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# Wolverine habitat selection in response to anthropogenic disturbance in the western Canadian boreal forest

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ABSTRACT

We evaluated alternative hypotheses that anthropogenic disturbance can attract versus displace wolverines (*Gulo gulo luscus*). Our research took place in boreal forests of northwestern Alberta where we employed radiotelemetry to track wolverine habitat use over three years. We used resource selection functions (used/available design) to analyze wolverine habitat selection patterns during summer and winter seasons. We focused our analyses on the effects of active logging, intermediate-aged cutblocks (11–25 years old), seismic lines, roads, and borrow pits on wolverine habitat selection. Our analysis of active logging used a before, during, interim, and after design. We found wolverines were attracted to logging areas. The strongest selection for logged areas occurred during logging and in the following summer. We suggest logged areas provide foraging opportunities and movement routes for wolverines. Male wolverines were attracted to the edges of intermediate-aged cutblocks (11–25 years old) during summer whereas females were attracted to cutblock edges in winter. However, females avoided intermediate-aged cutblock edges in summer. Moreover, both male and female wolverines avoided the interior of these cutblocks. We would suggest that cutblock edges can provide wolverines with foraging opportunities. We also found wolverines were attracted to seismic lines and borrow pits along roads. Regenerating seismic lines and borrow pits (inhabited by beavers) might offer wolverines foraging opportunities. Our research highlights the need for managers to appreciate the potential for anthropogenic disturbance to either attract or repel wolverines. We warn that attraction of wolverines to industrial features might lead to increased mortality. We also stress that the age of a disturbance can influence its effect on wolverines.


## 1. Introduction

The boreal forests of western North America are fragmented by resource extraction through the creation of infrastructure to access, harvest, and transport natural resource to markets (Schneider, 2002; Pickell et al., 2013, 2014). These developments continuously reshape the distribution of predation risks and foraging opportunities for wildlife. Therefore, it is imperative that we learn how animals perceive land-use changes so that boreal landscapes can be managed to conserve wildlife populations.

Wolverines (*Gulo gulo luscus*) are mesocarnivores that exist in remote circumboreal regions (Hornocker and Hash, 1981; Magoun, 1985; Banci, 1987). Wolverines in Canada are of conservation concern because of industrial development that is occurring throughout their range (COSEWIC, 2014). Our aim was to investigate the response of wolverines in the boreal forest to disturbances that are shown to have negative effects on populations in other regions of North America (e.g., Krebs et al., 2007; Fisher et al., 2013). More specifically, we used resource selection functions (RSFs, Manly et al., 2002; Lele et al., 2013) to evaluate competing hypotheses that individual wolverines were attracted versus displaced by logging, seismic lines, roads, and borrow pits. Aside from studies in northern Ontario (Bowman et al., 2010; Dawson et al., 2010), there has been limited research on wolverines in northern boreal forests.

Logging involves concentrated human activity to extract and transport timber from patches of forest to mills. Wolverines are considered sensitive to forestry activities (e.g., Krebs et al., 2007; Bowman et al., 2010; Fisher et al., 2013). Similarly, wolves (*Canis lupus*) and other wildlife avoid areas that are being actively logged (Smith et al., 2000; Houle et al., 2009; Lesmerisis et al., 2012). Therefore, it is probable that logging could displace wolverines

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from upland habitats they prefer (Wright and Ernst, 2004; Heim, 2015). However, wolverines could be attracted to areas with logging because of foraging opportunities on displaced small animals (Ferron et al., 1998; Potvin et al., 1999; Turcotte et al., 2000) or because logging roads provide travel routes (e.g., Copeland et al., 2007). Because wolves are displaced by logging activities (Houle et al., 2009; Lesmerisis et al., 2012), wolverines might be able to use these areas free of their predation risk.

After logging ends, timber-harvest companies typically replant cutblocks and leave them to regenerate so they can be logged again in the future. Early-seral cutblocks provide habitats for many wildlife species that wolverines either hunt or scavenge (Fisher and Wilkenson, 2005). For example, regenerating cutblocks can provide horizontal cover sought by snowshoe hares (*Lepus americanus*) and grouse (*Bonasa umbellus* & *Falcipennis canadensis*; Conroy et al., 1979; Parker, 1984; Potvin et al., 1999; Bellefeuille et al., 2001). These species might be more abundant at cutblock edges where habitat heterogeneity is high (Lidicker, 1999). Moreover, moose (*Alces alces*) abundance increases in early-seral cutblocks (Potvin et al., 2005). Wolverines are facultative scavengers (Magoun, 1987; van Dijk et al., 2008) and might feed on wolf-killed moose carcasses in or near regenerating cutblocks. While these factors suggest that wolverines could be attracted to cutblocks that offer foraging opportunities, some evidence indicates that wolverines avoid cutblocks and other regenerating areas (Hornocker and Hash, 1981; Lofroth et al., 2007; Bowman et al., 2010; Fisher et al., 2013). This avoidance is likely associated with hesitance to use open areas or because wolves often use regenerating cutblocks to hunt large prey (Courbin et al., 2009; Houle et al., 2009; Lesmerisis et al., 2012). Therefore, predation risk might deter wolverines from using these areas.

