

## **AVALANCHE HAZARD MAPPING FOR SNOWMOBILES AND OTHER WINTER TRAIL USERS**

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**ABSTRACT:** Snowmobilers have become the most likely user group in the United States to become involved in a fatal avalanche (Utah Avalanche Center, 2008). Greater awareness and education is necessary.

Wyoming has over 3,000 kilometers of maintained trails that are machine groomed for winter use. These trails are extremely popular, and are frequented by winter travelers with a large variation in avalanche knowledge and experience. The trails avoid most avalanche prone slopes; however, along some portions of the trails avalanches are a threat to trail users and trail grooming/maintenance personnel.

To address this problem avalanche specialist used global positioning satellite (GPS) and geographic information system (GIS) technologies to locate and characterize the avalanche hazard impacting a portion of these trails.

Avalanche hazard maps and accompanying text were created and posted on the internet at [jhalananche.org/statetrailmaps/](http://jhalananche.org/statetrailmaps/). This website is expected to be a useful means to raise avalanche awareness among this important user group.

**KEYWORDS:** Avalanche hazard mapping, snowmobile trails, geographic information system

### 1.0 INTRODUCTION

During the winter, the Wyoming Department of State Parks and Cultural Resources (DSP&CR) machine grooms nearly 3,000 kilometers of trail for multiple winter users. These trails are located in 11 major areas within four regions. This project focuses on trails in two of these areas. During daylight hours these trails are used by snowmobilers, dogsledders, cross country skiers and other winter sport enthusiasts. This diverse group includes single users and groups which may be guided or unguided. Trail grooming efforts are conducted at night.

To address the potential hazard from avalanches to trail users, the DSP&CR partnered with the Bridger-Teton National Forest Avalanche Center (BTAC) to use GPS and GIS technologies to delineate avalanche hazards along the Continental Divide and Southwest Trails areas in Western Wyoming. This research was funded by a Recreational Trails Program Grant obtained from the Federal Highway Administration by the BTAC in partnership with the DSP&CR.

The Continental Trails area is comprised of 750 kilometers of maintained trail along the Continental Divide in Western Wyoming. This 8,000 square kilometer area includes Togwotee Pass, the Upper Green River Drainage and the Gros Ventre River Drainage.

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Figure 1: Portion of the machine groomed winter trail system on the west side of the Continental Divide maintained by the Wyoming Department of State Parks and Cultural Resources.

The Southwest Trails area is comprised of 500 kilometers of maintained trail in Western Wyoming. This 8,500 square kilometer area encompasses the Wyoming Range, the Salt River Range and the Greys River Drainage.

The elevation of these areas ranges from 1,500 to 3,350 meters above sea level. The climate is cold and dry with an annual snowfall of 3 to 12 meters depending on elevation and location.

Portions of these areas typically have a continental or inter-mountain snowpack. The distribution of these snowpack types is location and elevation dependant and varies on a seasonal basis.

There have been 19 avalanche fatalities by recreational users in these areas. Twelve of these were snowmobilers. None of these incidents occurred on maintained trails.

## 2.0 TRAIL AVALANCHE HAZARD MAPPING

Over the course of five seasons avalanche specialist from the BTAC used handheld GPS devices to map the trails. These data were superimposed upon topographic base maps and aerial photographs using GIS technology. Concurrently, the location of avalanche terrain known, or judged to have, some potential to impact the trails was mapped using these tools.

Field observations, historical knowledge and key topographic attributes derived with the GIS were used to characterize these avalanche hazards.

### 2.1 Trail avalanche hazard ratings

This project characterized the potential avalanche hazard to the trail network using the following hazard rating scheme. These ratings only apply to the groomed or maintained trails. In some areas dangerous slopes exist immediately adjacent to safe sections of the trails system.

This nomenclature was derived for the purpose of communicating identified avalanche hazards to the public. An objective was to provide this information in a simple non-technical format.

**BLACK** – Sections of the trail system where avalanches are not expected except during extreme or very unusual conditions.

**SOME HAZARD (YELLOW)** – Sections of the trail system where dangerous avalanches are possible.

**GREATER HAZARD (ORANGE)** – Sections of the trail system where dangerous avalanches occur on a more frequent basis or where infrequent avalanches with very serious consequences are possible.

Figure 2 is an overview map of the Southwest Trails Area that uses this scheme to display trail avalanche hazard ratings.

### 2.2 Avalanche feature classification

Individual avalanche hazards to the trails had a variety of forms. These included well defined avalanche paths that slide on a frequent basis, known avalanche paths that slide on an infrequent basis and a wide variety of steep hillsides and banks. Other considerations such as terrain traps contributed to the seriousness of the avalanche hazard.

