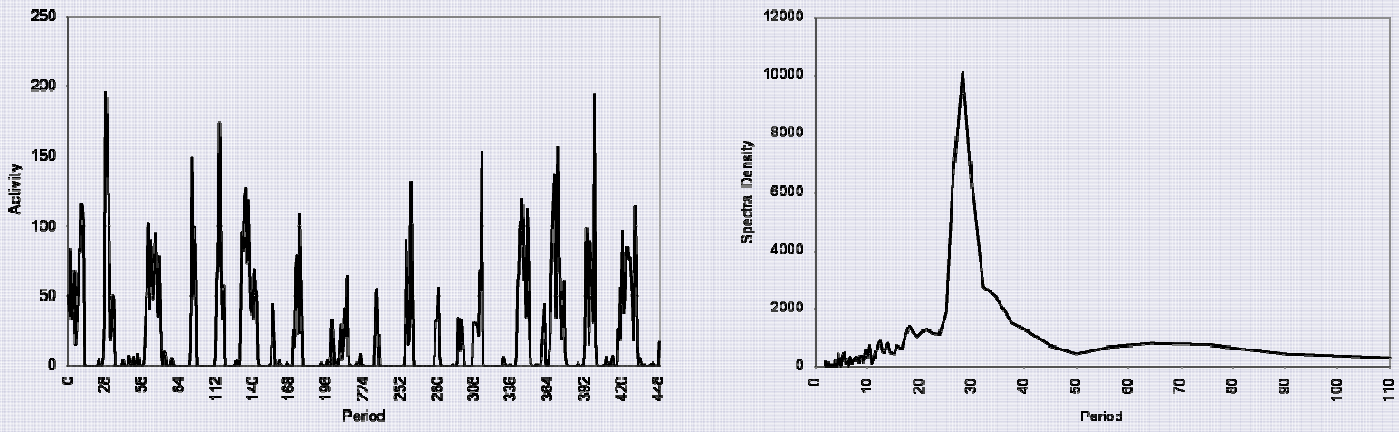


Figure 12. The graph on the left shows activity cycling across a 37 hour (448 periods times 5 minute/period) stay at a cluster site. The graph on the right (spectral density plot) is used to determine the periodicity, indicating that the primary activity cycle is 28 periods, or about 140 minutes.

While Glacier National Park manages its winter landscape as wilderness, thereby restricting motorized access during winter months, spring snow plowing on the Going-to-the-Sun road occurs very near to areas of documented wolverine denning. The timing of a den abandonment in Alder Creek coincided with the onset of snow plowing in 2004. Females are known to occasionally move kits to secondary dens prior to weaning so while this particular incident cannot be directly tied to the plow activity, it is certainly notable in its coincidence. The Sun road is included in the home ranges of at least 3 adult female wolverines so it is recommended that potential disturbance related to plowing be considered in future planning.

Glacier National Park provides what may be the best opportunity in the world to observe a wolverine in a natural setting. GNP should take considerable pride in the knowledge that this fact alone makes this site unique in the national park system.

Products

A comprehensive report will detail all aspects of this research and data analysis. Data that provide adequate sample size and quality will be submitted to peer-reviewed journals and included as appendices to the comprehensive report. Listed below are current published works, papers in review or preparation, or papers planned for preparation which include data collected in this study.

1. *Sources and patterns of wolverine mortality in western Montana. Squires et al. 2007. Journal of Wildlife Management 71(7).*
2. *Volatile compounds from headspace of wolverine urine—in review*
3. *Does spring snow define a bioclimatic niche for the wolverine?—in prep*
4. *Global warming and a snow dependent species: a case for the wolverine—in prep*
5. *Deriving minimum-cost pathways for wolverine movement through habitat resistance modeling—in prep*
6. *Fine-scale genetic structuring in exploited and non-exploited wolverine populations.*
7. *Defining patterns and scale of wolverine movement in winter.*
8. *Activity cycling of wolverine in Glacier National Park.*
9. *Socio-spatial structuring in non-exploited wolverine populations.*
10. *The reproductive dens of the wolverine in Glacier National Park.*
11. *Energetics and foraging strategies of the wolverine in Glacier National Park.*
12. *Food habits of the wolverine in Glacier National Park.*