

From: [Grizzle, Betty](#)
To: [John Guinotte](#)
Subject: Road crossings study - Greater Yellowstone area
Date: Friday, June 16, 2017 10:20:48 AM
Attachments: [Packila et al 2007.pdf](#)

Just an FYI - see attached 2007 paper.

--

Betty J. Grizzle, D.Env.
Fish and Wildlife Biologist
U.S. Fish and Wildlife Service
Carlsbad Fish and Wildlife Office
2177 Salk Ave, Suite 250
Carlsbad, CA 92008
760-431-9440, ext. 215
760-431-5901 fax

Chapter 7

Wolverine Road Crossings in western Greater Yellowstone

MARK L. PACKILA, *Wildlife Conservation Society, 2023 Stadium Drive 1A, Bozeman, MT 59715, USA*

ROBERT M. INMAN, *Wildlife Conservation Society, 2023 Stadium Drive 1A, Bozeman, MT 59715, USA, and Swedish University of Agricultural Sciences, Dept. of Ecology, Grimsö, SE - 730 91 Riddarhyttan, Sweden*

KRISTINE H. INMAN, *Wildlife Conservation Society, 2023 Stadium Drive 1A, Bozeman, MT 59715, USA*

ANTHONY J. MCCUE, *Wildlife Conservation Society, 2023 Stadium Drive 1A, Bozeman, MT 59715, USA*

ABSTRACT Populations of rare carnivores, including wolverines, are particularly vulnerable to the direct and indirect impacts of roads. Information on areas used by wolverines as they cross roads would be valuable for addressing potential impacts, but these data are sparse to non-existent in the Greater Yellowstone Area (GYA). As part of a larger telemetry-based study of wolverine ecology in GYA, we documented 43 crossings of U.S. or State highways by 12 wolverines. The most concentrated areas of wolverines crossing U.S. or State highways occurred at Teton Pass (WYO22); near the Henrys Lake Range at Earthquake Lake (US287) and Reynolds Pass (ID/MT 87); in Yellowstone National Park (US191); at Palisades Reservoir (US26); and across the Snake River Canyon between Hoback Junction and Alpine, Wyoming (US89/26). Subadults making dispersal or exploratory movements comprised the majority of road crossings, most of which were made during January–March. We documented U.S. or State highway crossings in <8% of the annual home ranges of resident adults ($n = 28$ annual home ranges). Sixty-two percent of road crossings occurred at night and 38% occurred during the day ($n = 13$). We considered the Big Sky, MT area separately because the characteristics of MT64/Jack Creek Road differ greatly (road type and traffic volume) and we obtained only 1 site-specific crossing. Wolverines crossed MT64/Jack Creek Road a minimum of 67 times; the majority of crossings were made by the Madison Range's resident adult male whose annual home range spanned the Spanish Peaks south to Hebgen Lake. Habitat modeling, a few VHF locations, and data from a single GPS collar (the only site-specific crossing in this area) suggest that crossings in this area are now most likely to occur through the head of Jack Creek (west side of divide, private Jack Creek road, less development and traffic). We consider road crossing locations indicative of linkage areas and discuss 4 examples of possible mitigation: 1) general management techniques applicable to all road situations, 2) maintaining permeability in an area where a major road passes through linkage habitat that is mostly private lands, 3) maintaining permeability in an area where a major road passes through public lands that are primary wolverine habitat, and 4) maintaining permeability in an area where the potential for significant private development occurs in primary wolverine habitat. Linkage is a necessary component of wolverine's existence in the island-like habitat of the conterminous U.S.; because of the relatively permanent nature of human-induced habitat changes affecting linkage (e.g., road expansions, housing developments, human population growth), proactive management is required more so than with any other management issue.

KEY WORDS corridor, *Gulo gulo*, linkage, road, wolverine, Yellowstone.

The Greater Yellowstone Area (GYA) has experienced rapid human population growth in the recent past (Johnson 2001). As a result, road densities have increased as well as traffic volumes. The impacts of roads on wildlife can manifest themselves in a variety of ways depending on species, but the true extent of these impacts are not entirely known (Transportation Research Board 2002). Potential impacts include habitat degradation or fragmentation, barrier effects, direct mortality, and behavioral changes (reviewed by Forman and Alexander 1998, Ruediger 2000, Forman et al. 2003). When considering rare carnivores, which are particularly vulnerable to roads, it is vital to determine the effects of roads and implement adequate mitigation for those effects (Ruediger 2000).

Wolverine populations exist at a regional scale and are demographically vulnerable (Persson et al. 2006, Inman et al. 2007a, 2007b). In the conterminous U.S., habitat exists in island-like fashion and successful movement among patches of primary habitat is critical (Cegelski et al. 2006, Brock et al. 2007). Roads have been documented as a direct threat to wolverines via road-kill mortality (Krebs et al. 2004, Inman et al. 2007c). Roads may also be an indirect threat to wolverine populations. Austin (1998) suggested behavioral modification in wolverines attempting to cross the Trans-Canada highway,

where individuals repeatedly approached roads and then retreated. In addition, recent genetic analyses suggest this behavioral modification may be present and have effects at the population level despite the capability to disperse long distances through atypical habitat (Cegelski et al. 2006, Inman et al. 2007a). However, it is unknown how much the current genetic structure in the conterminous U.S. differs from that of historical populations, i.e., is due to roads and human presence vs. is the result of island-like wolverine habitat (Brock et al. 2007). In either case, the trajectory of human population growth in the Rocky Mountains suggests that failure to begin managing roads as a source of wolverine mortality and limiting the potential for roads to act as barriers to movement could easily result in increased isolation among areas of a wolverine metapopulation in the conterminous U.S., a situation conducive to long-term population declines. Unfortunately, data on areas used as road crossings by wolverines in GYA are sparse to non-existent.

As part of a larger study of wolverine ecology, we included efforts to identify potential linkage zones within our study area. We also gathered information on the time of day that wolverines crossed roads; when combined with data on wolverine activity pattern, this information may provide insight into the effects of roads on wolverine movements and gene-flow.

STUDY AREA

We conducted our telemetry-based research at 2 sites within GYA, a 108,000 km² ecosystem geographically based on the Yellowstone Plateau and 14 surrounding mountain ranges in Idaho, Montana, and Wyoming (Marston and Anderson 1991, Patten 1991, Noss et al. 2002). Elevations ranged from approximately 1,400–4,200 m. Precipitation increased with elevation and varied from 32–126 cm (NOAA 2007, NRCS 2007). Snow usually fell as dry powder and depths at higher elevations were often in excess of 3.5 m. A variety of vegetative communities were present (Despain 1990). Low-elevation valleys contained short grass prairie or sagebrush communities. The transition to forest often occurred with lodgepole pine (*Pinus contorta*) or Douglas fir (*Pseudotsuga menziesii*). Engelmann spruce (*Picea engelmannii*), subalpine fir (*Abies lasiocarpa*), and whitebark pine (*Pinus albicaulis*) became more common with increasing elevation. Mixed forest types were common throughout the ecosystem and all forest types were interspersed with grass, forb, or shrub meadows. Moist areas often contained aspen (*Populus tremuloides*), willow (*Salix* spp), and alder (*Alnus* spp). The highest elevations had alpine tundra or talus fields and snow was typically present for at least 9 months of the year (NRCS 2007). A diverse fauna was present (Bailey 1930, Streubel 1989) and included a variety of ungulates and carnivores that are not found in many areas where wolverines exist. Wolverine habitat in this area has been characterized as island-like (Brock et al. 2007), and most, but not all, U.S. or State highways occur in valley bottoms that are not considered to be primary wolverine habitat.

METHODS

Capture and Monitoring

We captured wolverines during winters of 2000–2007 in log box traps (e.g., Copeland et al. 1995, Krebs and Lewis 2000) equipped with trap-transmitters (Telonics, TBT-500, Mesa, AZ, USA). We also captured juvenile wolverines by hand at den or rendezvous sites (Persson et al. 2006). We used a variable-powered CO₂ pistol (CO₂ PI, Dan-Inject, Fort Collins, CO, USA), a syringe pole, or a hand syringe to deliver an initial dose of 8.0mg/kg ketamine + 0.05mg/kg medetomidine + 0.40mg/kg turbogezic (Quigley 2000) or approximately 7.5mg/kg ketamine + 0.25mg/kg medetomidine (Arnemo 2006, Atkinson 2006). We surgically implanted all wolverines with an intra-peritoneal VHF radio-transmitter (Telonics Imp400L, Imp300L, Mesa, AZ, USA; Advanced Telemetry Systems M1250, M1245, Isanti, MN, USA). We followed handling procedures approved by the Animal Care and Use Committees of the Hornocker Wildlife Institute/Wildlife Conservation Society (2000-RMW-504, 2000–2006) and Montana Department of Fish, Wildlife and Parks (IACUC 1-2006, 2006–2007) as permitted by U.S. Department of Agriculture, Animal and Plant Health Inspection Service (Permits 81-R-0015 and 81-R-0018). We attempted to collect aerial VHF telemetry locations at an approximate 10 day interval. We also fit 11 wolverines with global positioning system (GPS) collars programmed to collect locations at various

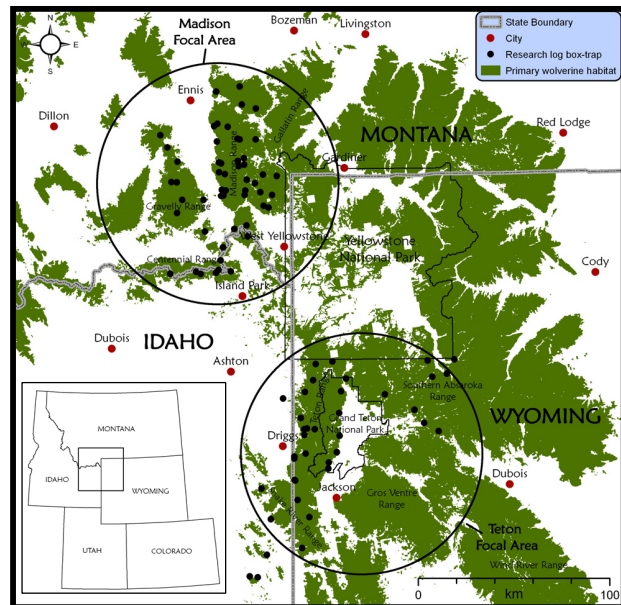


Figure 1. Madison and Teton study sites of the Greater Yellowstone Wolverine Program, Montana, Idaho, and Wyoming, USA, 2000–2007.

intervals (Televilt POSREC 300, Telemetry Solutions, Concord, CA, USA; Lotek Wireless, 3300SL, Newmarket, ON, Canada). We assigned ages based on a known age (cub captures at dens), cementum annuli and lack of descended testes. Based on reproductive maturity of female wolverines (Persson et al. 2006) and the age through which dispersal continued, we classified wolverines ≥ 3 yrs old as adults and < 3 yrs as subadults.

