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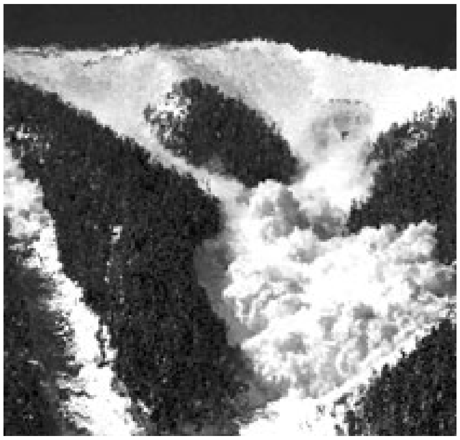
Reassessing a troublesome fact of mountain life: Avalanches in Glacier National Park



Tim Lane; source: Colorado Avalanche Information Center, modified by NPS.

For the past decade, our U.S. Geological Survey (USGS) research team has rummaged through Glacier National Park's archives looking for records of snow avalanches. Our searches have paid off. We have found photographs that show snow avalanches blocking progress during the annual spring opening of the famed Going-to-the-Sun Road, ranger logs that describe cabins and telephone lines destroyed by avalanches, and superintendents' reports that recount avalanche accidents that killed employees or visitors. Recently, we have combined these historical sources with field studies to investigate whether snow avalanches in the park may be more cyclical than random and as much an ecological process as a natural hazard. Our ongoing research in Montana has yielded relevant information for park managers elsewhere who deal with avalanche threats to park infrastructure and for ecologists seeking a better understanding of how mountain ecosystems function.

Our research has focused on two transportation corridors: the Going-to-the-Sun Road that bisects the center of the park, and John F. Stevens Canyon, at the park's southwest corner (fig. 1). The Going-to-the-Sun Road is the park's most visited attraction; deep snow and avalanches force the road's closure each winter, and in spring, park crews dig it out using bulldozers and other heavy equipment (fig. 2). Springtime avalanches can bury workers or push equipment off the road and over cliffs (figs. 3a and 3b), as happened in 1953, when two workers died. Our research started with a study of how interannual variations in snowfall and avalanches affect the road opening. The initial study helped park managers predict and plan for the road opening in spring and respond to the many topical questions from park visitors and locals. More recent studies have focused on determining the conditions that create springtime avalanches, which are a poorly understood aspect of the avalanche phenomenon.

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The research has culminated in a partnership between the National Park Service and U.S. Geological Survey to improve the safety of the snow removal crews while providing data for long-term studies of avalanche-climate relationships. During spring opening operations, Glacier National Park Meteorological Technician Mark Dundas and USGS Physical Science Technician Blase Reardon dig snow pits and analyze data from three ridge-top weather stations to issue a daily avalanche hazard forecast for the park snow removal crews. The two technicians also maintain an extensive database of weather and snow conditions and avalanche occurrence. Combining those data with historical data has al l owed us to start examining the climate patterns that create the springtime avalanches. In spring 2006, we provided avalanche and meteorological data for a study by the USDA Forest Service Nat ional Avalanche Center that investigated wet-snow avalanches and weather patterns in snow climates ranging from Alaska to Colorado and Norway.

In Stevens Canyon, wintertime avalanches can disrupt traffic on the only year-round transportation routes across the northern Rockies—U.S. Highway 2 and the Burlington Northern-Santa Fe Railroad. The highway and railroad run through or adjacent to the Glacier National Park boundary and, significantly, in the runouts of numerous avalanche paths that lie within the park. Using data from mountaintop weather stations, we have investigated a distinct weather pattern that creates these avalanches—bitter cold temperatures and heavy snowfall followed by rapid warming. Descriptions of that pattern appear frequently in the historical records of avalanche incidents in the canyon; the earliest is a 1910 report by the Weather Bureau (now the National Weather Service) that details the temperatures and precipitation leading to several avalanche cycles in Stevens Canyon. It is one of the earliest scientific examinations of the weather precursors to avalanches in the United States. Our investigations build on the historical knowledge by quantifying the factors that combine for a dramatic avalanche cycle in Stevens Canyon: average snowfall amounts, typical snow depths, typical temperatures, and number of avalanches. Still, one ranger's frank but unscientific comment in a 1961 log may sum up the pattern most succinctly: "We had rain last night, and hell this morning."

In the course of our research we compiled a century-long record of natural avalanches caused by that pattern. That record has led to additional studies. It is one of the longest, most complete records of natural avalanches available. Most avalanche data are from sites where avalanches are controlled, either with skier compaction or explosives. The fact of avalanche control means you cannot compare avalanche frequency data from those sites with long-term climate records to see how avalanches and climate relate like you can in Glacier. We noticed that the Stevens Canyon record alternates between decade-long periods when avalanches disrupted transportation in the canyon most winters, often multiple times a winter, and periods when avalanches rarely occurred. Most periods of frequent, large-magnitude avalanches correspond with cool phases of the Pacific Decadal Oscillation, a low-frequency climate oscillation involving sea surface temperatures and atmospheric pressure near the Aleutian Islands and along the Pacific Northwest coast.

As an ecologist, Dan Fagre is ultimately interested in avalanches for their effects on the park's mountainous landscape. Avalanches are a natural disturbance like fire. There are avalanche paths on most slopes across the park, and the forests on those slopes are much more complex than forests on slopes undisturbed by avalanches (fig. 4). Large, infrequent avalanches can uproot and snap old trees, leaving openings in mountain forests. Smaller, more frequent slides maintain those openings by destroying slow-growing trees but leaving fast-growing trees and shrubs such as aspen, birch, and alder. The result is greater vegetation diversity and more ecotones—edges between ecological communities. More ecotones means more diverse habitat for wildlife, especially ungulates and birds. We believe the climate patterns that influence the frequency of natural avalanches in the park have broad, long-lasting ecological effects, so any climate changes that alter the frequency or magnitude of natural avalanches will in turn change the forests in the park.

Recently, with our collaborators, we have turned to tree-ring studies to complement our historical research. Trees injured by avalanches respond with scars, reaction wood, or other growth anomalies that can be dated. The tree rings record nearly twice as many avalanches as appear in the historical documents, enabling us to conduct higher-resolution studies of avalanche-climate relationships. The data confirm the association between avalanche frequency and the Pacific Decadal Oscillation we see in the historical record. Though our work continues, our initial results have helped Glacier's managers address avalanche hazards in the park. The park is completing an environmental impact statement (EIS) analyzing a proposal by the railroad to use explosives to mitigate avalanche hazard in Stevens Canyon. The EIS team has used the avalanche history compiled by our USGS research team to assess the extent and frequency of the hazard in the canyon. Such immediate management application for research results is uncommon and rewarding.

Blase Reardon is a physical science technician with the USGS Northern Rocky Mountain Science Center in Glacier National Park, West Glacier, Montana. He can be reached at 406-888-7926 and blase_reardon@usgs.gov. Dan Fagre is an ecologist with the USGS Northern Rocky Mountain Science Center and can be reached at 406-888-7922 and dan_fagre@usgs.gov.