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Active fans and grizzly bears: Reducing risks for wilderness campers

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ABSTRACT

Active geomorphic fans experience debris flows, debris floods and/or floods (hydrogeomorphic processes) that can be hazards to humans. Grizzly bears (*Ursus arctos*) can also be a hazard to humans. This paper presents the results of a cross-disciplinary study that analyzed both hydrogeomorphic and grizzly bear hazards to wilderness campers on geomorphic fans along a popular hiking trail in Kluane National Park and Reserve in southwestern Yukon Territory, Canada. Based on the results, a method is proposed to reduce the risks to campers associated with camping on fans. The method includes both landscape and site scales and is based on easily understood and readily available information regarding weather, vegetation, stream bank conditions, and bear ecology and behaviour. Educating wilderness campers and providing a method of decision-making to reduce risk supports Parks Canada's public safety program; a program based on the principle of user self-sufficiency. Reducing grizzly bear–human conflicts complements the efforts of Parks Canada to ensure a healthy grizzly bear population.

1. Introduction

Kluane National Park and Reserve (Kluane) in southwestern Yukon, Canada is a mountainous area with many active alluvial and colluvial fans that are affected by debris flows, debris floods, and floods. World-wide, many lives are lost to these hydrogeomorphic processes each year (Jakob, 2005; Sidle and Ochiai, 2006). Much of the damage and loss occurs on fans where the material from these processes is deposited (Jakob, 2005). Due to the relatively gentle slopes of fans, often people do not realize they are exposing themselves to potentially hazardous processes. Recognition of hydrogeomorphic processes and fan landforms is an important first step toward understanding the hydrogeomorphic risk.

Within Kluane is the Ä'äy Chù (hereafter, Slims River) valley, renowned for its scenic landscape, grizzly bears, and wilderness recreation opportunities, primarily hiking and camping. Though rare, some interactions between humans and bears in this area have had serious consequences—for both humans and bears (Leonard et al., 1990; MacDougall et al., 1998; MacDougall and Young, 2005). Where people and bears overlap temporally and spatially, bears are susceptible to becoming human-habituated. They may become human food-conditioned, and may be involved in conflicts with people (Gunther, 1994). Sound bear–human management focuses on preventing conflicts rather than reacting to them as they occur (Herrero, 2003). Progressive programs following this approach have been successful in reducing bear–human conflicts in parks, largely through education and appropriate food and garbage management (Dalle-Molle and Van Horn, 1989; Gunther, 1994; Gniadek and Kendall, 1998; Schirokauer and Boyd, 1998). Since 1988, all overnight campers to the Slims River valley have been required to carry and store their food and garbage in bear-resistant canisters (MacDougall et al., 1998). This management action has decreased the frequency of conflicts with food-conditioned bears. Parks Canada also implements other strategies to address specific bear–human conflict issues (e.g., bear awareness education, bear–human interaction monitoring, periodic trail closures). Unfortunately, conflicts between people and bears are still reported on an annual basis (MacDougall et al., 1998; MacDougall and Young, 2005). To support Parks Canada's efforts in preventing negative bear–human interactions, hazard analyses of bear–human interaction were conducted at campsites and along trails in the Slims River area (MacDougall et al., 1998; Wellwood and MacDougall, 2009). These studies investigated numerous undesignated sites that had evidence of use for camping, as well as the Canada Creek campsite at the head of the valley. All the campsites identified, except for the more open areas of the Canada Creek campsite, were rated as moderate to high hazard for bear–human interaction for a period of time each year. As possible alternatives, some areas sparsely vegetated or devoid of vegetation were identified (Wellwood and

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MacDougall, 2009). Unfortunately, these locations are the recently-active portions of fans that have the potential to be extremely hazardous from a hydrogeomorphic perspective. This collaborative project was initiated because further investigation was required.

The objective of this study was to explore the risk associated with camping on fans; specifically the risk derived from hazards associated with hydrogeomorphic processes and bear–human interactions. The intent of the project is to provide information that will enable Parks Canada to increase the level of safety for the campers and the bears of the Slims River valley. The key method to reduce risk is to reduce the exposure of campers to hazardous camp locations from a combined hydrogeomorphic and bear–human interaction perspective. (Herrero et al., 1986; McCrory et al., 1986; MacHutchon and Wellwood, 2002).

The result of the analysis of multiple hazards is a decision-making framework that can be applied to reduce risks for campers. Developing this framework required the integration of expertise on the hydrogeomorphology of the Slims River valley and its tributaries, and the ecology and behaviour of grizzly bears that use the valley.

2. Study area

The Slims River valley is located in Kluane in southwestern Yukon Territory, Canada. Geomorphically, the valley bottom is a broad outwash plain — 2 km wide and approximately 25 km long. The valley walls are steep and local relief is 1500 to 2000 m. At the head of the valley is the Kaskawulsh Glacier, a tongue of the St. Elias Icefield (the largest non-polar icefield in the world). The presence of the icefield results in strong down-valley winds that entrain silt and fine sand, producing loess storms (Marcus, 1974). Debris flows and debris floods occur in the short, steep tributary watersheds of the Slims River, forming a series of moderately-sloped fans along the valley margins. Several larger tributaries have produced significant alluvial fans that have forced the Slims River across the wide valley flat.

