# Effects of industry on wolverine (*Gulo gulo*) ecology in the boreal forest of northern Alberta

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## ***RESEARCH SUMMARY***

Alberta wolverine (*Gulo gulo*) populations *May be at Risk* but are considered *Data Deficient* by the Alberta government. Similarly, in Canada, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) classifies wolverines as a *Species of Special Concern* yet there are very few data to support this population assessment. Industrial activity is cited in both assessments as a potentially key negative influence on wolverine distribution. Our goal is to understand the effects of industrial traffic patterns and infrastructure on wolverine movement and distribution in northwest Alberta. With industry rapidly expanding in Alberta and the rest of northern Canada, these data are paramount for the proper management of wolverine populations. Our methods centered around attaching GPS radio collars to wolverines and relating their movements to industrial traffic patterns quantified with remote sensor cameras along roads. Our wolverine live-traps were open for 108 days (579 trap nights) between November 2013 and April 2014. During that time, we live-trapped and radio collared 24 different wolverines. We caught 13 males with an average weight of 13.62 (range is 12-15.5 kg) and 11 females with an average weight of 9.7 (range is 8.5-13 kg). Currently, 18 wolverines are wearing GPS radio collars that will be collecting data through early-winter 2014/2015. We found that male (n = 5) home ranges cover 400 - 1200 $km^2$ while female (n = 5) home ranges cover 200 - 500 $km^2$. GPS data reveals regular wolverine movement through areas with dense industrial infrastructure, although we did see a tendency for wolverines to avoid being very close to roads (< 300 m). We monitored industrial traffic patterns on over 100 roads in Rainbow Lake. Although we have not yet analyzed these data, our initial inspection reveals wolverines regularly crossing high-grade industrial and paved roads with > 100 vehicles/day. In visiting GPS data clusters, we found wolverines were feeding on moose (*Alces alces*), caribou (Rangider tarandus), and black bear (*Ursus americanus*) carcasses. We found evidence of wolverines hunting and killing snowshoe hare (Lepus americanus), grouse (spruce grouse (*Falcipennis canadensis*) and ruffed grouse (*Bonasa umbellus*)), and beaver (*Castor canadensis*). Wolf (*Canis lupus*) tracks were abundant on the landscape but did not appear to influence wolverine movement. Lastly, we found a wolverine den with two kits in the rot wad of a fallen tree. The den had 20 - 30 cm of snow on its roof in mid-March and was in an area with high wolf activity. Next winter, we plan to expand our live-trapping to include study areas with less industrial development.

## ***RESEARCH OBJECTIVES AND RATIONAL***

The wolverine is valued by the trapping, conservation, and First Nations communities in Canada as a symbol of wilderness. Wolverines roam large areas, exist at low densities, and are tenacious scavengers and hunters. The wilderness areas that wolverine inhabit in Canada, however, are quickly being altered for the extraction of oil, gas, minerals, and timber. The negative effects of industrial infrastructure and activities on wolverine movement and distribution are the main reason COSEWIC has considered wolverines a *Species of Special Concern* since 1982 (COSEWIC 2014) and why they *May be at Risk* in Alberta (ESRD 2010). Wildlife officials at both a national and provincial level, however, have cited a lack of adequate data for making these wolverine population assessments. For example, much of the population assessment of wolverines in Canada is based on a harvest records that are often incomplete and underreported (COSEWIC 2014). In Alberta, wolverines are considered *Data Deficient* because there have been so few wolverine research studies outside of the Rocky Mountains. To ensure the long term presence of wolverines in Canada, it is paramount that we understand wolverine ecology and population status in industrial landscapes that are becoming common in the wolverine's North American range. The objective of our research is to evaluate wolverine ecology along a gradient of industrial disturbances in the vicinity of Rainbow Lake, Alberta. Specifically, we will investigate: 1) the influence of traffic, land use, and industrial infrastructure on wolverine movement and den site selection; 2) wolverine density; and 3) wolverine food habits.

Wolverines are generally associated with undisturbed habitats. Lending support to the idea of wolverines as a wilderness species, researchers in the mountains of Scandinavia, Idaho, and British Columbia found that wolverines avoided low-elevation forests with roads and other infrastructure and instead appeared to prefer alpine areas (May et al. 2006, Copeland et al. 2007, Krebs et al. 2007). Researchers have questioned, however, whether the apparent avoidance of roads by wolverines could be because roads do not readily occur in rugged mountainous wolverine habitats (Copeland et al. 2007). Because northwest Alberta is relatively flat boreal forest, roads created by industry for resource extraction permeate even the most remote and inhospitable of areas where wolverines occur. This gives us the unique opportunity to understand wolverine movement and distribution relative to roads.

Although wolverines have been described as avoiding roads or areas of human disturbance, there has been minimal investigation by researchers into the reasons for avoidance (Ruggiero et al. 2007). For example, Krebs et al. (2007) found that wolverines in the mountains of British Columbia did not use areas with back-country recreation. To understand the reasons for this avoidance by wolverines, researchers in Idaho are attaching GPS devices to skiers and snowmobilers so that human movements can be related to those of radio collared wolverines in the area (Heinmeyer et al. 2012). Similarly, the intensity of human use of roads, or traffic, is likely an important driver of wolverine use of roads. Although traffic effects on movement have been researched for other wildlife species (Northrup et al. 2012, Roever et al. 2012), there has been no attempt to model the timing and frequency of road traffic in relation to wolverine distribution and movement. These data would better clarify the relationship between wolverines and roads and inform land and wildlife managers of traffic volume thresholds that might alter wolverine behaviours.

Researchers also have found that wolverines select den sites away from areas of human disturbance (May et al. 2012). Besides direct displacement of denning females from industrial activity, there also are indirect effects from industry. For example, pipelines, clear cuts, and other disturbances that create open spaces and edge habitats might increase ungulate and, in turn, wolf abundance. Researchers suggest that wolverines avoid these disturbed areas in mountain foothills and lowland boreal forests because of increased predation risk from wolves (Bowman et al. 2010, Fisher et al. 2013). In the mountains, wolverine den sites are located in high elevation areas that wolves cannot access because of deep snow (Magoun and Copeland 1998) and which generally have minimal industrial development. In northwest Alberta, however, wolverines exist year round in the same industrialized low-elevation habitats as wolves, providing us with the opportunity to examine the effects of industrial infrastructure and wolves on den site selection.

We are also in a unique position to understand how snow impacts wolverine den site selection and success. In the Rocky Mountains, deep snow through the time kits are weaned occludes wolves from wolverine denning areas and also provides structure and insulation for wolverine den sites (Magoun and Copeland 1998, Copeland et al. 2010). As a result of wolverine dependency on snow, climate change and its effects on spring snowpack is seen as a rationale for listing wolverines as *Threatened* on the Endangered Species List in the USA. Northwest Alberta lacks deep spring snowpack such that wolverines likely rely on different habitat characteristics for successful den sites. Consequently, our research will provide unique insight into wolverine denning ecology in the boreal forest.