Road Crossing

We obtained site-specific road crossing data while snow-tracking wolverines to obtain data on food habits, when we made a visual observation of a wolverine crossing a road, and at wolverine road-kill mortality sites. We were also able to document site-specific crossing locations in several instances when VHF locations made at short intervals indicated that a road crossing had occurred and snow conditions were conducive to documenting the specific site. We also considered GPS locations made ≤ 2 hours apart to be site-specific crossings. We obtained general road crossing data with GPS collar locations made > 2 hrs apart and when field conditions were not conducive to documenting the specific site of a crossing between successive VHF locations. We estimated these general crossing locations with a straight-line travel path between successive GPS or VHF locations.

We estimated the time of day that the wolverine crossed the road with GPS collar data, knowledge of the time of consecutive VHF locations, or track conditions relative to snow and weather factors. For purposes of determining day and night crossings, we considered day and night being the time before or after nautical twilight (nautical twilight is approximately 1 hour before sunrise, 1 hour after sunset). In cases where we could not confidently assign the crossing to either day or night, we categorized it as unknown.

We used Idaho Transportation Department hourly traffic volume reports from January–December 2006 to determine

average traffic volumes and peak traffic times for Idaho 33 on the west side of Teton Pass (ITD 2006).

RESULTS

We documented 43 crossings of U.S. and State highways by 12 wolverines (Tables 1–2, Figs. 2–3, Photos 1–6). We obtained site-specific information in 14 instances (Table 1, Figs. 2–3) and a general location in 29 instances (Table 2, Figs. 2–3). The most concentrated areas of wolverine road crossings occurred at Teton Pass (WYO22) between the Teton and Snake River Ranges; near the Henrys Lake Range at Earthquake Lake (US287) and Reynolds Pass (ID/MT 87) between the Madison, Henrys Lake, Gravelly and Centennial Ranges; and in Yellowstone National Park (US191) between the Madison and Gallatin Ranges. Other locations where we documented or estimated crossings and which may be of significant linkage value included Palisades Reservoir (US26) between the Snake Range and areas to the south that may serve to facilitate southward dispersal (Brock et al. 2007); and the Snake River Canyon between Hoback Junction and Alpine, Wyoming (US89/26) between Snake and Salt/Wyoming Ranges.

We considered the Big Sky, Montana area separately. A wolverine crossing through the Big Sky area would not have to cross a U.S. or State highway; MT64 climbs from the Gallatin River Valley on the east, to the divide between the Gallatin River watershed and the Madison River watershed, where the road then becomes the private, gated, Jack Creek road which descends to the Madison Valley on the west. However, we thought this area worthy of consideration due to its growing human development with associated roads and thus the potential for habitat fragmentation within the Madison Range. We documented 67 crossings of MT64/Jack Creek Road by 4 wolverines, 1 of which was site-specific and occurred at night (Table 3, Fig. 3, Photo 7). Three of these individuals were subadults and one was an adult with an annual home range ($n = 4$ years) that included the Spanish Peaks south to Hebgen Lake.

Subadult wolverines made the majority of road crossings (76%) while making exploratory or dispersal movements. The one technique that sampled evenly across time, i.e., included all months, was VHF telemetry locations connected by a straight line between points. Eighty-three percent of subadult road crossings documented with this technique occurred during January–March ($n = 12$). In general, resident adults did not have U.S. or State highways within their annual home range (<8% of $n = 28$ annual adult home ranges included a U.S or State highway crossing during the year, excluding M205 in the Big sky area as it was unknown whether he crossed MT64 or the Jack Creek road; Inman et al. 2007a).

We were able to categorize time of crossing as either day or night in 13 of 43 cases (30%); 8 crossings occurred at night (62%) and 5 occurred during the day (38%, Tables 1–2).

DISCUSSION

Although wolverines have been assumed to display a nocturnal activity pattern, the scant empirical data available suggest that

crepuscular activity may be more accurate (Copeland and Yates 2006, McCue et al. 2007). The prevalence of road crossings we documented occurring at night is interesting in that it suggests the possibility of wolverines waiting to cross roads during non-typical hours of wolverine activity, when traffic volumes are generally lower. This begs the question of whether wolverines use temporal avoidance to move across roads just as frequently as they would without the road being there or whether this could be an indication of the inclination to avoid roads which, overall, leads to a reduction in the availability of habits, foraging efficiency, or gene flow. Our data presented here and those on activity pattern are certainly not definitive.

Home ranges of resident adults in our study area were generally bound by major roads (see Inman et al. 2007a), and residents did not typically cross these roads. The degree to which this is a response to broad-scale habitat selection by wolverines (Brock et al. 2007) rather than roads is unknown. F106, a resident in the Henrys Lake Range, had a relatively small home range that was bounded by U.S. and State highways; she had not reproduced by 5 years of age (she is currently 5 years old and still being monitored). The Henrys Lake Range is much smaller than the smallest adult male home range documented on our study area, and both males we documented using the Henrys Lake Range crossed roads. One of these males was road-killed shortly before mating season. It is possible that the small size of the Henrys Lake Range and the traffic volumes around the range could reduce the effectiveness of the Henrys Lake Range as a source of reproduction (due to the increased risk of mortality for wolverines, especially males).

Wolverine habitat in the conterminous U.S. is island-like (Brock et al. 2007). Given the ubiquitously low densities and reproductive rates of the species, proactive management ensuring effective linkage is one of the critical issues regarding wolverine persistence in the conterminous U.S. We documented a number of road crossings, thus most roads in our study area certainly do not currently function as absolute barriers to wolverine movement. However, roads do have direct impacts on wolverines via road-kill mortality of wolverines (Krebs et al. 2004, Inman et al. 2007c), and appear to have indirect impacts on individuals and populations (Austin 1998, Cegelski et al. 2003, 2006). Successfully managing the critical issue of linkage for wolverines over the next 25 years and forward, requires defining the areas most likely to be used, followed by collaborative and creative partnerships and incentives that can put the appropriate actions into place as soon as possible. It is worth noting that other factors that may have significant influences on wolverine populations (e.g., fur-harvest and winter recreation) are managed through established governmental agencies with defined protocols for creating laws related the issue; whereas linkage, because of private property issues, is not to our knowledge formerly regulated, and may not be regulatable. In addition, if population monitoring indicated that factors such as harvest or recreation had caused population declines (or even extirpation), management of these issues could be altered and populations could be reintroduced. But because of the relatively permanent nature of human-induced habitat changes affecting linkage (e.g., road expansions, housing developments, human population growth), population recovery