Bedrock in the area is dominated by the presence of Paleozoic (Wrangellia Terraine) volcanics, greywacke, and carbonates all of which have been altered by low grade metamorphism, deformed three times, and intruded by diorite and granodiorite plutons (Wheeler, 1963). This bedrock, along with high relief, steep mountain slopes, and the climate, results in abundant sediment for fan building. The presence of carbonates results in calcareous soils and causes high pH ($\geq$8) in the Slims River (Nickling, 1973; Hoefs et al., 1975).

The closest long-term weather station to the Slims River valley is at Burwash Landing, approximately 45 km to the northwest (Environment Canada, 2007). Annual precipitation at Burwash Landing is approximately 280 mm, with 30–40% occurring as snow. July is the wettest month, with almost 25% of the total annual precipitation. Average temperatures are −22 °C in January and 12.8 °C in July with an average annual temperature of −3.8 °C. Conditions are likely slightly different in the study area due to strong down-valley winds from the icefield, but the area can be characterized as a semi-arid, cold climate. The Slims River valley is within the zone of discontinuous permafrost with permafrost likely to be present on mid and upper slopes (at elevations >1150 m) (Johnson and Nickling, 1979).

The fans of the Slims River valley are within the lower elevation region of the montane vegetation zone (Parks Canada, 1983) where the lower mountain slopes are dominated by white spruce (*Picea glauca*) forest. Forests on less-active portions of fans along the valley bottom include mixtures of white spruce and balsam poplar (*Populus balsamifera*).

The Slims West Trail, one of Kluane's most popular overnight backcountry trails (MacDougall et al., 1998; MacDougall and Young, 2005), is located along the west side of the valley (Fig. 1). The 23 km long trail crosses a series of fans before it ends at the Canada Creek campsite near the toe of the Kaskawulsh Glacier. Multi-day use of the trail in recent years is summarized in Table 1. Most trail users spend three days in the valley with the majority of recreational use occurring from June to September; the highest frequency of use occurs in July and August (MacDougall et al., 1998; MacDougall and Young, 2005).

3. Methods

3.1. Terminology

Risk is the product of the probability of occurrence of a hazard and the consequence of that hazard. A hazard is defined as a harmful or potentially harmful event (Wise et al., 2004). Elements at risk are those features of value that could be exposed to, and negatively affected by, the occurrence of a hazard. Consequence refers to the exposure and vulnerability of elements at risk to the specific hazard. Exposure includes the spatial and temporal probability of an element at risk being exposed to a given hazard. Vulnerability is the probability of damage, injury or death once exposed to the hazard (Wise et al., 2004).

Specific to wilderness camping on alluvial fans along the Slims West Trail, hydrogeomorphic processes and grizzly bears are considered hazards when they are present at a campsite location. Other hazards, such as black bears, snow avalanches and rockfall were considered minor in comparison and are not addressed in this risk assessment. The probability of spatial and temporal overlap of one of the hazards and a wilderness camper (i.e., both present at a campsite at the same time) defines the probability of exposure. Though bear–human interactions can range from positive to neutral to negative from a human or bear perspective, we only consider grizzly bears as a potential hazard to people. In this study, wilderness campers are the only element at risk considered; however, it is recognized that people can also pose a threat to grizzly bears.

Definitions for terms specific to bear–human interactions were adapted from Wellwood and MacHutchon (1999) and are the same as those used in recent analyses of reported bear–human interactions for the Slims River area (MacDougall and Young, 2005). To maintain consistency with previous research in Kluane:

> We define *bear–human interaction* as any activity and its effect involving bears and humans, including observations, encounters, and conflicts. We define a *bear–human encounter* as a situation when a bear is aware of human presence, regardless of whether people are aware of the bear. During encounters, bears can be displaced, may ignore people, or may approach people. We define a *bear–human conflict* as a more serious interaction where a bear charges people, people take extreme evasive action in response to a bear, people use a deterrent on a bear, property is damaged, or a bear makes physical contact with a person (MacHutchon and Wellwood, 2002:293).

3.2. Fans selected for analysis

Five fans and their tributary watersheds, each of which are crossed by the Slims West Trail, were selected for this analysis (Fig. 1). The fans were identified by creek name (Bullion Creek Watershed) or by number (Watersheds 1, 2, 3, and 4) and were selected for three reasons:

1. the potential to provide campsites with lower likelihood of bear–human encounters than other sites (Wellwood and MacDougall, 2009);
2. their attractiveness for camping in favourable weather conditions; and
3. their intermediate distance from the trailhead — approximately one-quarter to three-quarters of the distance from the trailhead to the Canada Creek campsite (to allow for late-day starts and average hiker speeds).

3.3. Human exposure

Hazards were assessed for the prime recreational use period of mid-June through to the end of August. Data regarding wilderness camping