Lastly, researchers propose that high wolverine abundance is found in areas with good denning habitat and large populations of ungulates (Lofroth and Krebs 2007). According to these criteria, northwest Alberta would be considered poor quality wolverine habitat. Moose and white-tailed deer (*Odocoileus virginianus*) are rarely observed and caribou populations have declined because of industrial disturbance (Cichowski 2010). Additionally, a lack of deep spring snow in northwest Alberta would appear to offer marginal wolverine denning habitat. We plan to estimate wolverine density using mark-recapture techniques and collect scat for food habits analysis. If we find wolverines are abundant and

do not rely on ungulates or snowpack as readily, it will refute many of the traditional ideas of ideal wolverine habitat.

***PROJECT BACKGROUND***

Research on wolverines was initiated by the Alberta Trappers Association (ATA) and the Alberta Conservation Association (ACA). The ATA/ACA have been using run-pole camera stations to document wolverine distribution on registered traplines throughout Alberta. ATA trappers have been placing and maintaining run-poles in the field. The University of Alberta was asked to participate in this partnership and to design a study that investigated wolverine ecology in Alberta at a finer grain. Our goal is to meld both academic and trapper knowledge and skills in our wolverine research project.

***STUDY AREA***

We focused our field activities in northwest Alberta around the town of Rainbow Lake (Figure 1, population of 870). Our live-traps sampled an area of approximately 1,624 km$^2$ (minimum convex polygon (MCP) of trap array) from the British Columbia border to 30 km east of the Rainbow Lake townsite. The Hay-Zama Lakes Complex bounded our study area to the north and Rainbow Lake (widening of the Hay River) bounded our study area to the south (30 km south of Rainbow lake townsite). Elevations at live-traps ranged from 428 to 612 m. Major river drainages in the study area include the Hay and Chinchaga. The natural subregion north of Rainbow Lake is central mixedwood whereas south of Rainbow Lake is lower boreal highlands (Natural Regions Committee 2006). The study area has paved highway, winter roads, high-grade roads (dirt/gravel roads that are open year round), and secondary roads (dirt/gravel roads open year round but narrower than high-grade roads). Winter roads are generally open from late-November to late-March. Road density averaged across the 1,624 km$^2$ study area trap array is 0.65 km/km$^2$. The study area also has an abundance of pipelines, seismic lines (in varying stages of regeneration), transmission lines, well sites, pump jacks, oil and gas processing plants, and pump stations. Forestry activities were minimal in our study area this winter, although the opening of a pulp plant next winter in nearby High Level, Alberta will result in increased logging activity in Rainbow Lake. Other than industrial activity, there is very little use of the Rainbow Lake landscape by recreationalists during winter.

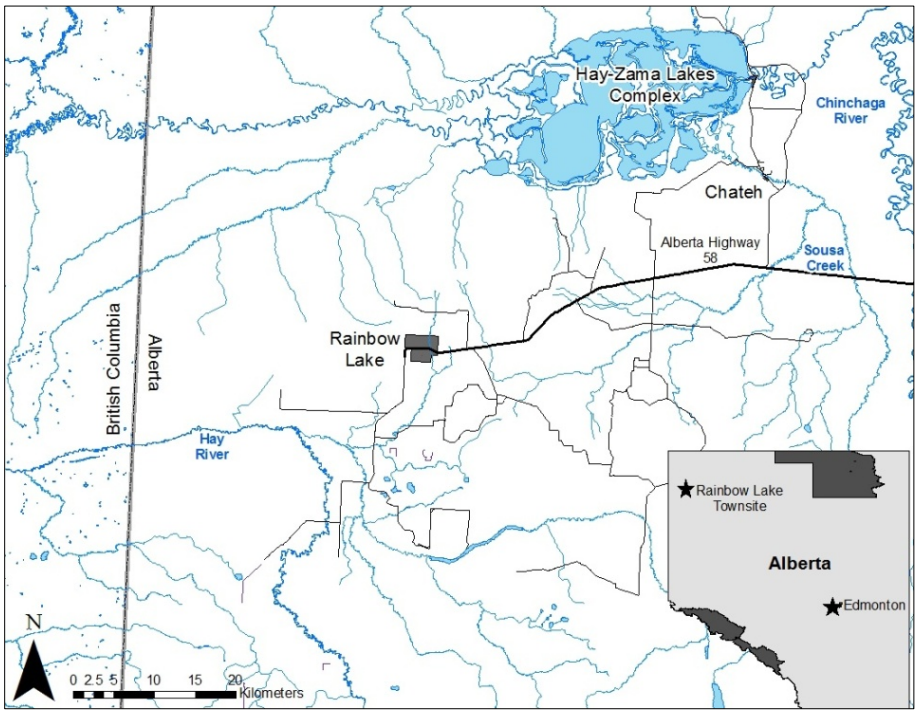


Figure 1. Field site in the northwest corner of Alberta

## ***METHODS***

*Live-trapping*

Our main goal this first winter was live-trapping wolverines and attaching GPS radio collars. To capture wolverines, we used 18 wolverine live-traps. During summer and fall of 2013 we built these traps with the help of the Dene Tha First Nation, Husky Oil, and the ATA. Traps were built as described in Copeland et al. (1995) and Lofroth et al. (2008). We generally built a single trap with two spruce or pine trees that were 30-40 cm DBH. Floors were made of 2 x 10" rough cut spruce. We used a vice grip trigger system that was baited with skinned beaver carcasses donated by the ATA (Figure 2). To sample wolverines with different behaviours, we placed live-traps in habitats with low, medium, and high industrial development. We used road density as a surrogate for industrial development. Within these areas, we located traps in the best available habitats, generally along streams or in stringers of intact forest through fragmented areas. Traps were spaced 10-20 km from the nearest trap and 0.1 - 7.0 km from the nearest road, with most live-traps (14 of 18) 100 - 900 m from a road.

We monitored live-traps with satellite trap transmitters (Vectronic TT3 on the GlobalStar system). We would receive emails from the trap transmitters every 30 minutes after the trap lid closed. We would respond to tripped traps at all hours of the day and process trapped animals immediately. During denning, we would release wolverines we suspected were females if we did not think they could be processed and released within 12 hours. We immobilized wolverines with a jab stick loaded with ketamine and dexdomitor and attached 180 g Telemetry Solutions remote download GPS radio collars (Quantum 4000). We attached cotton rot offs to all radio collars in case we were unable to recapture the wolverine. We programmed radio collars to take GPS positions every two hours. Data recovery was accomplished using remote download equipment during wolverine recaptures.


Figure 2. Wolverine live-trap diagram.

*Vehicle traffic, wolverine density, and food habits*

We used 17 motion-sensor cameras positioned along industrial roads to quantify the frequency and timing of vehicle traffic. Cameras were set-up at road intersections so that multiple roads could be surveyed with a single camera. Cameras took three pictures in succession when a vehicle drove by. We

rotated cameras every two weeks and sampled high-grade, secondary, and winter industrial roads throughout the study area.

We also positioned motion-sensor cameras at wolverine live-traps to capture images of wildlife visits. We plan to estimate wolverine density in the Rainbow Lake area using images of marked and unmarked wolverine visits to traps.

We collected scat for food habits analysis from live-traps if the wolverine entered the trap within a few hours of us processing the animal. We also back-tracked wolverines to collect scat. We visited GPS point clusters, or GPS points from a wolverine that were within close proximity of each other (generally 20-30 points < 200 m apart), when we had enough GPS data from a wolverine radio collar. At clusters, we would collect scat and identify the reasons a wolverine was in the area.