Each avalanche feature with potential to impact a trail was classified as a major or minor slide path based on the following definitions.

**Major Slidepath** – Generally larger steep topographic features that can produce avalanches that could cross a portion of the trail system.

**Minor Slidepath** – Generally smaller topographic features, such as an open hillside or a steep bank, that could produce an avalanche that would flow onto or across a trail.

Terrain Traps were defined as topographic features that could cause a small volume of avalanche debris to accumulate to significant depths, or dangerous features that could harm a person who was swept into or over them. Examples are creek bottoms, rivers, v-shaped gullies, benches, cliffs, trees and rocky areas. If present, terrain traps are discussed in the text that accompanies the avalanche hazard maps.

### *2.3 Trail hazard communication and dissemination*

To communicate the hazard to the public, a GIS was used to create avalanche hazard maps for these areas of the trails. These maps and accompanying text can be found at [jhalavalanche.org/statetrailmaps/](http://jhalavalanche.org/statetrailmaps/).

This website has a home page with links to the Continental Divide and Southwest Trails areas. Pull down menus link to overview maps for each of these areas that depict trails avalanche hazard ratings and eight inset avalanche hazard feature maps. The inset maps depict specific features that threaten the trails and include text that describe these avalanche hazards.

The inset maps and accompanying text can also be accessed by moving a cursor over areas of the overview map where hazard exist. All of these maps are low resolution JPEG images that load quickly. High resolution PDF versions of these maps can also be viewed, downloaded or printed from the website.

An example of an area overview map that delineates the trail hazard ratings is provided as Figure 2. An example of a detailed inset map that depicts avalanche features and the accompanying descriptive text in a relatively simple setting is provided as Figure 3. Figure 4 is an example of

an avalanche feature inset map in a more complex area.

The home page also provides links to sites with avalanche awareness information and to the daily avalanche hazard advisories for these areas. Figure 5 is a screenshot of the homepage.

### 3.0 CONCLUSIONS

GPS and GIS technologies provide an excellent means to characterize and display avalanche hazard to winter trail users. This project has used these tools to create avalanche hazard maps for two areas of the State of Wyoming winter recreation trail network that are threatened by avalanches.

The maps and text that describe and identify the location of these avalanche hazards are available on the internet where they can be viewed, downloaded or printed.

This project will also enable trail users who observe avalanche activity on any of the mapped trails to decisively communicate the location of these events to other users and the BTAC.

The attributes of project slide paths have been estimated using the GIS. Timely field reports of avalanche activity on avalanche paths with known attributes will enhance the BTAC ability to provide accurate avalanche bulletins for these areas.

It is hoped that this avalanche hazard website will increase avalanche awareness for a wide variety of winter visitors. These maps will help trail users learn to identify avalanche prone terrain. Visitors to this website can easily navigate to other avalanche awareness websites.

### 4.0 REFERENCES

Utah Avalanche Center, 2008. Graphic Avalanche Stats, U.S. Avalanche Fatalities by Activity 1997-2007. [www.avalanche.org/%7Euac/ed\\_graphs.htm](http://www.avalanche.org/%7Euac/ed_graphs.htm)

