A REVIEW OF AVALANCHE ECOLOGY: FOREST HABITAT STRUCTURE AND WILDLIFE BIODIVERSITY

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ABSTRACT: Avalanches are significant drivers of natural processes in mountain ecosystems. This study reviews previous research on the effects of avalanches to the structure and biodiversity of mountain ecosystems. Avalanches shape the landscape, thus habitat and biodiversity of the ecosystem. Avalanche chutes and debris provide important habitat for plants, insects and both aquatic and terrestrial animals. They shape the vegetation mosaic of an area, as well as the survival, growth rate and forms of trees. Trees affect the snowpack, thus influencing the frequency of avalanches. Avalanche debris can impact bark beetle outbreaks and forest fires, acting as fuel or firebreaks. Avalanches play a critical role in mountain ecology, and must be considered when managing avalanche prone forests.

KEYWORDS: Mountain ecosystems, forest structure, wildlife habitat, biodiversity, bark beetle (Coleopter: Scolytidae), vegetation mosaic.

1. INTRODUCTION

Avalanche ecology is the study of how avalanches affect the mountain ecosystem. Avalanches, as defined by the Avalanche Information Center, are a mass of snow sliding, tumbling or flowing down an inclined surface. Avalanches are extremely important to the mountain ecosystem. They shape the landscape, adding heterogeneity, thus biodiversity, to an area. Avalanche chutes and debris create habitat for both flora and fauna, and can serve as firebreaks and affect bark beetle outbreaks (Bebi et. al 2009; Hebertson and Jenkins 2006).

2. AVALANCHES AND FORESTS

Avalanches influence forests, and forests influence avalanches. Trees affect the snowpack, thus the likelihood of avalanches. They stabilize snow in starting zones, and fallen logs, stumps and roots can prevent the creation of small avalanches. The snowpack around trees can be uneven. Trees intercept falling snow, and when it warms or gets windy snow unloading from branches creates an uneven surrounding snowpack. Forests modify radiation and temperature regimes. They block solar radiation during the day, and outgoing long-wave radiation at night. This results in less rapid formation of surface hoar. Forests reduce wind speed, creating a more even distribution of snow and reduce accumulation of snow in gullies and depressions, preventing avalanche conditions from forming. Tree stems support snowpack, preventing the creation of slab avalanches, especially in denser forests (1000 trees per hectare) (Bebi et. al 2009).

Avalanches influence the survival, growth rates and forms of trees. They can have an impact on tree morphology, which can be observed in tree ring character. Frequently disturbed stands of trees have a smaller diameter, are shorter, have slow annual growth rates, are shade intolerant and have thinner stands. Chutes with less avalanche activity and more time between avalanche events leads to a shift from shrub to trees (Bebi et. al 2009).

Coniferous mountain forests are generally homogenous, with tall trees and thick growth. Avalanche frequency affects the diversity of the vegetation mosaic, adding to the structural habitat diversity. The more active the avalanche chute, the greater the structural habitat diversity. Avalanche tracks have smaller individuals, creating different habitat for insects, birds and mammals. Avalanches do not usually run to the ground, so they do not lead to new seedling recruitment. As opposed to recruitment, avalanche chutes have a “reorganization of surviving vegetation” (Bebi et. al 2009).

3. AVALANCHES AND FAUNA

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Although avalanche chutes are known to have high floristic, habitat and structural diversity, there is little research on their impact on wildlife diversity. It is known that avalanche chutes are preferred habitat for the grizzly bear (*Ursus arctos*), caribou (*Rangifer tarandus*) and wolverine (*Gulo gulo*) in North America and the chamois (*Rupicapra rupicapra*) and several threatened bird species in the Alps (Bebi et. al 2009). Deer, elk and other ungulates forage in the diverse and nutritious plant communities of avalanche tracks (Hebertson and Jenkins 2006). Avalanche chutes provide ideal foraging habitat from the early spring to autumn. In the early spring, plants often emerge from avalanche chutes that have slid, exposing the ground much sooner than the surrounding snowpack. Alternately, debris in the run-out zone prolongs vegetation emergence until later in the season, providing a longer foraging opportunity than the surrounding ecosystem (Serrouyo et. al 2011).