## ***RESULTS***

*Live- trapping*

Live-traps were open from mid-November through late-April for a total of 108 days or 579 trap nights. We live-trapped and processed 24 wolverines over this period (Table 1). We caught 13 males with an average weight of 13.62 (range is 12-15.5 kg) and 11 females with an average weight of 9.7 (range is 8.5-13 kg). Also, we released three wolverines that we suspected were lactating and had been in the trap over eight hours, bringing the total of live-trapped wolverines to 27. We averaged 24 traps nights/new wolverine capture and captured wolverines in 13 of our 18 live-traps. We recaptured 15 wolverines. The wolverines that we did not recapture were first live-trapped towards the end of the live- trapping season. The success of individual traps is displayed in Table 2.

Table 1. List of wolverines captured in Rainbow Lake, Alberta between November 2013 and April 2014. If a wolverine is "radio collared", it means the wolverine will be wearing the radio collar through summer 2014.

| Animal ID | Weight (kg) | Notes |
|---|---|---|
| F1 | 9 | Radio collared |
| F2 | 13 | Dropped radio collar |
| F3 | 10 | Dropped radio collar |
| F4 | 10.5 | Dropped radio collar; lactating |
| F5 | 10.5 | Radio collared; lactating |
| F6 | 9 | Radio collared; missing eye; lactating |
| F7 | 9 | Radio collared; exploratory movements |
| F8 | 9 | Radio collared; lactating |
| F9 | 9.5 | Radio collared; older; lactating |
| F10 | 8.7 | Radio collared; lactating |
| F11 | 8.5 | Radio collared; lactating |
| M1 | 13 | Dropped radio collar; dominant male |
| M2 | 14.5 | Dropped radio collar; appears to use same area as M5 but unsure of their relationship |
| M3 | 12 | Dropped radio collar |
| M4 | 15.5 | Radio collared |
| M5 | 14.25 | Radio collared; dominant male |
| M6 | 15.5 | Radio collared; dominant male |

| | | |
|---|---|---|
| M7 | 14 | Radio collared; dominant male |
| M8 | 12.5 | Radio collared; likely son of M6; yearling |
| M9 | 15 | Radio collared; dominant male |
| M10 | 13.3 | Radio collared; exploratory movements; yearling |
| M11 | 11.5 | Radio collared; scar on top of head; yearling |
| M12 | 14 | Radio collared; very old male with missing teeth |
| M13 | 12 | Radio collared; yearling |

Table 2. The success of wolverine live-traps in capturing wolverines. Although 27 individuals in total were captured between November 2013 and April 2014, some of the animals were captured in multiple traps, hence the sum of the "# of wolverines captured" being 35. Traps 15 - 18 are made of 4x4" lumber whereas traps 1-14 are log box live-traps.

| Trap ID | Nights open | # of wolverines captured | Nights open/capture |
|---|---|---|---|
| 1 | 22 | 2 | 11 |
| 2 | 57 | 2 | 28.5 |
| 3 | 42 | 4 | 10.5 |
| 4 | 15 | 3 | 5 |
| 5 | 42 | 1 | 42 |
| 6 | 56 | 5 | 11.2 |
| 7 | 49 | 3 | 16.3 |
| 8 | 14 | 3 | 4.7 |
| 9 | 45 | 1 | 45 |
| 10 | 82 | 3 | 27.3 |
| 11 | 56 | 2 | 28 |
| 12 | 2 | 0 | 0 |
| 13 | 48 | 5 | 9.6 |
| 14 | 8 | 1 | 8 |
| 15 | 21 | 0 | 0 |
| 16 | 0 | 0 | 0 |
| 17 | 0 | 0 | 0 |
| 18 | 20 | 0 | 0 |

*A few of the characters*

**M7 and M9** - We believe that M7 (bottom left corner of Figure 3) is the father of M9 (in trap). We saw these two at the traps together regularly. M9 has established a home range just south of M7's. M7 also spends lots of time at the trap with F9, a lactating female, and we suspect he is the father of her kits. Through our motion-sensor cameras positioned at live-traps, we have been able to view numerous interactions between sub-adult male and female wolverines and their parents. We also got to see a lynx get chased off by a wolverine!

Figure 3. M7 and M9 at a live-trap.

**M6 and M8 -** We believe that M6 (in trap in Figure 4) is the father of M8 (seen in Figure 4 investigating the trap that M6 is within). M8 would disappear when he heard us walking to the trap and re-appear immediately after we left. M8 followed the movements of M6 almost exactly over the course of an entire month. M6 is likely the father of F8's kits.

Figure 4. Wolverine M8 investigating the live-trap that M6 is within.

**F8** (Figure 5) - We were able to find F8's den this spring. When F8 leaves her den to find food, she often crosses Alberta Highway 58 and moves precariously close to the town of Rainbow Lake.

*Wolverine movement and food habits*

As of mid-April, we collected 425 days of GPS data at two-hour fix rates (Table 3). The 100% MCP of 10 wolverines can be seen in Figure 6. Male wolverines (n = 5) have home ranges that cover 400 - 1200 $km^2$ while females (n = 5) have home ranges that cover 200 - 500 $km^2$. The vast majority of wolverine movements were less than 1 km over a two-hour period (n = 1,782). These movements are likely of wolverines that are at carcasses or are resting. The greatest movement distance over a two hour period was by M6 (14.35 km, Figure 7).

We visited wolverine GPS clusters and found wolverines feeding on the carcasses of black bears, moose, and caribou (Table 4). We also found the carcasses of grouse, beaver, and snowshoe hare at clusters, leading us to believe wolverines were hunting these species.

Figure 5. F8 stretching her legs at a live-trap

We found many sites that appeared to be resting areas for wolverines, where the animals would create latrines, caches, and dens throughout a system of tunnels and holes under down trees. The wolverines would use these areas for weeks at a time, likely hunting for grouse, snowshoe hare, and beaver in the area. We found evidence of females (F7 and F8) spending large amounts of time hunting grouse and snowshoe hare in areas with numerous highly suitable den structures. We collected scat during backtracking efforts and will analyze these data during summer 2014 to better understand wolverine food habits.

