DEEP SLAB INSTABILITY CHARACTERIZING THE PHENOMENA – PART 1

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ABSTRACT: Deep slab avalanches cause property damage and kill people. A better understanding of the characteristics of deep slab avalanches could increase the effectiveness of mitigation efforts.

The Bridger-Teton National Forest Avalanche Center has a database with over 18,000 avalanche events. Part 1 of this study has isolated 800 deep slab avalanches in this database for further investigation. A simple database search indicates these deep slab avalanches are generally larger, harder and tend to occur more frequently in December and January than other avalanche types. A large seasonal variation was found in the frequency of the occurrence of these deep slab events.

Knowledge of load rates and load rate durations necessary to release deep slab avalanches and snow settlement rates observed as stability is gained would be useful to manage deep slab instability. Complex database searches are being conducted in an effort to gain insight into this important topic. The results of these efforts will be reported as Part 2 of this study.

KEYWORDS: Deep slab avalanches, avalanche database search

1.0 INTRODUCTION

The uncontrolled release of deep slab avalanches has historically caused fatalities and damage to property. A better understanding of the characteristics of these deep slabs would be useful to personnel who are tasked to manage the hazard from this phenomenon.

2.0 HISTORICAL DATABASE

Since 1974 the Jackson Hole Mountain Resort and the Bridger-Teton National Forest Avalanche Center have recorded daily meteorological, snow pack and avalanche observations.

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The meteorological data originates from a network of remote automated weather stations and daily manual measurements taken at snow study plots. The snowpack data is comprised of snow surface and snow structure observations collected on a daily basis from a network of snow study plots. The avalanche activity data is comprised of avalanche observations from the resort and the backcountry.

Hand written daily records of this data have been entered into an electronic database. This database is comprised of 5,256 daily records that span 33 seasons from 1974 to 2007. There are 18,831 avalanches are in the database. The vast majority of these (17,390) were dry slab avalanches.

3.0 SIMPLE SEARCH OF THE AVALANCHE OCCURRENCE DATABASE

For the purpose of this study, deep slabs were defined as any slab avalanche with a crown greater than 1.18 meters (44 inches) deep. This value was selected based on knowledge gained during the process of converting the hand written records into an electronic format.

An avalanche specialist with 29 years of field familiarity with the data recommended this crown depth for the purpose of isolating deep slab avalanche events after he completed the data entry process. As the data was entered, notes regarding pertinent field recollections of substantial deep slab avalanche cycles were added to the database.

A goal of this research was to characterize deep slabs based on this criterion, and then use these characteristics to isolate other avalanches in the database with similar characteristics but shallower crown depths, in a later study.

In essence this value was a best guess starting point based on a review of 33 seasons of data, and field knowledge of these events.

There are 17,546 slab avalanches in the database. Eight hundred of these slabs had a crown depth that exceeded 1.18 meters in depth. Table 1 provides a breakdown of the number of avalanches by avalanche type and the number deep avalanches by avalanche type.

Avalanche Type	All Depths	Crown Depth > 1.18 meters
Hard Slab	908	272
Soft Slab	16,482	514
Wet Slab	156	14
Loose Snow	830	0
Wet Loose	425	0
TOTAL	**18,801**	**800**

Table 1: Number of avalanches by avalanche type and avalanches with crown depths > 1.18 meters by avalanche type.

The data in Table 1 shows there were no loose snow avalanches in the database with depths at the point of failure greater than 1.18 meters.

3.1 Deep slab avalanche size

Figures 1-4 present bar graphs that plot the number of occurrences by size relative to the their paths for soft, hard, wet and deep slab avalanches, respectively.

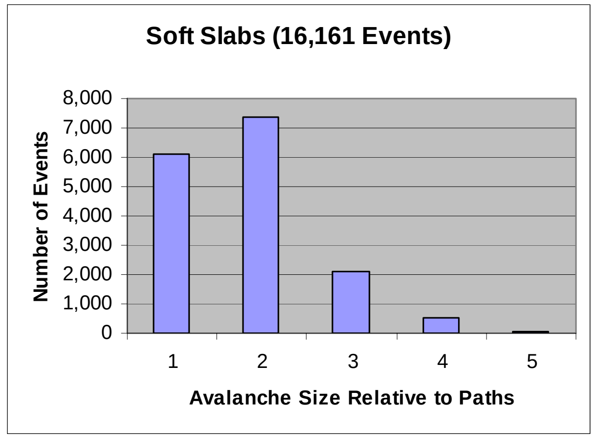

Figure 1: Number of soft slab avalanches by size relative to their paths.

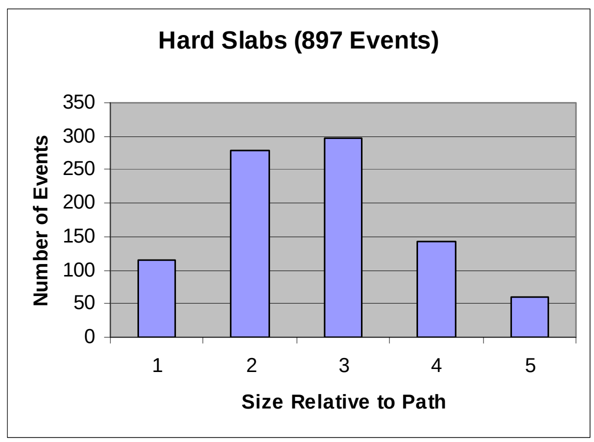

Figure 2: Number of hard slab avalanches by size relative to their paths.