A number of studies on grizzly bears throughout North America found that avalanche chutes are their preferred habitat. Using radio-tracking collars in British Columbia, Serrouya et. al, found that grizzly bears prefer large avalanche chutes (>100m wide) with solar radiation because they have a higher proportion of forb cover, thus more forage opportunities. A different study found half of the locations of radio-collared grizzly bears to be in avalanche chutes in the spring, and about one third to be in summer and fall where this habitat only covers 15 percent of the study area (Serrouya et. al 2009). Another study found that bears prefer avalanche chutes with high forb and grass content (Serrouya et. al 2009). Overall, grizzly bears prefer areas with a high density of avalanche chutes, large, south-facing chutes, and use them as foraging habitat primarily in the spring, but also throughout the season.

Much like the grizzly bear, the wolverine (*Gulo gulo*) utilizes avalanche chutes. Unlike the grizzly bear, female wolverines prefer to establish dens in avalanche debris. Wolverines have been found to feast on avalanche-killed ungulates. Wolverines benefit from both avalanches and avalanche chutes (Krebs and Lewis 1999).

Avalanches can be harmful to some wildlife, while benefitting others. On December 23, 2002 in Twin Lakes, Alaska at least 143 caribou were killed in a slide. It is possible that this slide was caused by the herd moving across it, perhaps going to forage along the windblown ridge or moving to a better location. It is also possible that the slide was natural, and they were simply foraging at the bottom of the slope. Either way, this carnage was beneficial to predators in the area. Scientists observed bears, wolves and eagles feasting on the caribou carcasses. A U.S. Fish and Wildlife Official reported seeing a pack of 12 wolves in the area, most likely feeding on the caribou. Prior to this accident, the total number of caribou in the area was 700 (Fesler 2002). This may be the most detrimental avalanche event for a herd of ungulates recorded; it exemplifies the impact of avalanches on the wildlife in mountain ecosystems, serving as a threat to some, and creating available food for scavengers and carnivores.

Bark beetles (Coleopter: Scolytidae) have an interesting relationship with avalanches. Coniferous mountain forests in North America are affected by the Engelmann spruce beetle (*Dendroctonus rufipennis* Kirby) and the douglas-fir beetle (*D. pseudotsuggae* Hopkins). Adults lay their eggs in the bark of downed trees; the larvae hatch, grow and feed on the inner bark until they reach maturity. If, when they hatch, there are insufficient amounts of downed trees, they will attack and kill live trees. Bark beetle tree mortality is often observed on adjacent slopes to avalanche chutes, because the avalanche chutes have large quantities of debris, allowing for many young beetles. If the host material is deteriorated when the larvae hatch, the new adult beetles feast on live trees nearby (Hebertson and Jenkins 2006). Alternately, frequent avalanche areas are less likely to be affected by spruce beetle outbreaks because they have small tree diameters (Bebi et. al 2009). Beetle-infested forests have an impact on the ecosystem, generally leading to nutrient-depleted soil, deterring establishment of seedlings, and affecting the species composition of an area. The increase in fuel from beetle-kill forests may increase fire hazard. The relationship between avalanche debris and bark beetles can have an affect the surrounding ecosystem, though this is not the only cause of bark beetle outbreaks (Hebertson and Jenkins 2006; Jenkins et. al 2014).

4. CONCLUSIONS

Avalanche damage and debris can play a big role in mountain ecosystems. Damaged trees and vegetation adjacent to avalanche chutes can become attacked by fungi and insects. Cavities created by decay from fungi can become nesting

habitat for birds. The decomposition of debris enriches the soil and adds to the nutrient cycle. Debris can increase fire hazard by contributing to local fuel loads. It can also act as food, shelter, hiding cover and breeding habitat for terrestrial insects and animals. It can create habitat for fish by stabilizing channels; however, it can also disrupt stream channels, destroying vital spawning habitat. Debris prevents erosion from wind, rain and melting snow. It traps soil and provides shade, facilitating the growth of new trees (Hebertson and Jenkins 2006). Avalanche debris contributes to the cycles of mountain ecosystems.

Avalanches shape landscape and habitat, acting as an integral part of mountain ecosystems. They create a unique vegetation mosaic, providing habitat for many different species of plants, insects and terrestrial and aquatic animals. Climate change may have an effect on avalanche ecology; further research is needed in order to understand the impact of climate change on avalanche ecology (Bebi et. al 2009). Avalanche management, such as barricades, can also affect avalanche ecology (Bebi et. al 2009). The critical ecological role of avalanches should be considered when managing avalanche prone forests. Avalanches are essential for the biodiversity of mountain ecosystems.

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