Table 3. Summary of wolverine GPS data downloaded from radio collars. There are 18 wolverines currently wearing radio collars that are collecting GPS data through summer, fall, and early winter 2014.

| Animal ID | Start | End | Total (days) |
|---|---|---|---|
| F3 | 12/4/2013 | 12/31/2013 | 27 |
| F4 | 12/14/2013 | 12/23/2013 | 9 |
| F5 | 1/12/2014 | 3/12/2014 | 59 |
| F6 | 1/30/2014 | 3/20/2014 | 49 |
| F7 | 2/7/2014 | 4/11/2014 | 63 |
| F8 | 3/14/2014 | 4/10/2014 | 27 |
| M3 | 12/17/2013 | 1/21/2014 | 35 |
| M6 | 2/7/2014 | 4/11/2014 | 63 |
| M7 | 2/8/2014 | 3/31/2014 | 51 |
| M8 | 2/24/2014 | 3/14/2014 | 18 |
| M9 | 3/18/2014 | 4/11/2014 | 24 |
| | | Sum | 425 |

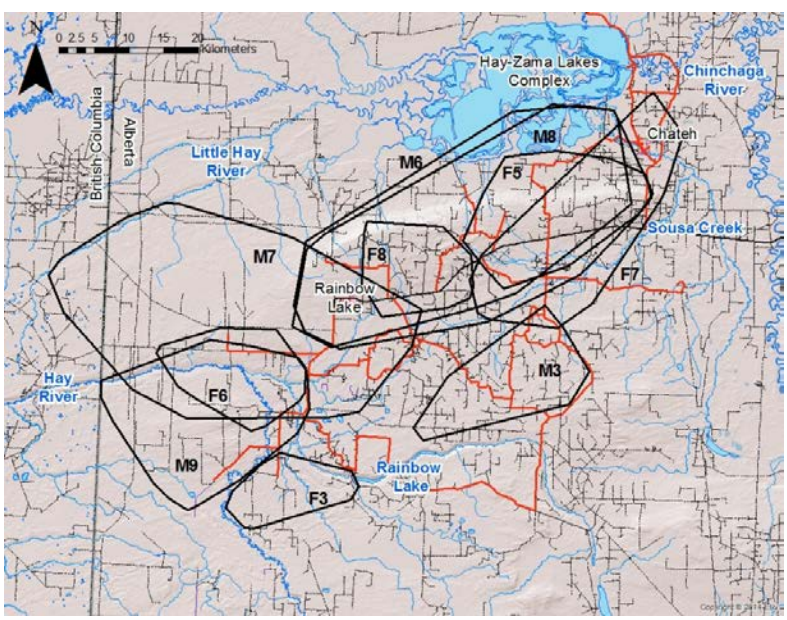


Figure 6. Wolverine (*n* = 10) home range (100% MCP) boundaries in Rainbow Lake, Alberta. Roads in red are considered to be high-grade industrial roads.

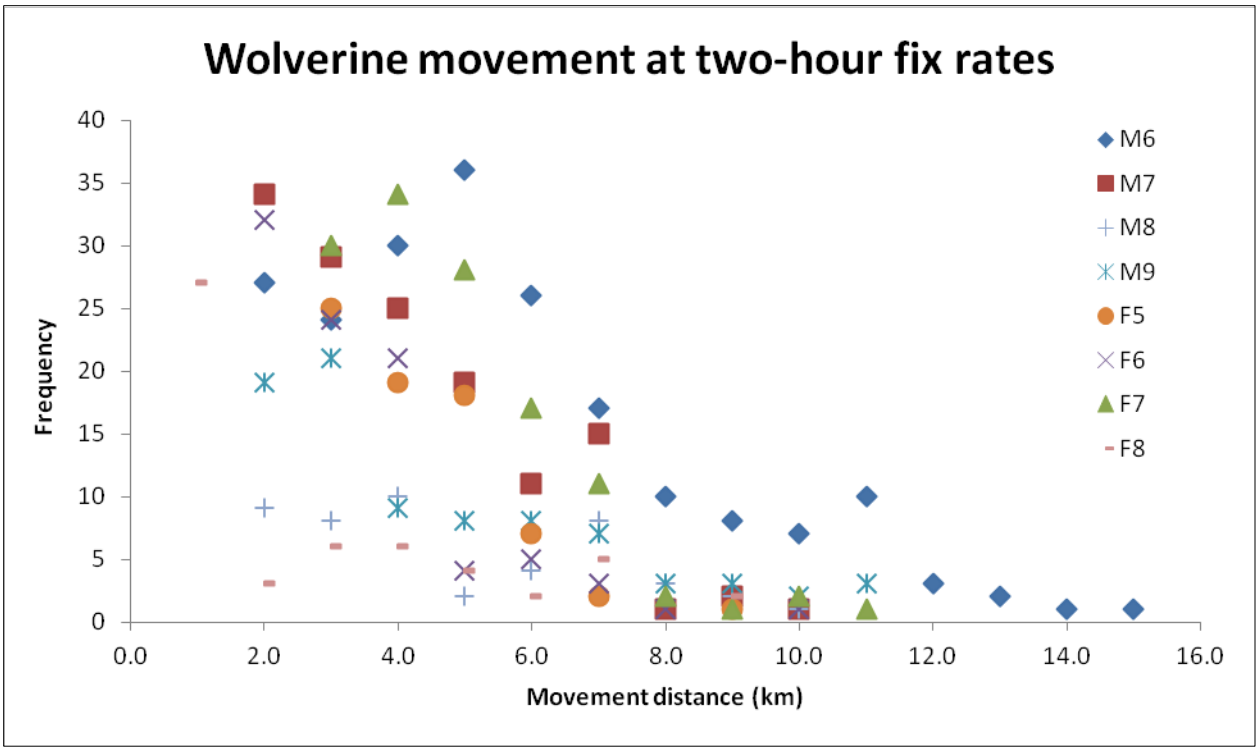


Figure 7. Movement distance of eight wolverines over two-hour periods. Although not included in this figure, the majority of movements (n = 1, 782) by these eight wolverines were less than 1 km.

Table 4. Potential sources (remains, attractants) of wolverine GPS clusters.

| Source | Frequency |
|---|---|
| Caribou | 3 |
| Moose | 4 |
| Black bear | 1 |
| Beaver | 2 |
| Grouse | 1 |
| Snowshoe hare | 2 |
| Bush cabin | 1 |
| Resting area | 10 |
| Unknown | 6 |

*Wolverine habitat associations*

We used the Alberta Biological Monitoring Institutes Wall-to-wall Land Cover Map 2010 Version 1.0 (ABMIw2wLCV2010v1.0) to investigate course scale wolverine habitat associations in the Rainbow Lake area. As a group, male wolverines did appeared to avoid use of broadleaf forests (they used them less than their availability) (Figure 8). Females did appear to slightly prefer coniferous forests and avoid deciduous forests (Figure 9). Within male and female wolverine groups, there was individual preference that we will have to account for in later analyses.

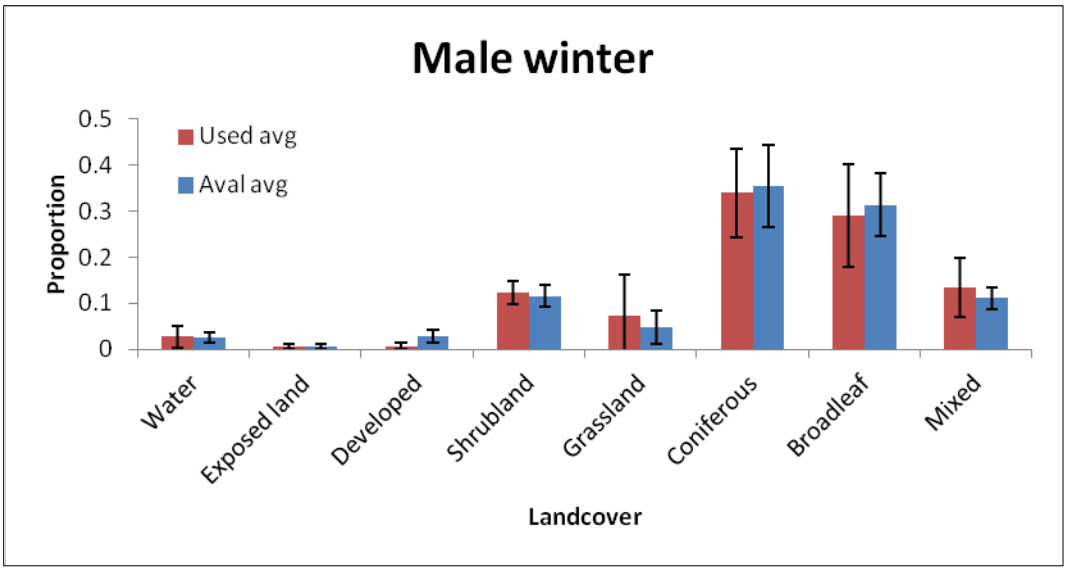


Figure 8. Selection of landcover types by male wolverines (n = 4) in Rainbow Lake, Alberta. Used locations are wolverine GPS points whereas available locations are randomly placed within the MCP of each wolverine.