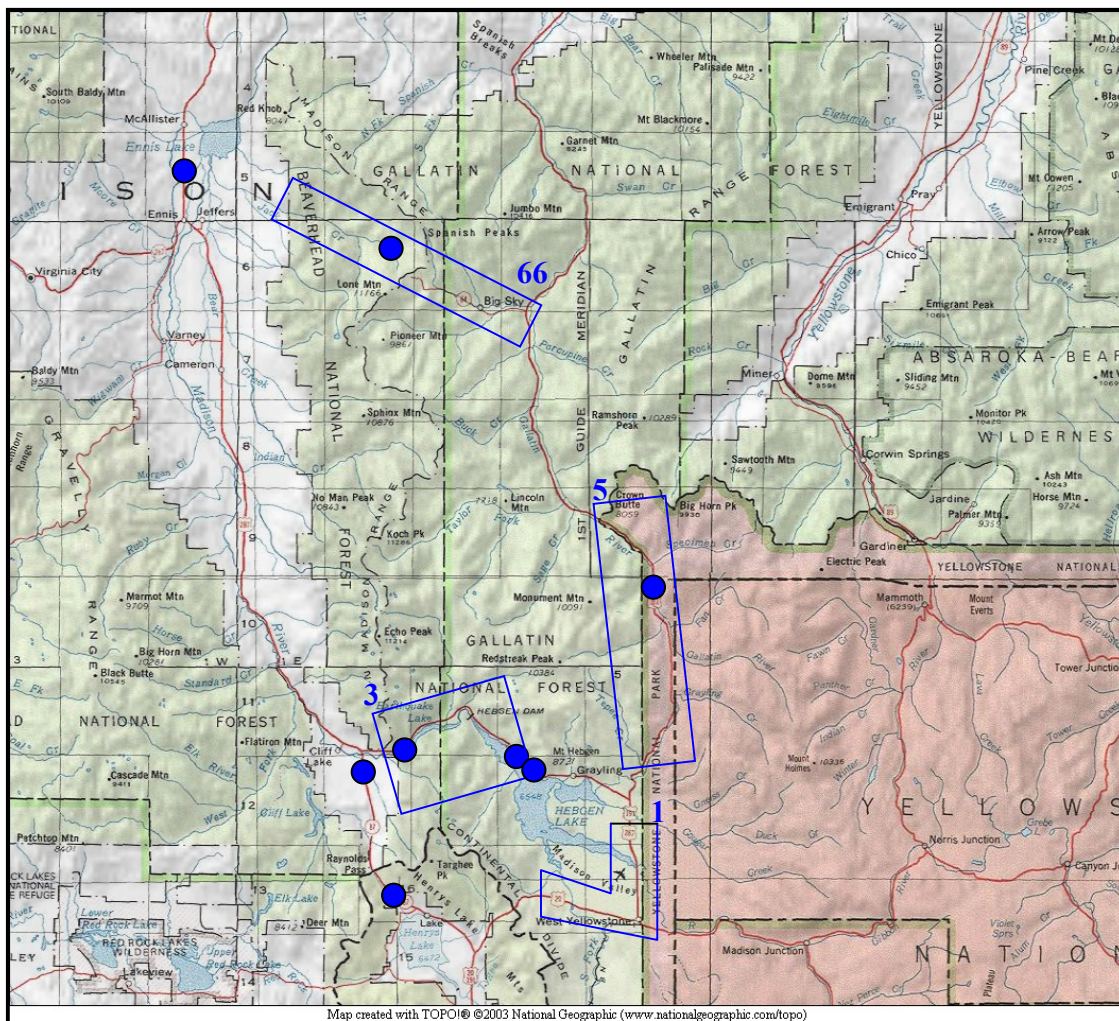


Figure 2. Putative linkage zones as indicated by wolverine road-crossings on the Madison study site, Greater Yellowstone Area of Idaho, Montana, and Wyoming, 2002–2007. Blue dots are tracks followed across a road, road kill mortalities, visual observations of crossings, or GPS collar locations that have successive points crossing the road that are ≤ 2 hours apart. Blue boxes are our estimate of the area within which the wolverines were likely to have crossed based on VHF or GPS locations > 2 hours apart. Blue numbers are the number of crossings in addition to the blue dots.

after detecting any negative affect would likely be futile. For these reasons, proactive management regarding linkage is required more so than with any other management issue.

The road crossings we documented indicate putative, local areas for linkage. Because our study area likely includes portions of the major linkage between the Greater Yellowstone Area and Central Idaho, which are two of the largest patches of wolverine habitat in the conterminous U.S. (Brock et al. 2007), some of the linkages we identified may be of critical importance at a regional scale also (i.e., conterminous U.S.). In addition, our study area is also the current southern extent of known wolverine distribution, and linkage therein may be critical for further recovery to historically occupied areas to the south.

Developing effective mitigation for the effects of roads is a complicated process that requires consideration of multiple factors including multiple species needs, surrounding habitat, ecosystem level effectiveness, and human factors (e.g., costs, political will, driver participation; Ruediger 2000, Forman et al. 2003, Clevenger and Waltho 2004, Hardy et al. 2004). With

these considerations in mind, we believe these data can apply towards broader efforts to ensure linkage for multiple species. Mitigation methods that would benefit wolverines, as well as many other species, could be relatively simple or quite complex, as the following 4 examples show:

- 1) general techniques applicable to all road situations,
- 2) maintaining permeability in an area where a major road passes through mostly private lands that are “linkage” habitat (as opposed to primary habitat, Brock et al. 2007) and where habitat characteristics prevent identification of a specific crossing site (e.g., Reynolds Pass),
- 3) maintaining permeability in an area where a major road passes through public lands that are primary wolverine habitat but, again, where identification of a specific crossing location is difficult (e.g., Teton Pass), and
- 4) maintaining permeability in an area where the potential for significant private development occurs within primary wolverine habitat (e.g., Big Sky, Montana Area).

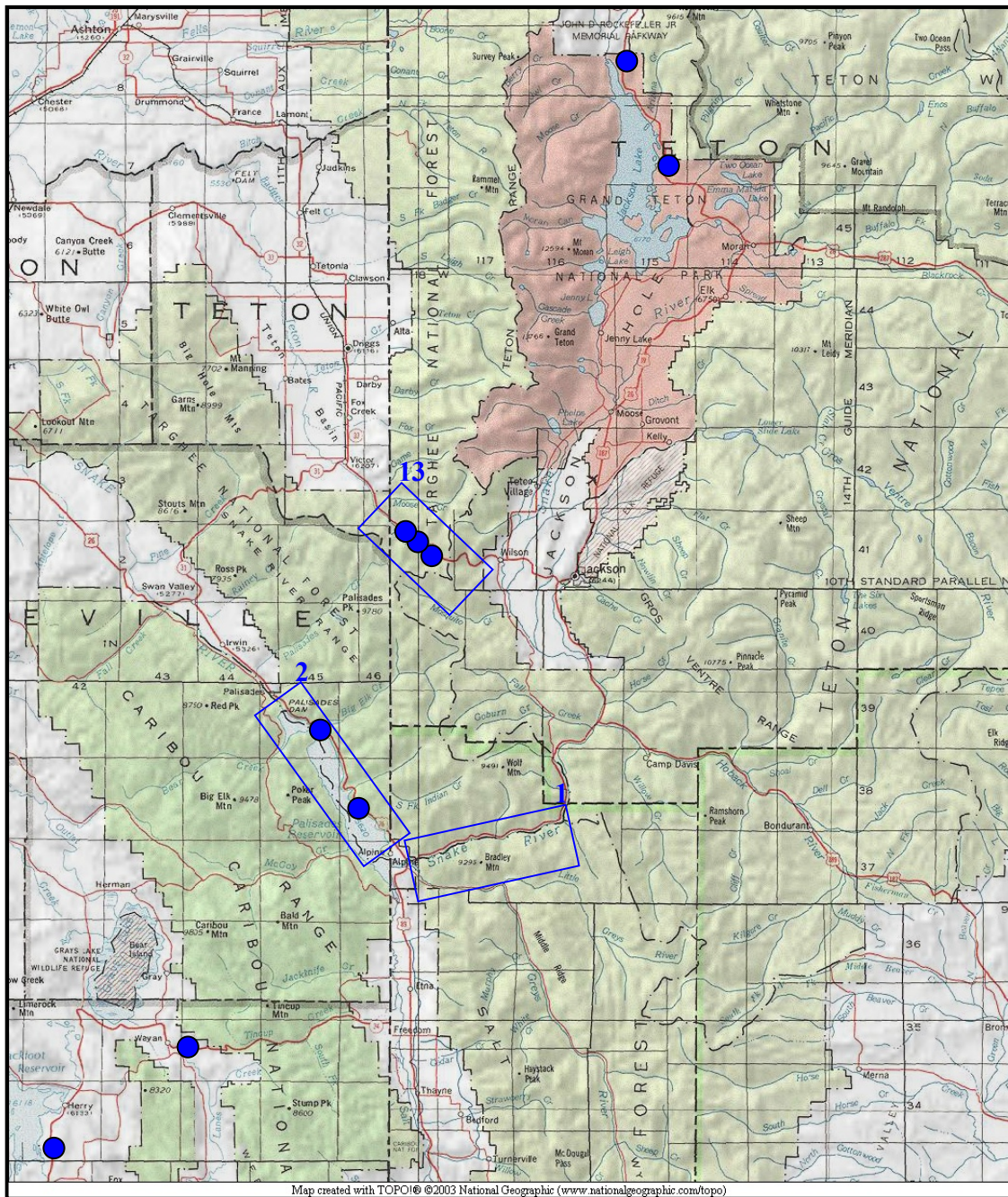


Figure 3. Putative linkage zones as indicated by wolverine road-crossings on the Teton study site, Greater Yellowstone Area of Idaho, and Wyoming, 2002–2007. Blue dots are tracks followed across a road, road kill mortalities, or GPS collar locations that have successive points crossing the road that are ≤ 2 hours apart. Blue boxes are our estimate of the area within which the wolverines were likely to have crossed based on VHF or GPS locations > 2 hours apart. Blue numbers are the number of crossings in addition to the blue dots.

General Techniques

As illustrated by the road-kill death of M204 as he utilized a road-killed elk carcass, the generally applicable technique of quickly removing road-killed wildlife from highways could provide important benefits for a relatively low cost. Since most road crossings were made by subadults, and they appear to cross roads more frequently during January–March (probably related to the timing of dispersal movements [Inman et al. 2007a]),

efforts during this period may be most critical. In addition to the data presented herein, habitat models such as that developed by Brock et al. (2007) could provide important information on where to focus road-kill removal efforts. Road-killed ungulates are sometimes removed from highways and deposited at a carcass dump; in some cases the carcass dump is essentially just off of a road and down a steep embankment. Carcass dumps are obviously an enticement to wolverines and other carnivores such

as bears, and should be located well-away (>1 km) from traffic.

Slowing vehicle speed is another generally applicable technique; and, in some places, speed is the primary factor influencing wildlife collisions (Gunther et al. 1998). Compared to construction methods of mitigation, speed reduction is inexpensive to implement. Speed limits could be limited to time periods when and/or general locations where most species are active. Crepuscular activity is common in many wildlife species and this time of day makes it difficult for drivers to see and avoid wildlife. Thus, a speed limit reduction at this time of day may be beneficial. A reduction in speed limit over a short distance may be beneficial if somewhat specific areas along a road are identified as crossing locations. A 3-mile stretch of road where the speed limit was reduced from 60 miles per hour to 30 miles per hour would require an extra 3 minutes to traverse. Effective implementation of speed limits requires adequate enforcement and driver participation.