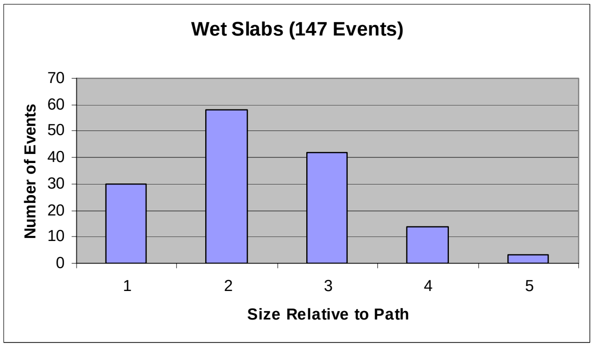

Figure 3: Number of wet slab avalanches by size relative to their paths.

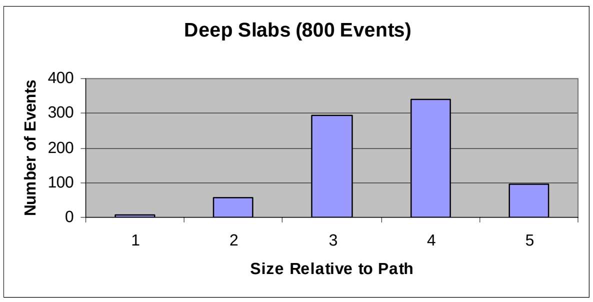

Figure 4: Number of deep slab avalanches by size relative to their paths.

The data in Figures 1-4 indicate that deep slabs, as defined by this study, are generally larger relative to the size of their paths than hard, soft and wet slab avalanches. This search indicates that the 800 deep slab avalanches isolated by this study are larger than other slab avalanche types in this database.

3.2 Deep slab hardness

A simple database search revealed five percent of the 17,546 slab avalanches were hard slabs. Thirty-four percent of the 800 avalanches with crown depths > 1.18 were hard slabs. Thirty-eight percent of the slab avalanches with crown depths greater than 1. 37 meters deep were hard slabs. These search results indicate deeper slabs are more likely to be harder slabs.

Slabs Avalanches All Depths	**17,546**	
Hard Slabs	908	5%
Wet Slabs	156	1%
Soft Slabs	16,482	96%
Slabs > 1.18 Meters Deep	**800**	
Hard Slabs	272	34%
Wet Slabs	14	2%
Soft Slabs	514	64%
Slabs > 1.37 Meters Deep	**333**	
Hard Slabs	128	38%
Wet Slabs	7	2%
Soft Slabs	198	59%

Table 2: Comparison of the percentage of hard slabs for all slab avalanches, slab avalanches with crown depths greater than 1.18 meters and slab avalanches with crown depths greater than 1.37 meters.

3.3 Deep slab occurrence by month

The distribution of occurrence of all avalanche types by month is presented in Figure 5. Figure 6 presents the same information for the 800 deep slab avalanches.

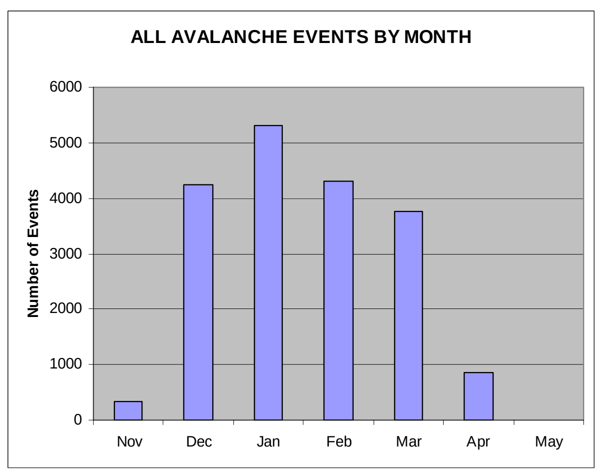

Figure 5: The distribution of avalanche occurrences for all avalanche types by month.

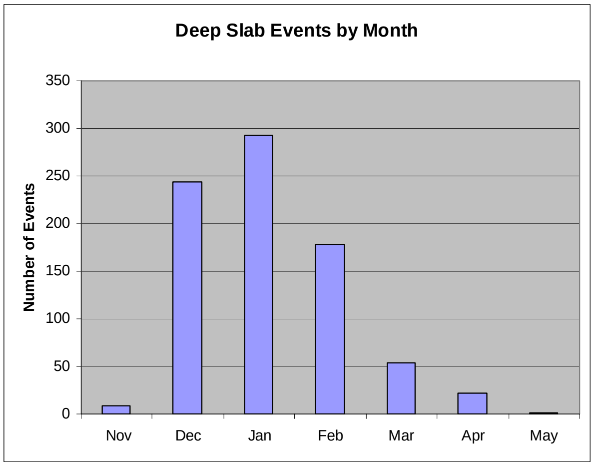

Figure 6: The distribution of deep slab avalanche occurrences by month.