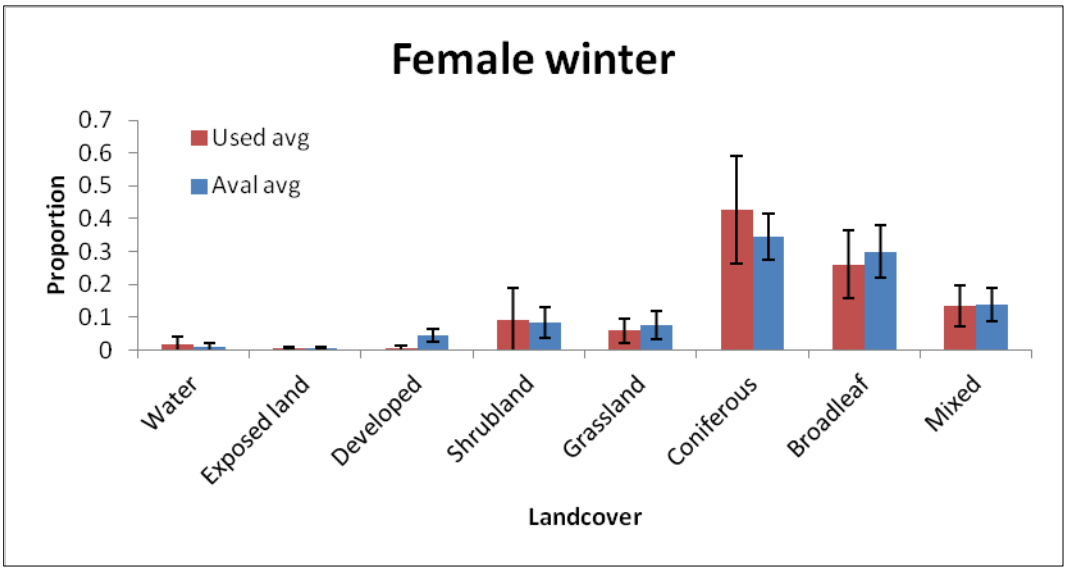


Figure 9. Selection of landcover types by female wolverine (n = 5) in Rainbow Lake, Alberta

*Wolverine response to industry*

Within the MCPs of wolverines, road densities ranged from 0.44 - 0.95 km/km$^2$ (Table 5). Wolverines F6 and M9 appeared to use high-grade industrial roads and pipelines as the boundaries of their home ranges (Figure 6). The movement routes of five wolverines can be seen in Figure 10. These GPS data show wolverines regularly crossing busy high-grade industrial roads and paved highways as well as the numerous secondary and winters roads that comprise the Rainbow Lake landscape. Although not included in Figure 10, pipelines, wells, transmissions lines, and other industrial infrastructure are ubiquitous in that area. Over 100 vehicles/day travel on many of the high-grade roads leading north and south of Highway 58 (Figure 10). When we investigated the distance of wolverine GPS

locations from roads, we found that male and female wolverines avoided habitats within 100 - 300 m of roads (Figure 11 - 15).

We had success trapping wolverines in heavily industrialized areas. Trap 6 was 1.5 km from Highway 58 (paved), 300 m from a high-grade industrial road, 700 m from an oil and gas camp, and 3 km from an oil and gas battery. We caught five different wolverines at this trap (Table 2), with many of the captures occurring during day when industrial traffic was at its peak. Additionally, trap 6 is along Sousa Creek, and we are seeing lots of evidence of wolverine moving along riparian corridors. Trap 13 also was a successful trap (Table 2). We caught numerous wolverines while a free-flowing gas well was being built within 400 m of the trap. The construction site included large fracking equipment, high-vehicle traffic during both day and night, and flood lights.

Table 5. Road densities within wolverine (n = 10) home ranges. Wolverine home ranges were created in a GIS using 100% MCPs. "Study Area" refers to the MCP surrounding the live-trap array. Road density is calculated with all road types combined (high-grade, secondary, paved, and winter roads).

| Animal ID | Road density (km/km$^2$) |
|---|---|
| F3 | 0.44 |
| F5 | 0.85 |
| F6 | 0.44 |
| F7 | 0.95 |
| F8 | 0.93 |
| M3 | 0.88 |
| M6 | 0.69 |
| M7 | 0.44 |
| M8 | 0.67 |
| M10 | 0.45 |
| Study Area | 0.65 |