Raynolds Pass Example

Squires et al. (2006) showed that small-scale wolverine movements are not strongly correlated to environmental characteristics; thus it would be difficult to conduct site-specific road crossing mitigation (i.e., underpasses/overpasses), and broad-scale measures, such as conservation easements, could provide some benefit at a lower cost. In many areas, like Raynolds Pass, this appears to be the most practical mitigation method. The habitat over the pass is open sagebrush, and it is difficult if not impossible to predict wolverine movements to within a few hundred meters as necessary to design effective site-specific mitigation. Easements are an attractive alternative because they promote connectivity by providing fairly broad approach and departure paths relatively free of human activity.

However, assuming that easements will actually be implemented and that they will be effective is risky. Even if all the appropriate properties were available for sale, finding conservation buyers for large areas of general linkage habitat will be difficult (although it is occurring to some degree in the Raynolds Pass area). Certainly, county-level land planning efforts (i.e., subdivision approval) that emphasize wildlife linkage could also be an important component in successful linkage. But, for wide-ranging species like wolverines and grizzly bears, this depends on local political willingness within numerous counties and states, which would no doubt be difficult given private property rights and economic factors. Even if all lands were protected with easements or county planning efforts, other influences could render these efforts practically worthless (e.g., major road modifications resulting in increased traffic volume or higher speeds; or human population growth in nearby valley bottoms that results in residents using the linkage zone during their routine travels). On the other hand, even if a massive highway project were implemented (e.g., an elevated 4-lane highway from Island Park, ID over Raynolds Pass to Squaw Creek in Montana), a lack of open space on private lands (via easements and county planning) could render these expensive highway construction efforts almost completely ineffective. Effective linkage requires that there is enough "open space" that animals will attempt to cross, and few enough hazards such that attempts are successful.

There are only a few sites in the conterminous U.S. like the Raynolds Pass–Squaw Creek area that likely serve as arteries for linkage between the major, large, wild, protected areas of the conterminous U.S. for multiple, rare species. These areas are prime candidates for major linkage efforts that include incentives for private easements and county planning in addition to major funding for construction of an elevated highway. Obviously, limiting the distance spanned by such a highway project would be financially beneficial, thus an intensive investigation into crossing locations by multiple species via GPS collar technology could prove valuable in the long-run.

Teton Pass Example

In some areas, like WYO22 near Teton Pass, US191 in Yellowstone National Park, US26 near Palisades Reservoir, and US287 near Earthquake Lake, no easements would be necessary because all or the majority of both sides of the highway are publicly owned. We can use Teton Pass (WYO22/Idaho 33) as an example to consider appropriate mitigation methods in these situations. Teton Pass is an important wildlife linkage corridor as well as an important wolverine linkage area for southerly population expansion. However, traffic volume is increasing and WYO22, including the valley portion, has the highest road kill rate of any U.S. or State Highway in Wyoming (BRC–JHWF 2003). Traffic volumes on both sides of the pass commonly exceed 4,000 vehicles per day (BRC–JHWF 2003, ITD 2006), a level which likely poses problems for carnivores, including the potential to become a functional barrier (Ruediger 2000). Traffic peaks on Idaho 33 occur at 07:00 and 17:00 (ITD 2006), as a result of commuter traffic to Jackson, WY. Depending on season, the peak traffic volumes occur during crepuscular periods when wolverines may be most active (Copeland and Yates, McCue et al. 2007). This temporal coincidence could be changing normal wolverine movements, i.e., prohibiting some movements across the highway, changing the time of movements, and making the crossings that do occur more dangerous (our time information for this crossing location is very limited: 1 day, 1 night). During this study, wolverines have crossed WYO22 during exploratory, dispersal, and a few normal home range movements. This suggests that WYO22 is not a barrier preventing wolverine movement at this time. However, this is not to say that improvements are not warranted or that future use-levels will not render it a barrier.

Since Teton Pass is critical for many species of wildlife there are stronger than usual incentives for mitigation. Many suggestions to improve the linkage across Teton Pass have been proposed. Suggestions include lower speed limits, unique signage, mass transit, crossing structures, and wildlife detection warning systems (BRC–JHWF 2003). Tunneling is common in Europe and was considered for Teton Pass at one time. Mass transit would reduce the total traffic volume over Teton Pass, especially daily commuter traffic in the morning and evening when wolverines are most active. Rather than trying to modify human behavior, other options focus on modifying animal behavior. A variety of species utilize overpasses and underpasses in Banff National Park (Clevenger and Waltho 2004), so this option may be beneficial on Teton Pass where there is concern for multiple species. Even though it is difficult

to predict wolverine movement, wolverines still may benefit from these structures if wolverine's apparent preference for forest cover when crossing roads is considered (Austin 1998, Squires et al. 2006). Also the size of the structure is important, the larger the better. Since the areas mentioned under this example would not need easements or county planning due to public land ownership, the degree to which roads are modified or managed will control the degree of success.

Big Sky, Montana Area Example

Similar to WYO22 at Teton Pass, at least some portion of the MT64/Jack Creek Rd is not currently a barrier to wolverine movement. Wolverine use of the northern Madison Range includes both adult and subadult age classes. Two adult wolverines currently have home ranges that include portions of the northern Madison Range (Inman et al. 2007a). A reproductively successful adult female, F105, resides in the northern Madison Range, exclusively north of MT64/Jack Creek Road. M205 is an adult male whose home range stretches from the northern to the southern Madison Range, including MT64/Jack Creek Road. M205 utilizes both the northern and southern portions of the Madison Range throughout the year, as his 56 documented crossings somewhere along the MT64/Jack Creek Road indicate. We have also documented subadult wolverines temporarily using the northern Madison and crossing MT64/Jack Creek Road, including an offspring of F105. Once again, similar to the Teton Pass area, future changes in human use around the Big Sky, Montana area may impact wolverine use of the area as well.

The Big Sky area is a resort community (Big Sky Resort, Moonlight Basin Resort, and the Yellowstone Club) undergoing rapid development. Currently, the eastern portion of the area, along MT64, contains the majority of development (Fig. 2). Moonlight Basin Resort owns the private Jack Creek road and much of the western portion. Moonlight Basin is undergoing a major expansion at this time. The limited information that we have (habitat modeling, a few VHF locations, and data from a single GPS collar) suggests that wolverines currently cross more often on the western portion of the divide between the Gallatin and Madison watersheds, i.e., head of Jack Creek. (It should be noted that the eastern side of the divide (MT64–Big Sky Resort–Yellowstone Club area) was once likely to be an equally important area for wolverine movement. Also, it is interesting to note that we have never documented the presence of a resident female in the Cedar Mountain/Fan Mountain/Lone Peak/Yellow Mule area despite capture efforts in the vicinity and what appears to be an adequately large area of high-quality habitat. See home range figures in the appendix of Inman et al. 2007a). If wolverines currently avoid the MT64 side and development occurs in the head of Jack Creek, at some point an effective barrier to regular wolverine movement may form. This may create a situation similar to what is possibly occurring in the Henrys Lake Range now: over time, the northern Madison Range could become an ineffective (or less effective) habitat island with regard to wolverine reproduction; primarily due to the increased mortality rates of males as a consequence of a large home range size requiring them to cross roads with increasingly heavy traffic volumes.

The single most important preventative measure in this type situation is incorporating undeveloped areas for wolverine movement through the area into the overall design. Incorporating appropriate measures can occur voluntarily by development interests or via the county planning/subdivision approval process. Obviously the specifics of how wide these undeveloped areas are, where they sit relative to roads and houses, what human activities are allowed within them, and other characteristics are key to their effectiveness (for example, locating a hiking trail within an undeveloped area/wildlife movement corridor might seem attractive, but could reduce use by wildlife). Specific work to determine the characteristics of effective corridors for wolverines is necessary before successful designs can be created with any confidence that they will achieve what they are intended to do. Until appropriate characteristics are determined, a conservative approach is essential given the relatively permanent effects of roads and houses.

In the case of the current Moonlight Basin expansion, the resort is planning to leave an area approximately ½ mile wide (possibly wider) as an undeveloped wildlife movement corridor. However, it remains to be seen whether the specific characteristics of the site (corridor) will be effective with regard to wolverine movements. Madison County has required that a wildlife monitoring program be implemented and has the option of reassessing the approved build-out if monitoring detects problems for wildlife. Consideration of wildlife in the design and approval of this development is a positive step; however, detecting any problem with the effectiveness of the corridor obviously depends on the accuracy of the monitoring program, and once monitoring determines there is a problem, it may be too late to restore linkage. Private land development in areas of significance to wolverines will continue to be a priority issue. One possibility for addressing this issue is the requirement by counties that approval of a proposed subdivision be based in part on the development having 1) taken action to document the high-value areas for wildlife, 2) incorporated appropriate measures into the overall design, 3) developed a monitoring program designed to test the effectiveness of the design, and 4) contributed to a Yellowstone Counties fund designed to establish and monitor recognized "GYA subdivision standards and protocols." These standards could be used to inform consumers of the efforts made by developers to adequately address wildlife needs. To the degree that incentives are possible to facilitate this process, they should be used.

In the case of a rare carnivore like the wolverine, specific efforts to document the movement routes of local individuals (e.g., with GPS technology) are the best, if not only, measures that can provide adequate information. Any effort to do so should be undertaken in a manner that increases the utility of this information at other sites.

MANAGEMENT IMPLICATIONS

Current levels of road use and development in our study area were not absolute barriers to wolverine movement. However, given the relatively permanent nature of habitat alterations that may reduce linkage for wolverines, in addition to the difficulties

inherent in regulating linkage, the demographically vulnerable nature of the species, and the island-like nature of habitat in the conterminous U.S., failure to proactively address local and regional linkage for wolverines could lead to permanent local or regional population declines. Linkage should be a primary focus of collaborative regional strategies for managing wolverines, and the inclusion of counties and private land owners in the process is critical.