Seismic lines are another disturbance associated with resource extraction that could either displace or attract wolverines. Seismic lines are created during exploration for oil and gas resources. Prior to the late 1990s seismic lines were constructed to approximately 5–8 m wide by removing all vegetation (e.g., logging) and were distributed on the landscape in a grid-like pattern (Schneider, 2002; Pattison et al., 2016). Wolves are known to use seismic lines because they increase their movement and hunting efficiency (McKenzie et al., 2012; Dickie et al., 2016) so we might expect wolverines to avoid seismic lines because of predation risk from wolves (Fisher et al., 2013). However, industrial resource extraction and mapping has been occurring in some regions of the boreal forest since the mid-20th century, which has provided time for seismic lines to regenerate (Lee and Boutin, 2005; van Rensen et al., 2015). Once regenerated, these seismic lines can provide early-seral habitats for wildlife (Tigner et al., 2014, 2015) and poor movement routes for wolves (Dickie, 2015) which might provide wolverines foraging opportunities free of predation risk.

Finally, borrow pits are dug near well pads and along forest roads to provide materials for their construction. Over time, borrow pits fill with water and can provide habitats for beavers (*Castor canadensis*), a preferred prey of wolverines (Lofroth et al., 2007). Thus, wolverines could be attracted to borrow pits for preferred foraging opportunities. At the same time, borrow pits are found along roads that often are avoided by wolverines (May et al., 2006; Copeland et al., 2007; Krebs et al., 2007), potentially leaving this food source unexploited.

Here, we evaluated alternative responses by wolverines to five industrial developments: (1) wolverines were attracted to sites of active logging because of foraging opportunities and mobility or displaced because of predation risk from human activity; (2) wolverines were attracted to intermediate-aged cutblocks because of foraging opportunities at cutblock edges or displaced because of wolf activity; (3) wolverines were attracted to seismic lines because of foraging opportunities for small prey or displaced because of wolf activity; and (4) wolverines were attracted to borrow pits because beaver occupy these sites or displaced because of human activity on roads. We also surveyed borrow pits to report on the extent that pits were inhabited by beaver.

## 2. Materials and methods

### 2.1. Study area

Our research took place the boreal forest surrounding the town of Rainbow Lake (population 870) (119°28′18.705″W, 58°32′22.3 61″N) in the northwest corner of Alberta. Our study site was approximately 12,754 km$^2$ [100% minimum convex polygon (MCP) around GPS relocations] in area and bounded by the Hay River to the south, the Hay-Zama Lakes Complex to the north, and the Chinchaga River to the east. The British Columbia border was an approximate study area boundary to the west.

The town of Rainbow Lake is located in the central mixedwood subregion of the boreal forest. Broadleaf forests in the subregion consisted of trembling aspen (*Populous tremuloides*), balsam poplar (*P. balsamifera*), and white birch (*Betula papyrifera*). Coniferous forests included white (*Picea glauca*) and black spruce (*P. mariana*), balsam fir (*Abies balsamea*), and jack pine (*Pinus banksiana*). Wetlands were 30% of the landscape and were comprised of peatlands (bogs and fens) with black spruce forests. The climate of Rainbow Lake was characterized by long, cold winters and short, warm summers. Average annual temperature was −1.3 °C with 414 mm of precipitation (Strong and Leggat, 1981).

Industrial resource extraction had been occurring in Rainbow Lake since the 1950s and associated infrastructure included winter roads, all-season roads, pipeline rights-of-way's, oil and gas wellsites, processing plants, and industrial camps. Most seismic lines were created between the 1960s and early-1990s, with some seismic activity occurring through present albeit over a limited area.

A logging program took place in Rainbow Lake from November 26, 2014 to March 3, 2015. In total, 13.13 km$^2$ of harvest occurred among 165 cutblocks [average size = 0.08 km$^2$ (SD = 0.11)]. In addition, there were 848 cutblocks between the age of 11 and 25 years (as of 2015) (Fig. 1). The average size of these cutblocks was 0.14 km$^2$ (SD = 0.21, Fig. 2) and the average age was 17.97 years (SD = 3.81). Most cutblocks were harvested with a two-pass clearcut system (personal communication, Michael Morgan, Tolko Ltd., High Level, Alberta).

We established 22 livetraps that were used to capture and radiocollar wolverines. The MCP bounding livetrap locations was 2380 km$^2$. Livetraps (Copeland et al., 1995) were placed across a range of road densities and separated by approximately 10 km. We captured and collared at least one wolverine in every livetrap. We monitored wolverines with GPS radiocollars programmed to take fixes at two-hour intervals. All capture and handling procedures were approved by the University of Alberta Animal Care Committee Protocol No. 00000743 and Province of Alberta Collection and Research Permit No. 55714.

### 2.2. Statistical analyses

#### 2.2.1. Logging program

We identified wolverine GPS relocations associated temporally and spatially with the logging program (referenced above) in four-winter periods (before, during, interim, and after logging) and two-summer periods (before and after logging) (Table 1). The winter season was from Nov. 1 to Apr. 1 and the summer season was from Apr. 2 to Oct. 31. We split GPS relocations by season to control for differences in habitat selection associated with snow-free periods. Moreover, wolverines will switch between scavenging