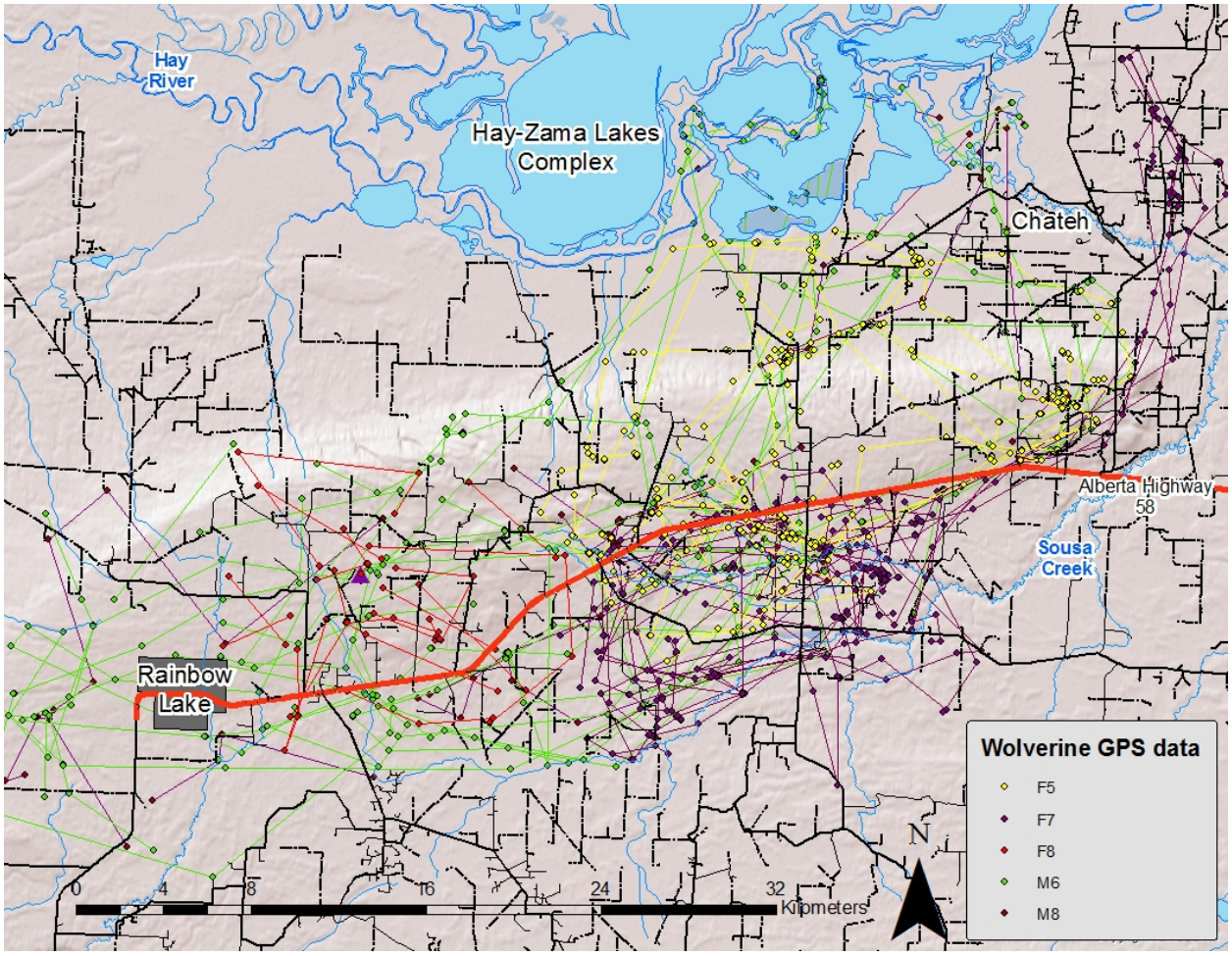


Figure 10. A sample of wolverine movement paths through paved, high-grade, secondary, and winter roads in the Rainbow Lake area.

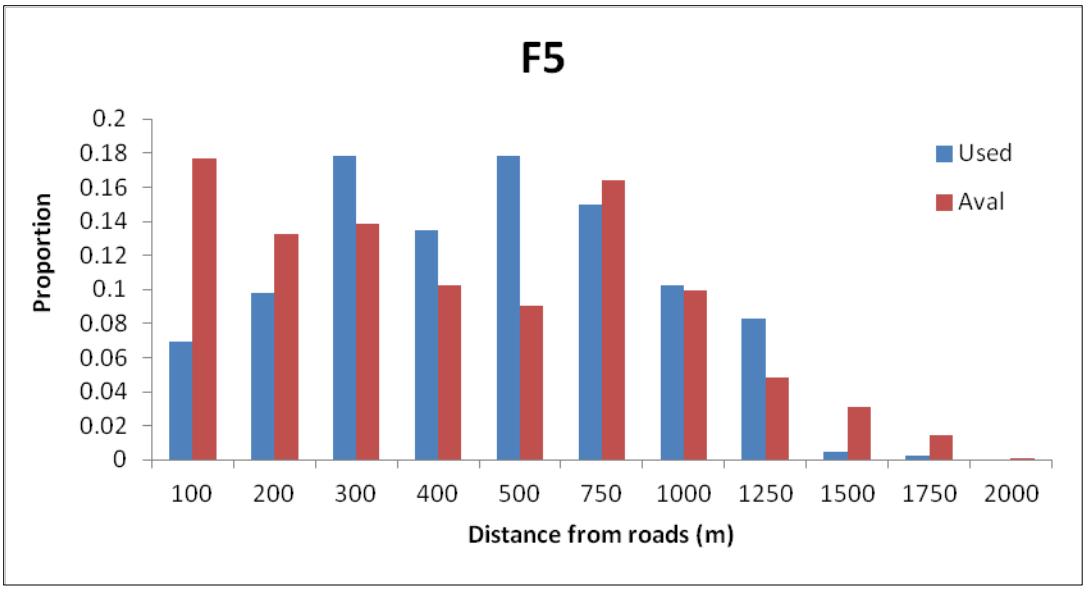


Figure 11. Wolverine F5's movement relative to roads in the Rainbow Lake area. Roads are inclusive of paved, high-grade, secondary, and winter roads. Used distances are those representing wolverine GPS data whereas available distances are from a random sample of distances within the MCP of the individual wolverine.

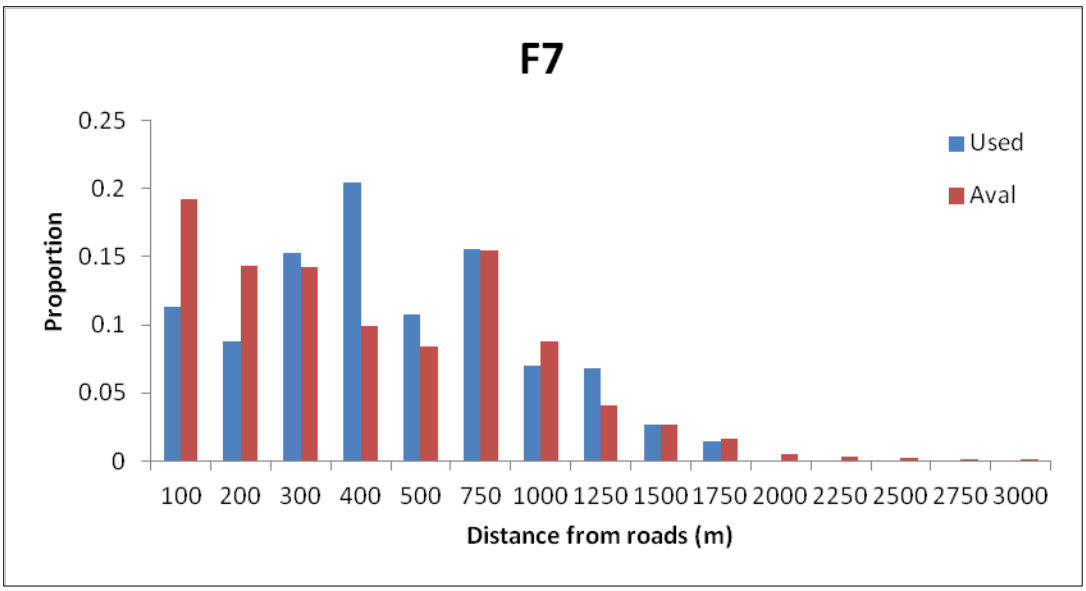


Figure 12. Wolverine F7's movement relative to roads in the Rainbow Lake area.