The most concentrated areas of wolverine road crossings that we identified occurred at Teton Pass (WYO22); near the Henrys Lake Range at Earthquake Lake (US287) and Reynolds Pass (ID/MT 87); and in Yellowstone National Park (US191). Long-term goals to improve these and other wolverine linkage areas will benefit a variety of species.

Addressing linkage regarding highways through USFS lands would benefit from a multi-species approach, and wolverine use of a linkage area is additional support to conduct mitigation methods such as reducing speed limits, implementing road crossing structures, and increasing public awareness of roadway/wildlife interactions. Prompt removal of road kill from areas likely to be used by carnivores could protect several species, including wolverines and grizzly bears. Conservation easements and county planning efforts could be effective in areas where private lands and the potential for development occurs; however, highway planning and projects must also occur in conjunction with easements and county planning to be effective. There are likely some specific sites, including the Reynolds Pass–Squaw Creek–Earthquake Lake area, which serve as major arteries for linkage among the remaining large, wild landscapes of the conterminous U.S. Considering these areas as candidates to receive major incentives for conservation easements and county planning efforts in addition to highway projects would benefit multiple species. We have initiated efforts to identify priority linkage areas for wolverines (Brock et al. 2007), and will continue these efforts in the near-future.

ACKNOWLEDGMENTS

We thank the following for providing major funding: Bridger-Teton National Forest Challenge Cost Share Program, Bullitt Foundation, Canyon Creek Foundation, Caribou-Targhee National Forest Challenge Cost Share Program, Disney Wildlife Conservation Fund, Doris Duke Charitable Foundation, Greater Yellowstone Coordinating Committee, Idaho Department of Fish & Game State Wildlife Grants Program, Laura Moore-Cunningham Foundation, Montana Department of Fish, Wildlife and Parks, National Fish & Wildlife Foundation, New York Community Trust, Richard King Mellon Foundation, Tapeats Fund, Wilburforce Foundation, Wyoming Game & Fish State Wildlife Grants Program, and private individuals. In-kind support was provided by Beaverhead-Deerlodge National Forest, Gallatin National Forest, and Grand Teton National Park. For their dedicated efforts in the field, we thank: B. Aber, B. Anderson, R. Angell, B. Bateman, S. Becker, J. Bell, T. Bennett, A. Bensted, N. Berg, D. Betts, C. Burr, E. Burr, A. Chapin, D. Chapman, T. Chu, S. Cleveland, C. Dickinson, B. Gathercole, R. Gray, V. Green, B. Harrower, A. Heffron, T. Heffron, D. Horvath, P. Knamiller, P. Kolar, D. Lingle, G. Lust, J. Mattisson, F. McCarthy, D. McCauley, C. McCullough, S. McKay, R. Murray, K. Quigley, H. Smith, R. Spence, S. Spilseth, D. Staiger, M. Szydlo, J. Troxler, Z. Walton, P.

Wedholm, R. Wigglesworth, J. Wilmot, K. Wilmot, and P. Wood. We also thank the following for providing valuable assistance: K. Alt, B. Alford, N. Anderson, V. Asher, S. & M. Atkinson, J. Beecham, J. Bigley, M. Bogle, J. Burrell, J. Burr, S. Cain, M. Cherry, S. Consolo-Murphy, D. Cunningham, B. Davis, R. Dickemore, B. Dixon, C. Engkjer, J. Fredrick, D. Garren, B. Giddings, M. Gocke, C. Gower, A. & B. Graham, T. Graham, S. Griffel, C. Groves, J. Halfpenny, N. Hall, L. Hanuska-Brown, C. Harris, R. & S. Hewitt, J. Hilty, M. Hornocker, G. Hoshide, D. Hunter, K. Johnson, S. Johnson, C. Jourdonnais, the Kelsey Family, J. Klein, L. Koch, K. Kunkel, R. Lang, Lighthawk Environmental Aviation, B. Long, S. Lust, A. Magoun, M. Maj, B. Oakleaf, K. O'Hara, M. Orme, D. Ovard, S. Patla, J. Pence, E. Periman, J. Persson, M. Petroni, M. Phillips, K. Pilgrim, A. Pils, D. Ragain, J. Reese, J. Rieck, L. & S. Robertson, M. Ross, M. Schwartz, M. Smith, K. Suzuki, G. Tabor, T. Turlano, B. Walker, B. Weber, and S. Wolf.

LITERATURE CITED

- Arnemo, J. 2006. Biomedical protocols for free-ranging brown bears, gray wolves, wolverines and lynx. Norwegian School of Veterinary Science, General Technical Report, Tromsø, Norway.
- Atkinson, M. 2006. Biomedical protocol for free-ranging wolverines (*Gulo gulo*) in Montana: Capture anesthesia, surgery, tagging, sampling and necropsy procedures. Montana Department of Fish, Wildlife and Parks Internal Report, Bozeman, Montana, USA.
- Austin, M. 1998. Wolverine winter travel routes and response to transportation corridors in Kicking Horse Pass between Yoho and Banff National Parks. Thesis, University of Calgary, Alberta, Canada.
- Bailey, V. 1930. Animal life of Yellowstone National Park. Charles C. Thomas, Springfield, Illinois, USA.
- Banci, V. 1994. Wolverine. Pages 99–127 in L. F. Ruggiero, K. B. Aubry, S. W. Buskirk, L. J. Lyon, and W. J. Zielinski, editors. The scientific basis for conserving forest carnivores, American marten, fisher, lynx, and wolverine in the western United States. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, General Tech Report, RM-254, Fort Collins, Colorado, USA.
- Biota Research and Consulting, Inc., and Jackson Hole Wildlife Foundation [BRC-JHWF]. 2003. Final Report, Jackson Hole roadway and wildlife crossing study, Teton County, Wyoming.
- Brock, B. L., R. M. Inman, K. H. Inman, A. J. McCue, M. L. Packila, and B. Giddings. 2007. Broad-scale wolverine habitat in the conterminous Rocky Mountain states. Chapter 2 in Greater Yellowstone Wolverine Study, Cumulative Report, May 2007. Wildlife Conservation Society, North America Program, General Technical Report, Bozeman, Montana, USA.
- Cegelski, C. C., L. P. Waits, and N. J. Anderson. 2003. Assessing population structure and gene flow in Montana Wolverines (*Gulo gulo*) using assignment based approaches. *Molecular Ecology* 12:2907–2918.
- Cegelski, C. C., L. P. Waits, N. J. Anderson, O. Flagstad, C. Strobeck, and C. J. Kyle. 2006. Genetic diversity and populations structure of wolverine (*Gulo gulo*) populations at the southern edge of their current distribution in North America with implications for genetic viability. *Conservation Genetics* 7:197–211.
- Clevenger, A. P. and N. Waltho. 2004. Long-term, year-round monitoring of wildlife crossing structures and the importance of temporal and spatial variability in performance studies. Pages 292–302 in C. L. Irwin, P. Garrett, and K. P. McDermott, editors. Proceedings of the 2003 International Conference on Ecology and Transportation. Center for Transportation and the Environment, North Carolina State University, Raleigh, North Carolina, USA.