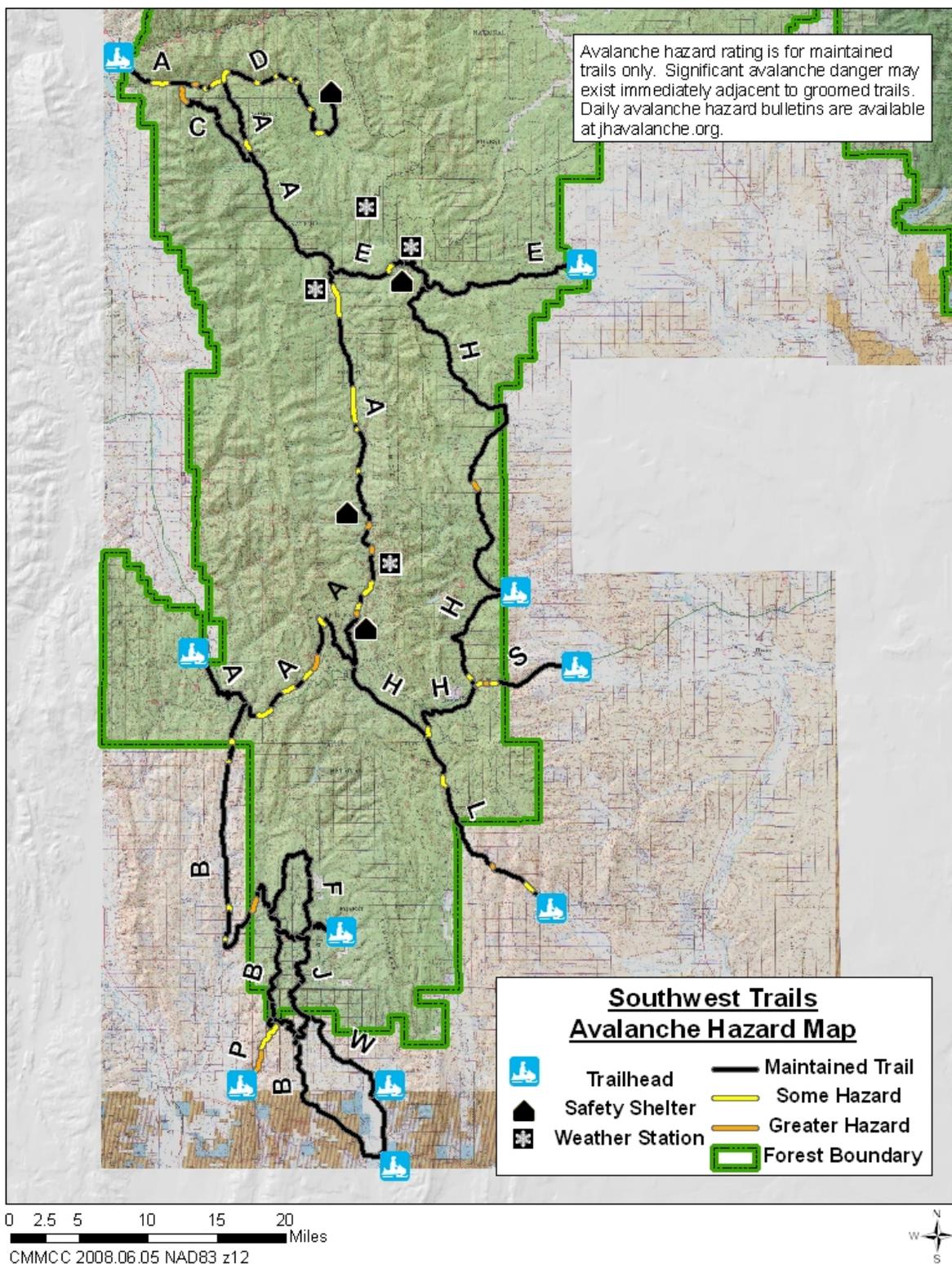
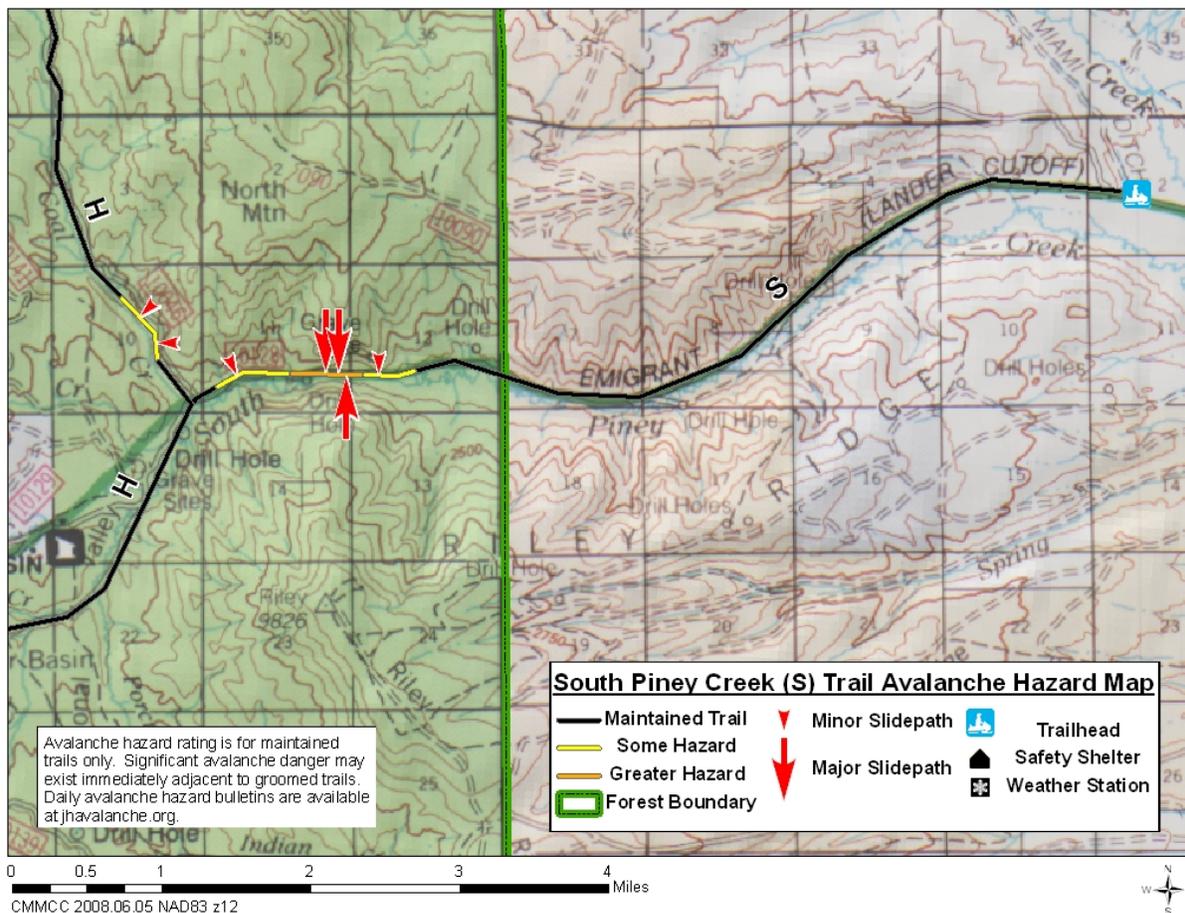