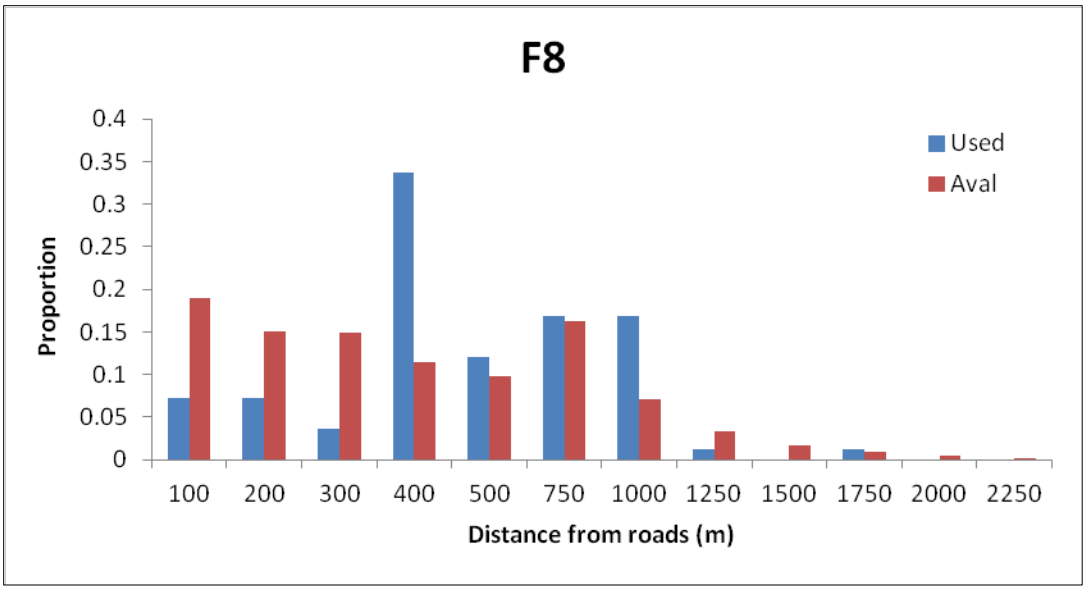


Figure 13. Wolverine F8's movement relative to roads in the Rainbow Lake area.

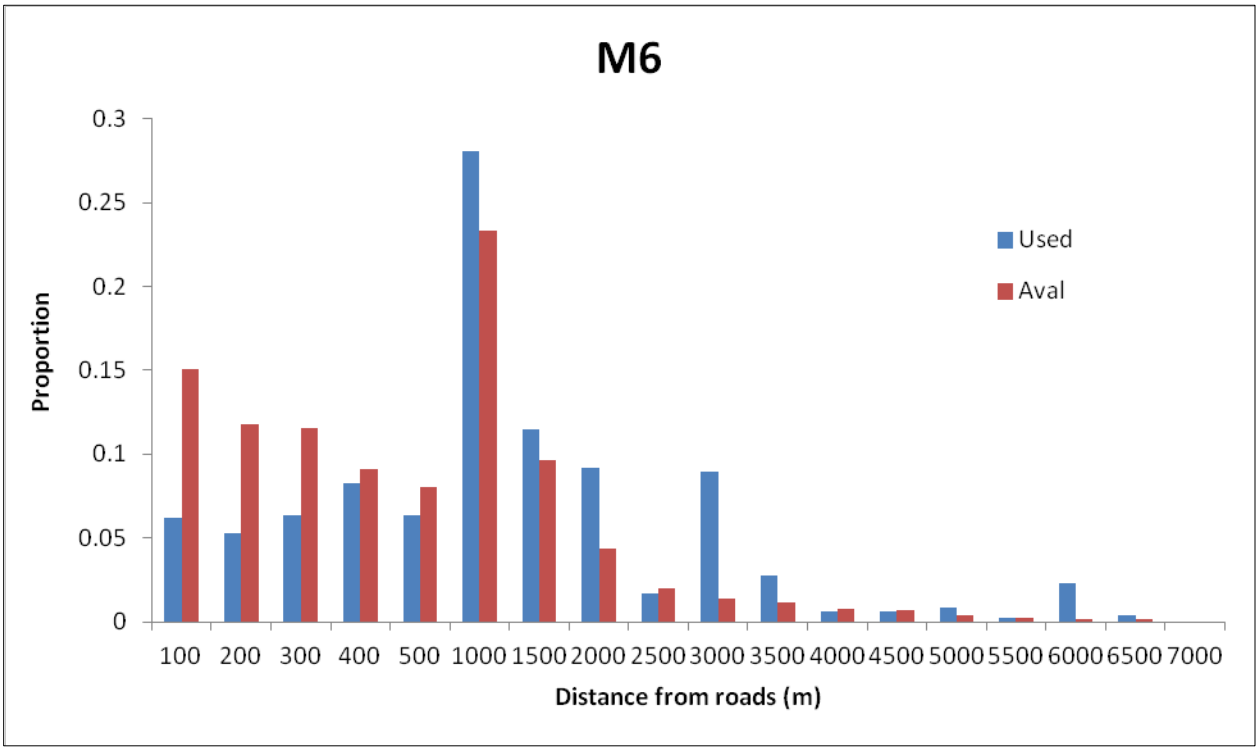


Figure 14. Wolverine M6's movement relative to roads in the Rainbow Lake area.

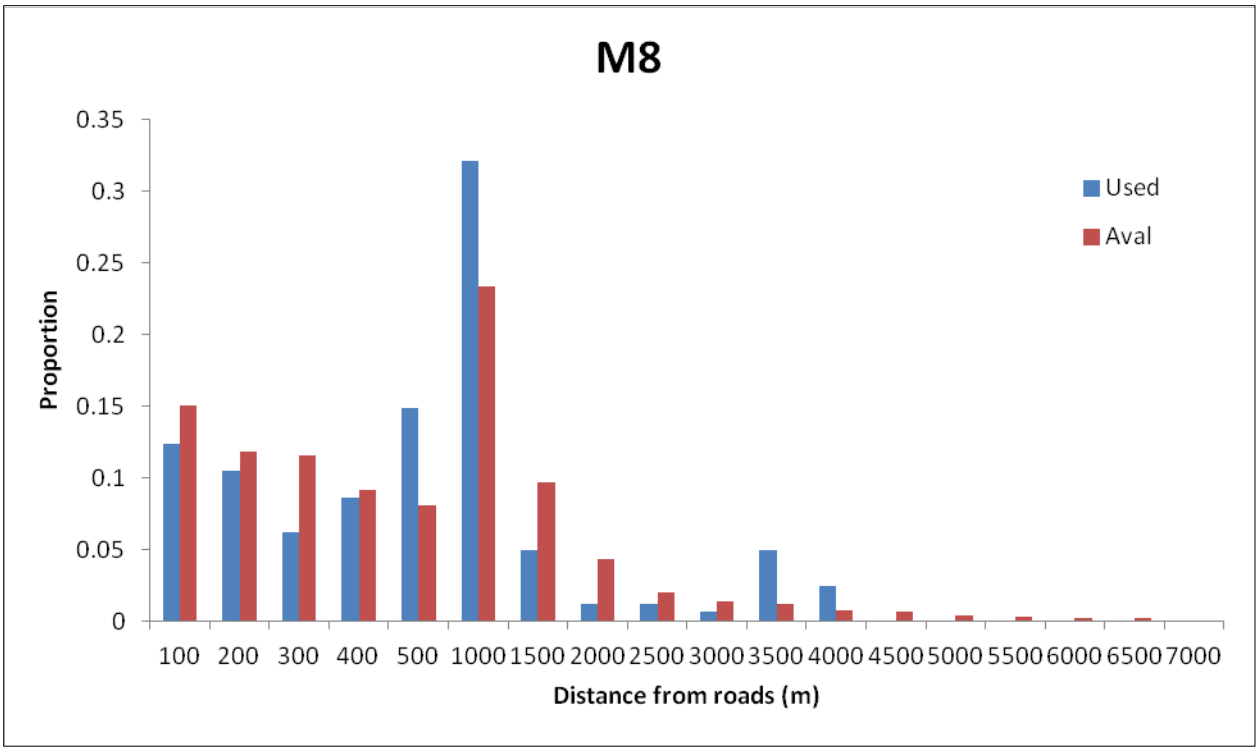


Figure 15. Wolverine M8's movement relative to roads in the Rainbow Lake area.