- Copeland, J. P., E. Cesar, J. M. Peek, C. E. Harris, C. D. Long, and D. L. Hunter. 1995. A live trap for wolverine and other forest carnivores. *Wildlife Society Bulletin* 23:535–538.
- Despain, D. G. 1990. Yellowstone vegetation: consequences of environment and history in a natural setting. Roberts Rinehart, Boulder, Colorado, USA.
- Forman, R. T. T., D. Sperling, J. Bissonette, A. Clevenger, C. Cutshall, V. Dale, L. Fahrig, R. France, C. Goldman, K. Heanue, J. Jones, F. Swanson, T. Turrentine, and T. Winter. 2003. Road ecology: science and solutions. Island Press, Washington, D.C., USA.
- Forman, R. T. T., and L. E. Alexander. 1998. Roads and their major ecological effects. *Annual Review of Ecology and Systematics* 29:207–231.
- Gunther, K. A., M. J. Biel, and H. L. Robison. 1998. Factors influencing the frequency of road-killed wildlife in Yellowstone National Park. Technical Paper at The 1998 International Conference on Wildlife Ecology & Transportation. Fort Myers, Florida, USA.
- Hardy A., A. Clevenger, M. Huijser, and G. Neale. 2004. An overview of methods and approaches for evaluating the effectiveness of wildlife crossing structures: emphasizing the science in applied science. Pages 292–302 in C. L. Irwin, P. Garrett, and K. P. McDermott, editors. Proceedings of the 2003 International Conf. on Ecology and Transportation. Center for Transportation and the Environment, N Carolina State Univ., Raleigh, N Carolina, USA.
- Idaho Transportation Department [ITD]. Hourly traffic volume reports. January–December 2006. Station: #102, Route: SH-33, 2.8 miles SE of Junction SH-31, Victor, ID. <http://itd.idaho.gov/>. Accessed 5/1/2007.
- Inman, R. M., R. R. Wigglesworth, K. H. Inman, M. K. Schwartz, B. L. Brock, and J. D. Rieck. 2004. Wolverine makes extensive movements in Greater Yellowstone Ecosystem. *Northwest Science* 78:261–266.
- Inman, R. M., K. H. Inman, A. J. McCue, M. L. Packila, G. C. White, and B. C. Aber. 2007a. Wolverine space use in Greater Yellowstone. Chapter 1 in Greater Yellowstone Wolverine Study, Cumulative Report, May 2007. Wildlife Conservation Society, North America Program, General Technical Report, Bozeman, Montana, USA.
- Inman, R. M., K. H. Inman, M. L. Packila, and A. J. McCue. 2007b. Wolverine reproductive rates and maternal habitat in Greater Yellowstone. Chapter 4 in Greater Yellowstone Wolverine Study, Cumulative Report, May 2007. Wildlife Conservation Society, North America Program, General Tech. Report, Bozeman, Montana, USA.
- Inman, R. M., K. H. Inman, A. J. McCue, and M. L. Packila. 2007c. Wolverine harvest in Montana: survival rates and spatial considerations for harvest management. Chapter 5 in Greater Yellowstone Wolverine Study, Cumulative Report, May 2007. Wildlife Conservation Society, North America Program, General Technical Report, Bozeman, Montana, USA.
- Johnson, V. K. 2001. Trends in rural residential development in the Greater Yellowstone Ecosystem since the listing of the grizzly bear, 1975–1998. *Yellowstone Science*. Spring:2–9.
- Krebs, J. A., and D. Lewis. 2000. Wolverine ecology and habitat use in the north Columbia mountains: Progress report 1999. Pages 695–703 in L. M. Darling, editor. Proceedings of a conference on the biology and management of species and habitats at risk. Volume 2. British Columbia Ministry of Environment, Lands and Parks, Victoria, British Columbia, Canada, and University College of the Cariboo, Kamloops, British Columbia, Canada.
- Krebs, J., E. Lofroth, J. Copeland, V. Banci, D. Cooley, H. Golden, A. Magoun, R. Mulders, and B. Schultz. 2004. Synthesis of survival rates and causes of mortality in North American wolverines. *Journal of Wildlife Management* 68:493–502.
- Marston, R. A., and J. E. Anderson. 1991. Watersheds and vegetation of Greater Yellowstone Ecosystem. *Conservation Biology* 5:338–346.
- McCue, A. J., R. M. Inman, K. H. Inman, and M. L. Packila. 2007. Diel winter activity of wolverines in Grater Yellowstone. Chapter 6 in Greater Yellowstone Wolverine Study, Cumulative Report, May 2007. Wildlife Conservation Society, North America Program, General Technical Report, Bozeman, Montana, USA.
- Natural Resources Conservation Service [NRCS]. 2007. National Water and Climate Center, SNOTEL data and products. Historical temperature and precipitation data for Carrot Basin, Montana, 1983–2006. <<http://www.wcc.nrcs.usda.gov/snow/>>. Accessed 5 Jan 2007.
- Noss, R., C. Carroll, K. Vance-Borland, and G. Wuerthner. 2002. A multicriteria assessment of the irreplaceability and vulnerability of sites in the Greater Yellowstone Ecosystem. *Cons. Bio.* 16:895–908.
- Patten, D. T. 1991. Defining the Greater Yellowstone Ecosystem. Pages 19–25 in R. B. Keiter and M. S. Boyce, editors. The Greater Yellowstone Ecosystem: Redefining America's Wilderness Heritage. Yale University Press, New Haven, Connecticut, USA.
- Persson, J., A. Landa, R. Andersen, and P. Segerström. 2006. Reproductive characteristics of female wolverines (*Gulo gulo*) in Scandinavia. *Journal of Mammalogy* 87:75–79.
- Ruediger, W. 2000. The relationship between rare carnivores and highways: An update for year 2000. USDA Forest Service Northern Region, Missoula, Montana, USA.
- Squires, J. R., D. H. Pletscher, T. J. Ulizio, and L. F. Ruggiero. 2006. The association between landscape features and transportation corridors on movements and habitat-use patterns of wolverines, Final Report, June 2006, Montana Dept of Transportation Project No. 8171.
- Streubel, D. 1989. Small mammals of the Yellowstone Ecosystem. Roberts Rinehart, Boulder, Colorado, USA.
- Transportation Research Board. 2002. Surface transportation environmental research: a long-term strategy. Special report 268, National Academy Press, Washington, D.C., USA.

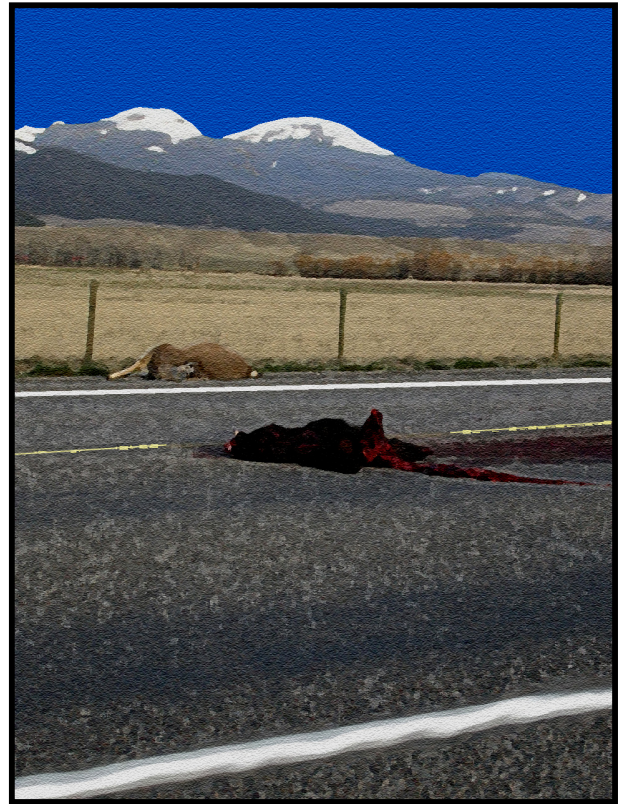




Photo. Development in primary wolverine habitat.

Table 1. Site-specific wolverine road crossings where exact location was documented or successive locations were ≤ 2 hours apart, Greater Yellowstone Area of Idaho, Montana, and Wyoming, 2002–2007.

ID	Method	Date	Time	Hwy Crossed	Near	Direction of Travel
M304	GPS	3/31–4/1/02	23:00–01:00	Idaho 34	Blackfoot Reservoir, ID	Fox Hills to Chesterfield Range
M230	GPS	3/27/2005	06:00–08:00	MT87	North Reynolds Pass, MT	Gravelly Range to Henrys Lake Range
F133	Track	3/4/2007	07:00–17:00	US191	Snowslide Creek, Yellowstone National Park	Madison Range to Gallatin Range
M304	GPS	3/29/2002	03:00–05:00	US26	Palisades Reservoir, ID	Snake Range to Caribou Range
M304	GPS	4/12/2002	02:00–04:00	US26	Palisades Reservoir, ID	Caribou Range to Snake Range
M230	GPS	3/30/2005	06:00–08:00	US287	Earthquake Lake, MT	Madison Range to Henrys Lake Range
	Visual	6/22/2006	21:00	US287	Hebgen Lake, MT	Henrys Lake Range to Madison Range
M204	Road-kill	3/10/2004	Approx 22:00	US287	Hebgen Lake, MT	Unknown direction
Munk3	Road-kill	3/31/2004	20:00–05:00	US287	McAllister, MT	Unknown direction
Funk4	Road-kill	3/21/2004	Unk	US30	Kemmerer, WY	Unknown direction
M304	GPS	4/30/2002	00:00–02:00	US89/287	North Boundary, Grand Teton National Park	Teton Wilderness to Teton Range
F405	Track	3/25/2005	Approx 16:00	WYO22	Squaw Canyon, Teton Pass, WY	Snake Range to Teton Range
M304	GPS	3/26/2002	19:00–21:00	WYO22	Teton Pass, WY	Teton Range to Snake Range
M304	GPS	4/13/2002	02:00–04:00	WYO22	Teton Pass, WY	Snake Range to Teton Range

Table 2. Wolverine road crossings where general area was estimated from GPS or VHF locations that were made >2 hours apart, Greater Yellowstone Area of Idaho, Montana, and Wyoming, 2004–2007. The majority of these crossing have successive locations ≤24 days apart, except one 82- and one 89-day interval.

ID	Method	Date	Time	Hwy Crossed	Near	Direction of Travel
M304	GPS	3/30–3/31/02	21:00–05:00	Idaho 34	Wayan, ID	Caribou Range to Grays Range
M230	GPS	3/24–3/25/05	22:00–10:00	Idaho 87	South Reynolds Pass, ID	Henrys Lake Range to Gravelly/Centennial
F133	VHF	2/25–3/2/07	.	US191	Yellowstone National Park	Gallatin Range to Madison Range
F107	VHF	3/3–3/15/03	.	US191	Yellowstone National Park	Madison Range to Gallatin Range
F107	VHF	4/22–5/7/03	.	US191	Yellowstone National Park	Gallatin Range to Madison Range
F107	VHF	5/14–6/7/03	.	US191	Yellowstone National Park	Gallatin Range to Madison Range
F107	VHF	5/7–5/14/03	.	US191	Yellowstone National Park	Madison Range to Gallatin Range
M221	GPS	4/13–4/16/05	.	US191/287 or US20	West Yellowstone, MT	Henrys Lake Range to Yellowstone Plateau
F405	VHF	2/17–2/22/05	.	US26	Palisades Reservoir, ID	Snake Range to Caribou Range
F405	VHF	2/28–3/3/05	.	US26	Palisades Reservoir, ID	Caribou Range to Snake Range
F421	VHF	4/2–6/23/05	.	US26/89	East of Alpine, WY	Snake Range to Salt River Range
M230	GPS	3/28–3/30/05	.	US287	Earthquake Lake, MT	Henrys Lake Range to Madison Range
M221	GPS	4/9–4/12/05	.	US287	Earthquake Lake, MT	Madison Range to Henrys Lake Range
M204	VHF	10/15/03–1/13/04	.	US287	Earthquake Lake, MT	Madison Range to Henrys Lake Range
M304	GPS	4/15/2002	12:00–22:00	US89/287	Colter Bay, Grand Teton National Park	Teton Range to Teton Wilderness
F405	VHF	1/14–1/17/06	.	WYO22	Teton Pass, WY	Snake Range to Teton Range
F405	VHF	1/29–2/9/05	.	WYO22	Teton Pass, WY	Teton Range to Snake Range
F405	VHF	1/6–1/14/06	.	WYO22	Teton Pass, WY	Teton Range to Snake Range
M301	VHF	10/15–10/26/06	.	WYO22	Teton Pass, WY	Teton Range to Snake Range
M301	VHF	10/26–10/31/06	.	WYO22	Teton Pass, WY	Snake Range to Teton Range
M301	VHF	11/29–12/3/06	.	WYO22	Teton Pass, WY	Teton Range to Snake Range
M301	VHF	12/3/06–12/7/06	.	WYO22	Teton Pass, WY	Snake Range to Teton Range
M301	VHF	2/17/07–2/28/07	.	WYO22	Teton Pass, WY	Teton Range to Snake Range
F421	VHF	2/22/05–2/26/05	.	WYO22	Teton Pass, WY	Teton Range to Snake Range
F405	VHF	3/14–3/25/05	.	WYO22	Teton Pass, WY	Teton Range to Snake Range
F405	VHF	3/3–3/8/05	.	WYO22	Teton Pass, WY	Snake Range to Teton Range
F405	VHF	4/30–5/14/05	.	WYO22	Teton Pass, WY	Teton Range to Snake Range
F405	VHF	7/17–7/22/05	.	WYO22	Teton Pass, WY	Snake Range to Teton Range
M221	VHF	1/4–1/28/06	.	WYO296	Between Cooke City, MT and Cody, WY	Not represented on map, SW to NE