Figure 2: Overview avalanche hazard map for the Southwest Trails Area in Western, Wyoming.



### South Piney Creek (S) Trail

The South Piney Creek or S Trail runs along the Lander Cut Off of the Emigrant Trail. Its east end is a parking area located approximately 13 miles west of Big Piney near Miami Ditch. From this parking lot it runs west 6.7 miles to a Junction with the H Trail at Coal Creek.

**Avalanche Hazards:** The primary avalanche hazard to this trail is from known avalanche paths that originate from very steep terrain on the north side of the trail 0.9 miles from the H Trail Junction and on both sides of the trail 1.0 mile east of the H Trail Junction. These slide paths are located 5.7 and 5.8 miles west of the parking area. Avalanches on the slide paths on the north side of the trail originate from starting zones at an elevation of 8,300 feet that face south. Avalanches on the path on the south side of the trail originate from starting zones at a similar elevation that face north.

Two other south facing hillsides along this trail have some potential to produce avalanches that could reach this trail when they are snow covered and conditions are unstable. One is located 0.3 miles from the H Trail Junction (6.4 miles from the parking area) and the other is located 1.3 miles from the H Trail Junction (5.4 miles from the parking area).

Figure 3: Map of the South Piney Creek (S) Trail (an inset in the map provided as Figure 2). This map details avalanche features that affect this trail and provides the above accompanying text that describes the location of the hazard delineated and provides information regarding the nature of the hazards.