*Denning*

Seven of the females were lactating and we were able to find one den with two kits in mid-March (Figure 16). This den was located approximately 400 m from a winter road north of Rainbow Lake. Major high-grade industrial roads were 2 - 3 km from the den. The female, F8, had denned within a rot wad created from fallen trees. The rot wad was covered in moss and had 20 - 30 cm of snow on the roof. We revisited the den again in April and F8 had abandoned it. There were small natural holes in the roof that likely seeped water as the snow melted, forcing F8 to move her den as conditions within the den deteriorated.

Figure 16. F8's den site.

*Vehicle traffic*

We monitored vehicle traffic on over 100 high-grade, secondary, winters roads in the Rainbow Lake area (Figure 17). These data, however, have not been analyzed.

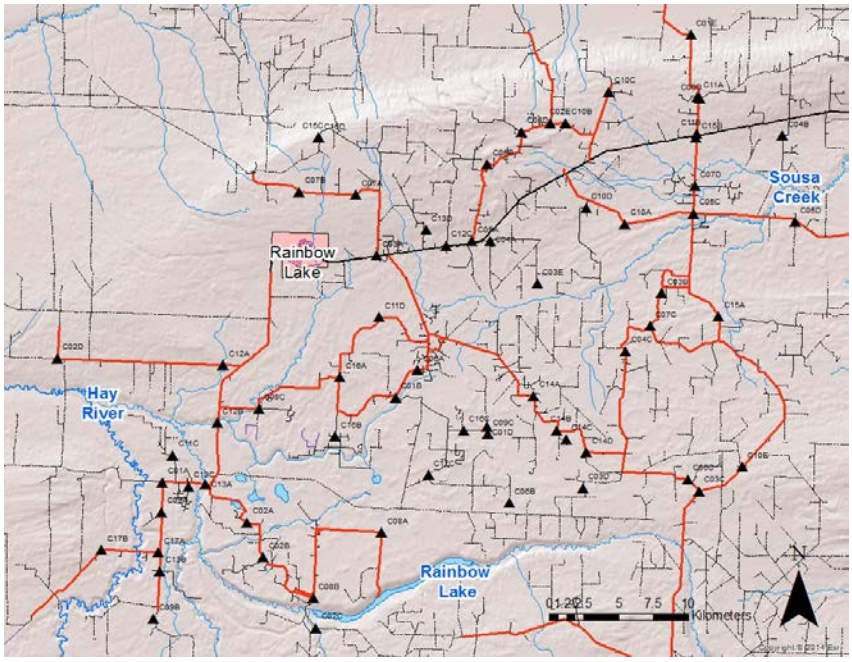


Figure 17. Motion-sensor cameras deployed to quantify traffic patterns.

*Wolverine density*

We have thousands of pictures of wolverines at our live-traps (see Figure 18). We have documented numerous wolverines that have not yet been captured. Although we have not analyzed these data yet, we plan to use these pictures to estimate wolverine density throughout the study area.


Figure 18. M7 before being recaptured at a log live-trap.

***DISCUSSION AND NEXT STEPS***

We are excited by our wolverine capture success and the opportunities this success affords us to learn more about wolverine ecology in northwest Alberta. Rainbow Lake is a unique area to research wolverines because of the accessibility of wolverine habitats. Industrial roads permeate nearly every corner of the Rainbow Lake landscape. As a result, we were able to drive trucks to most trap locations. The ease of travel by vehicle allowed us to cover a lot of ground each day and keep numerous traps open within the home ranges of four different dominant males. We believe this attribute of the study area drove the high wolverine capture rate. We will work this summer to better estimate wolverine density, based on a mark-recapture technique at trap locations, so that we can compare densities with other wolverine research projects. During winter 2014/2015, we plan to set-up run-pole camera stations to sample the abundance of wolverines in areas we are not planning to live-trap within.

We were surprised by the tolerance of wolverines to industrial activities in the Rainbow Lake area. This refutes many of the scientific community's traditional ideas of suitable wolverine habitat. An interesting attribute of Rainbow Lake is that although there are many industrial roads and other infrastructure, there are very few people using the landscape outside of the areas along high-grade industrial roads. In essence, there is a vast industrial network of linear features without much human use off of the main roads. This might serve as an advantage to wolverines as they can travel these linear features without the threat of contacting humans. Wolverines probably become more cryptic during the main construction phases of pipelines and well sites, but they likely resume normal use of these areas once construction activities have slowed. Overall, Rainbow Lake is an older oilfield that does not have the intense activity that is associated with many new developments and road building. A contrast to Rainbow Lake could be the oil sands of northeast Alberta, where new developments are rapidly appearing on the landscape.

Industry might be benefitting wolverines by providing supplemental food resources. Problem beavers, or those that flood industrial sites and roads, are trapped by industry each year in Rainbow Lake. These carcasses are left where the beavers are killed and are likely consumed by wolverines and other predators, such as black bears and wolves. This summer, we are working with local industry to take GPS locations of all sites where beavers are killed so that these locations can be related to wolverine movements.

We were able to find one wolverine den in an area with abundant wolves and minimal snowpack. Our initial observation in the Rainbow Lake area was that there was very little spatial separation between where wolverines were moving and where wolf tracks were found, mostly because we observed wolf tracks everywhere. We caught five wolves in our live-traps and wolf packs frequently moved near our trap locations and along industrial roads. F8's selection of a den site in an area with high wolf activity is in contrast to wolverines in the mountains that select den sites in high-elevation areas devoid of wolves (Magoun and Copeland 1998, Copeland et al. 2010). Additionally, there was only 20 - 30 cm of snow on the roof of F8's den in mid-March. By mid-April, there was barely any snow in the larger Rainbow Lake area, again in contrast to what is considered high-quality wolverine denning habitat in the mountains. We are aware that we need a larger sample size of den sites before we can make definitive statements about wolverine denning ecology in the boreal forest. We will work next winter to identify denning locations of the seven radio collared lactating females from late-winter 2014.

There are more remote areas of Rainbow Lake where we established live-traps, but because of the success of traps near roads we were unable to give these traps the attention needed to effectively catch wolverines. Next winter, we will work to capture and radio collar wolverines in more remote regions of Rainbow Lake to better document wolverine movement and distribution in less developed landscapes. Additionally, during winter 2013/2014 we planned to live-trap wolverines in Bistcho Lake with the help of the Dene Tha First Nation, but because of our success in Rainbow Lake, we were unable to shift our focus to a new trapping area. During winter 2014/2015, we plan to make another attempt

to live-trap and radio collar wolverines in Bistcho Lake. This area would serve as a good contrast to Rainbow Lake as there is less industrial development.

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