Table 3. Wolverine road crossings where site-specific and general area was estimated from GPS or VHF locations, Big Sky, Montana USA, 2004–2007.

ID	Method	Date	Time	Hwy Crossed	Near	Direction of Travel
F103	VHF	6/7-6/13/03	.	MT64/Jack Cr Rd	Big Sky, MT	N to S within Madison Range
F103	VHF	7/6-7/17/03	.	MT64/Jack Cr Rd	Big Sky, MT	S to N within Madison Range
F103	VHF	7/17-7/26/03	.	MT64/Jack Cr Rd	Big Sky, MT	N to S within Madison Range
F103	VHF	9/11-9/18/03	.	MT64/Jack Cr Rd	Big Sky, MT	S to N within Madison Range
F103	VHF	9/18-10/1/03	.	MT64/Jack Cr Rd	Big Sky, MT	N to S within Madison Range
M204	VHF	4/9-5/14/03	.	MT64/Jack Cr Rd	Big Sky, MT	N to S within Madison Range
M205	VHF	5/7-5/14/03	.	MT64/Jack Cr Rd	Big Sky, MT	N to S within Madison Range
M205	VHF	5/27-6/7/03	.	MT64/Jack Cr Rd	Big Sky, MT	S to N within Madison Range
M205	VHF	6/7-6/17/03	.	MT64/Jack Cr Rd	Big Sky, MT	N to S within Madison Range
M205	VHF	7/6-7/17/03	.	MT64/Jack Cr Rd	Big Sky, MT	S to N within Madison Range
M205	VHF	8/12-8/30/03	.	MT64/Jack Cr Rd	Big Sky, MT	N to S within Madison Range
M205	VHF	8/30-9/18/03	.	MT64/Jack Cr Rd	Big Sky, MT	S to N within Madison Range
M205	VHF	9/18-10/1/03	.	MT64/Jack Cr Rd	Big Sky, MT	N to S within Madison Range
M205	VHF	11/1-12/9/03	.	MT64/Jack Cr Rd	Big Sky, MT	S to N within Madison Range
M205	VHF	12/9-12/19/03	.	MT64/Jack Cr Rd	Big Sky, MT	N to S within Madison Range
M205	VHF	3/8-3/27/04	.	MT64/Jack Cr Rd	Big Sky, MT	S to N within Madison Range
M205	VHF	3/27-4/26/04	.	MT64/Jack Cr Rd	Big Sky, MT	N to S within Madison Range
M205	VHF	6/21-7/9/04	.	MT64/Jack Cr Rd	Big Sky, MT	S to N within Madison Range
M205	VHF	7/9-7/20/04	.	MT64/Jack Cr Rd	Big Sky, MT	N to S within Madison Range
M205	VHF	7/20-7/24/04	.	MT64/Jack Cr Rd	Big Sky, MT	S to N within Madison Range
M205	VHF	7/29-8/13/04	.	MT64/Jack Cr Rd	Big Sky, MT	N to S within Madison Range
M205	VHF	9/26-10/8/04	.	MT64/Jack Cr Rd	Big Sky, MT	S to N within Madison Range
M205	VHF	11/1-11/12/04	.	MT64/Jack Cr Rd	Big Sky, MT	N to S within Madison Range
M205	VHF	11/15-11/29/04	.	MT64/Jack Cr Rd	Big Sky, MT	S to N within Madison Range
M205	VHF	11/29-12/13/04	.	MT64/Jack Cr Rd	Big Sky, MT	N to S within Madison Range
M205	VHF	1/17-1/25/05	.	MT64/Jack Cr Rd	Big Sky, MT	S to N within Madison Range
M205	VHF	1/31-2/10/05	.	MT64/Jack Cr Rd	Big Sky, MT	N to S within Madison Range
M205	VHF	2/17-2/22/05	.	MT64/Jack Cr Rd	Big Sky, MT	S to N within Madison Range
M205	VHF	2/28-3/5/05	.	MT64/Jack Cr Rd	Big Sky, MT	N to S within Madison Range
M205	VHF	3/5-3/10/05	.	MT64/Jack Cr Rd	Big Sky, MT	S to N within Madison Range
M205	VHF	3/10-3/26/05	.	MT64/Jack Cr Rd	Big Sky, MT	N to S within Madison Range
M205	VHF	3/26-4/16/05	.	MT64/Jack Cr Rd	Big Sky, MT	S to N within Madison Range
M205	VHF	4/16-5/4/05	.	MT64/Jack Cr Rd	Big Sky, MT	N to S within Madison Range
M205	VHF	5/30-7/8/05	.	MT64/Jack Cr Rd	Big Sky, MT	S to N within Madison Range
M205	VHF	7/29-8/16/05	.	MT64/Jack Cr Rd	Big Sky, MT	N to S within Madison Range
M205	VHF	9/2-9/7/05	.	MT64/Jack Cr Rd	Big Sky, MT	S to N within Madison Range
M205	VHF	9/15-9/26/05	.	MT64/Jack Cr Rd	Big Sky, MT	N to S within Madison Range
M205	VHF	9/29-10/6/05	.	MT64/Jack Cr Rd	Big Sky, MT	S to N within Madison Range
M205	VHF	11/15-11/22/05	.	MT64/Jack Cr Rd	Big Sky, MT	N to S within Madison Range
M205	VHF	12/8-12/19/05	.	MT64/Jack Cr Rd	Big Sky, MT	S to N within Madison Range
M205	VHF	12/19/05-1/5/06	.	MT64/Jack Cr Rd	Big Sky, MT	N to S within Madison Range
M205	VHF	1/23-2/6/06	.	MT64/Jack Cr Rd	Big Sky, MT	S to N within Madison Range
M205	VHF	2/6-2/11/06	.	MT64/Jack Cr Rd	Big Sky, MT	N to S within Madison Range
M205	VHF	2/11-2/18/06	.	MT64/Jack Cr Rd	Big Sky, MT	S to N within Madison Range
M205	VHF	2/18-2/24/06	.	MT64/Jack Cr Rd	Big Sky, MT	N to S within Madison Range
M205	VHF	2/24-3/5/06	.	MT64/Jack Cr Rd	Big Sky, MT	S to N within Madison Range
M205	VHF	3/5-3/10/06	.	MT64/Jack Cr Rd	Big Sky, MT	N to S within Madison Range
M205	VHF	3/10-4/8/06	.	MT64/Jack Cr Rd	Big Sky, MT	S to N within Madison Range
M205	VHF	4/8-4/20/06	.	MT64/Jack Cr Rd	Big Sky, MT	N to S within Madison Range
M205	VHF	4/20-5/13/06	.	MT64/Jack Cr Rd	Big Sky, MT	S to N within Madison Range
M205	VHF	8/1-8/27/06	.	MT64/Jack Cr Rd	Big Sky, MT	N to S within Madison Range
M205	VHF	8/27-8/31/06	.	MT64/Jack Cr Rd	Big Sky, MT	S to N within Madison Range

Table 3 continued. Wolverine road crossings where site-specific and general area was estimated from GPS or VHF locations Big Sky, Montana USA, 2004–2007.