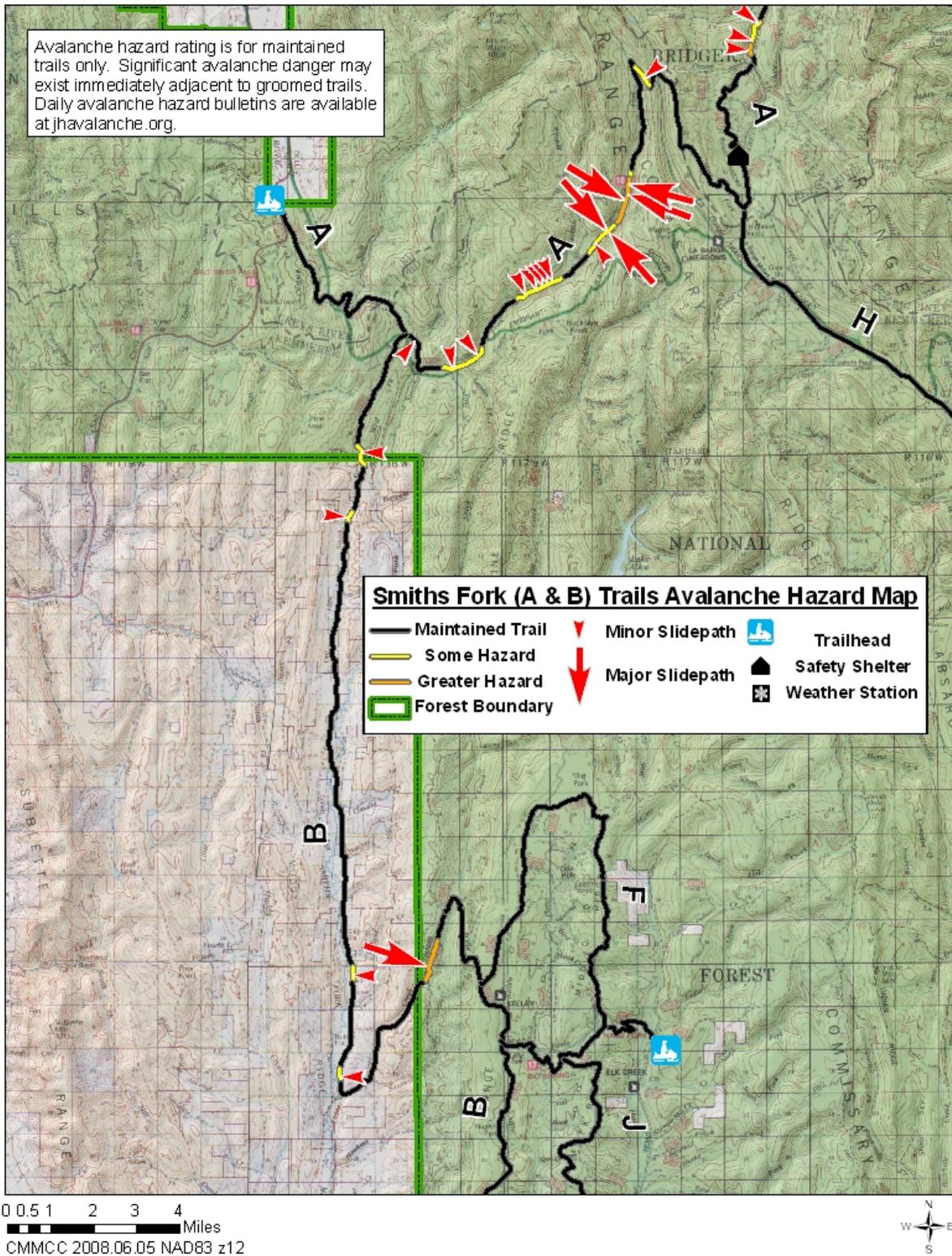


Figure 4: Map of the Smiths Fork Area (also an inset in the map provided as Figure 2). This map delineates avalanche features in more complex terrain. The text associated with this map is not included with this Figure.



Wyoming State Trails Avalanche Hazard Maps

This site provides maps that delineate the location and text that provide a brief description of avalanche hazards that could impact the maintained winter trail system in Western Wyoming. These trails have been designed to avoid most avalanche prone terrain, however in some places they cross beneath known avalanche paths, steep hillsides and/or steep banks that sometimes avalanche.

Most avalanches occur during and immediately after storms, especially those accompanied by high winds and/or extended periods of intense snowfall. Rapid warming and rain on snow events are also red flags for avalanche activity. The following web sites are excellent sources of information for people who travel in avalanche terrain.

[Avalanche Basics -US Forest Service, National Avalanche Center](#)

[Online Avalanche Class - Teton Gravity Research](#)

[The Avalanche Encyclopedia - National Avalanche Center and The Friends of the Utah Avalanche Forecast Center](#)

Daily avalanche hazard advisories are issued for the mountainous areas of Western Wyoming by the Bridger-Teton National Forest Avalanche Center at [jhalavalanche.org](http://jhalavalanche.org). These advisories are posted twice daily from early November to mid April.

### Trail Avalanche Hazard Ratings

This project has mapped the potential hazard to trails using the following color scheme. These ratings only apply to the immediate area of the groomed or maintained trails. In some areas dangerous slopes exist immediately adjacent to safe sections of this trail system.

**Black** - Sections of the trail system where avalanche are not expected except during extreme or very unusual conditions

**SOME HAZARD** – Sections of trail where dangerous avalanches are possible

**GREATER HAZARD** – Sections of the trail where dangerous avalanches occur on a more frequent basis, or where infrequent avalanches with serious consequences are possible.

### Avalanche Hazard Features

**Major Slidepath** - Generally larger steep topographic features that can avalanche across a section of the trail system

**Minor Slidepath** - Generally smaller topographic features such as open hillsides and steep banks that can avalanche onto or across a section of the trail system.

**Terrain Traps** are topographic features that could cause a small volume of avalanche debris to accumulate to significant depths or dangerous features that could harm a person who was swept into or over them. Examples are creek bottoms, v-shaped gullies, cliffs, trees and rocky areas.

Figure 5: Screenshot of the Wyoming State Trails Avalanche Hazard Map Project home page