M205	VHF	9/14-9/24/06	.	MT64/Jack Cr Rd	Big Sky, MT	N to S within Madison Range
M205	VHF	10/12-10/31/06	.	MT64/Jack Cr Rd	Big Sky, MT	S to N within Madison Range
M205	VHF	11/10-11/25/06	.	MT64/Jack Cr Rd	Big Sky, MT	N to S within Madison Range
M205	VHF	11/25-11/29/06	.	MT64/Jack Cr Rd	Big Sky, MT	S to N within Madison Range
M205	VHF	12/9-12/20/06	.	MT64/Jack Cr Rd	Big Sky, MT	N to S within Madison Range
M205	VHF	12/20-12/30/06	.	MT64/Jack Cr Rd	Big Sky, MT	S to N within Madison Range
M205	VHF	12/30/06-1/12/07	.	MT64/Jack Cr Rd	Big Sky, MT	N to S within Madison Range
M205	VHF	1/16-2/3/07	.	MT64/Jack Cr Rd	Big Sky, MT	S to N within Madison Range
M205	VHF	2/6-2/17/07	.	MT64/Jack Cr Rd	Big Sky, MT	N to S within Madison Range
M205	VHF	2/17-2/19/07	.	MT64/Jack Cr Rd	Big Sky, MT	S to N within Madison Range
M221	VHF	6/16/04-1/10/05	.	MT64/Jack Cr Rd	Big Sky, MT	N to S within Madison Range
M221	GPS/VHF	1/22-1/25/05	.	MT64/Jack Cr Rd	Big Sky, MT	S to N within Madison Range
M221	GPS	2/5-2/8/05	.	MT64/Jack Cr Rd	Big Sky, MT	N to S within Madison Range
M221	GPS	2/22/2005	21:00–23:00	MT64/Jack Cr Rd	Big Sky, MT	S to N within Madison Range
M221	GPS	3/30-4/2/05	.	MT64/Jack Cr Rd	Big Sky, MT	N to S within Madison Range



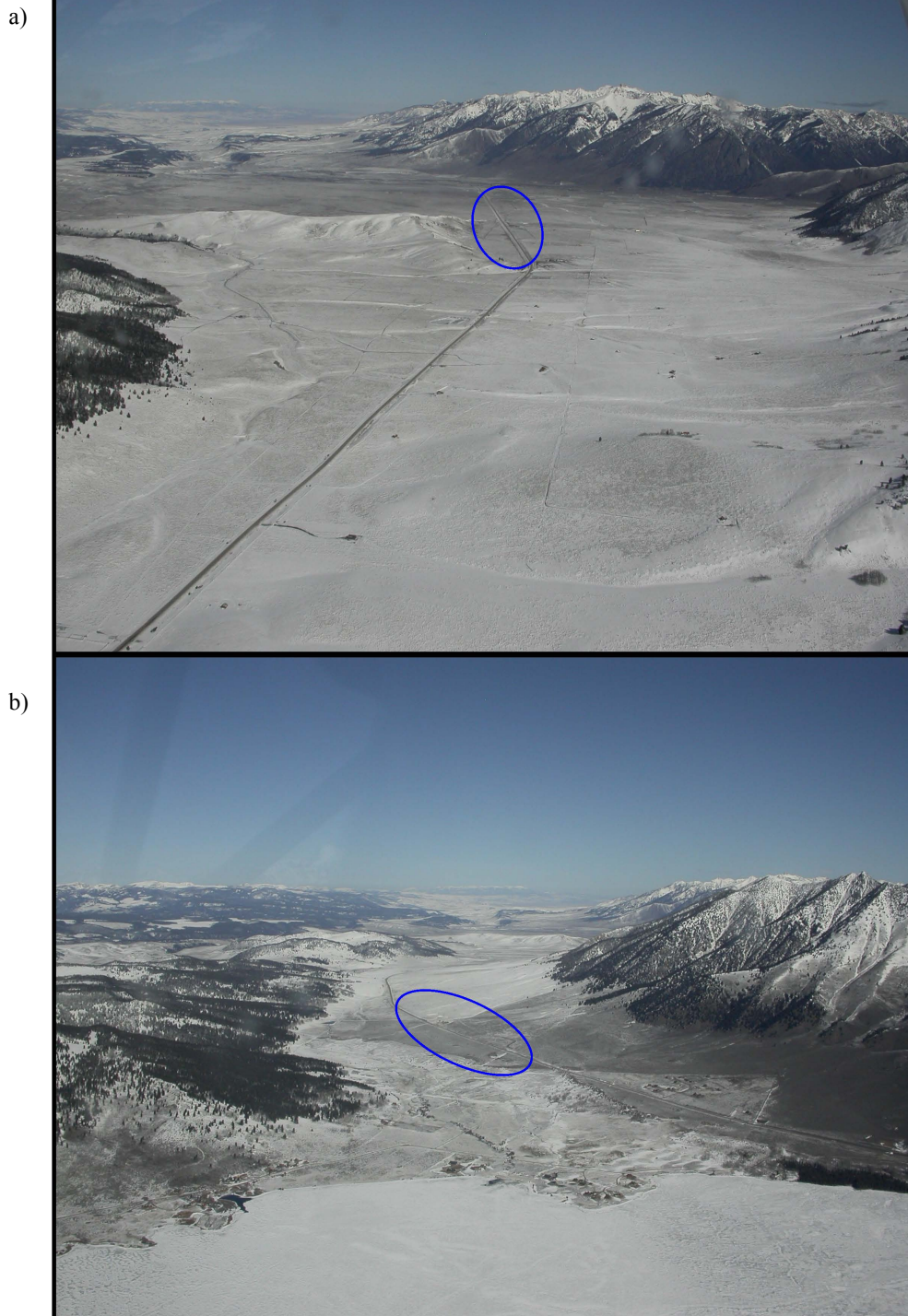
Photo 1. We have documented 4 crossings of US287 near Earthquake Lake. This view is looking east, the Henrys Lake Range is to the right and the Madison Range is to the left and in the background.



Photo 2. F133 road crossing within Yellowstone National Park on US191. We have documented 5 additional crossings of US191 in Yellowstone National Park. This view is looking south, the Madison Range is to the right and the Gallatin Range is to the left.



Photo 3. F405 road crossing of WYO22 on the west side of Teton Pass, Wyoming. We have documented a total of 16 crossings of WYO22. This view is looking west, the Teton Range is to the right and the Snake Range is to the left.



Photos 4A and 4B. The blue circle indicates the approximate location that M230 crossed MT/Idaho 87 a) north of Reynolds Pass in Montana and b) south of Reynolds Pass in Idaho. In both pictures the view is looking north, the Henrys Lake Range is to the right, the Gravelly Range is on the left, and the Madison Range is in the background. Henrys Lake is iced-over at the bottom of photo b). This area is likely one of the most important wolverine linkage zones in the conterminous U.S. as it occurs at a habitat “bottleneck” between the regional population centers of Greater Yellowstone and central Idaho (see Brock et al. 2007).



Photo 5. Road kill location of an unmarked subadult male that was killed on US287 between Ennis and McAllister in the Madison Valley, Montana. This view is looking northwest, the Madison Range is in the foreground and the Tobacco Root Range is in the background.



Photo 6. M204 was killed near an elk carcass on US287 on the north side of Hebgen Lake, Montana. This view is looking northeast, the Henrys Lake Range is in the foreground and the Madison Range is in the background.

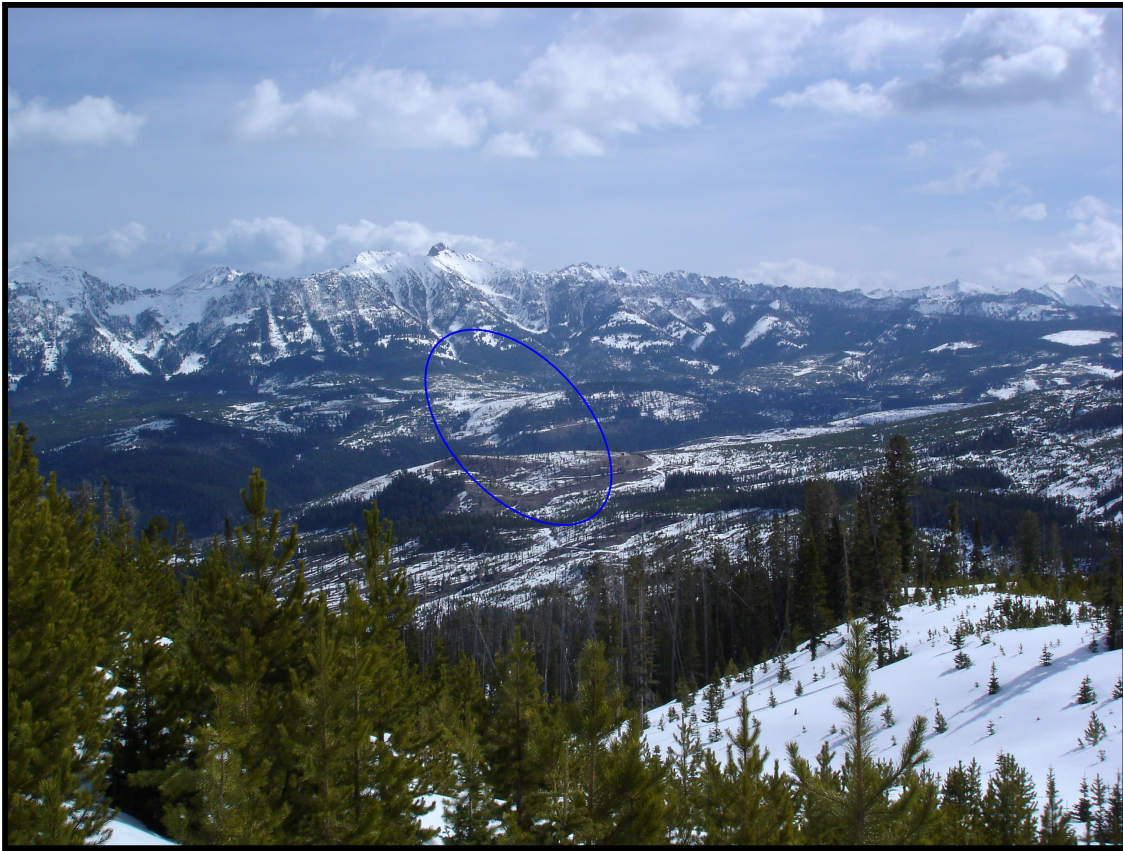


Photo 7. The blue circle represents the approximate area where M221 crossed the Jack Creek Road near Big Sky, MT. We have documented 66 additional crossings of MT64/Jack Creek Road. This view is looking north into Jack Creek on the west side of the Madison Range, the Spanish Peaks are in the background.