A comparison of the data presented in Figures 5 and 6 indicates deep slab avalanches tend to occur more frequently in December and January.

3.4 Deep slab occurrence by season

Figure 7 presents the number of deep slab avalanches by season. A large seasonal variation in the number of deep slab events exists. The maximum number of deep slab avalanches per season was 60 in 1995/96 and 2000/01. The minimum number of deep slab avalanches for a season was four in 1977/78. The mean number of deep slabs per season was 25.

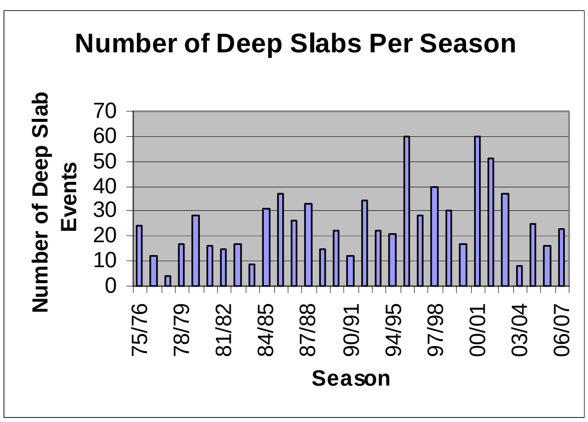

Figure 7: Number of deep slab avalanches per season from 1974 to 2007.

3.5 Deep slab triggers

A simple search of this database determined that the failure of deep slab avalanches had been caused by all trigger types. The most common triggers were explosives and spontaneous releases. Humans on skis or vehicles (snowmobiles and snow grooming equipment) triggered 12% of the deep slabs. Most (83%) of the natural avalanches in the database occurred in the backcountry.

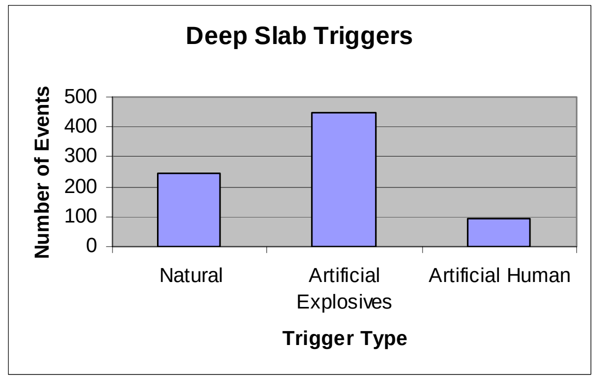

Figure 8: Deep slab triggers

3.6 Deep slab bed surfaces

A simple search of the deep slab avalanche events with respect to whether the bed surface of the slab was the ground or an old snow surface showed that 6.9% of the deep slab avalanches ran on the ground. The percentage of naturally triggered deep slab avalanches that ran on the ground was somewhat higher at 10.4%. The percentage of explosively triggered deep slab avalanches that ran on the ground was somewhat lower at 6.2%.

3.7 Deep slab occurrence

Most (59%) of the deep slab avalanches in the database occurred in the resort.

3.8 Simple search results summary

A simple search of deep slab avalanches in the database as defined by this study indicates deep slab are typically larger, harder, tend to occur with greater frequency in December and January and display a large variation in frequency of occurrence by season.

Deeps slabs can release spontaneously or be artificially triggered by explosives, humans or vehicles.

4.0 COMPLEX SEARCH OF MULITPLE DATABASES

A simple search of the historic avalanche database provided some information regarding the character of deep slab avalanches.

To gain further insight into the deep slab phenomena, complex data searches are being conducted. Complex searches relate the avalanche database to the historical meteorological and snow surface/structure databases.

The first task of the complex search was to isolate deep slab avalanche events and cycles for further study.

The second task was to investigate and attempt to characterize the conditions that led up to the failure of deep slab avalanches and conditions that lead to the stabilization of the snowpack after deep slab avalanches have occurred.

To accomplish the first task the number of deep slab avalanches per day was graphed for each of the 33 seasons in the database.

To accomplish the second task selected deep slab avalanche cycles are being investigated with respect to weather and snowpack databases. The data entry notes and field knowledge of these occurrences has enabled this study to isolate 60 deep slab avalanche cycles for further study.

Figures 9-12 are graphs that plot the number of deep slab avalanche events per day for individual seasons. A plot of the 24-hour new snow water equivalent accumulations and daily total snow depths at the resorts mid mountain snow study plot are also depicted on these graphs.

5.0 Deep Slab Characterization – Part 2

The second part of this research project will investigate these 60 deep slab cycles. This investigation will attempt to quantify load rates that result in the failure of deep slab avalanches and settlement rates that result in stabilization.

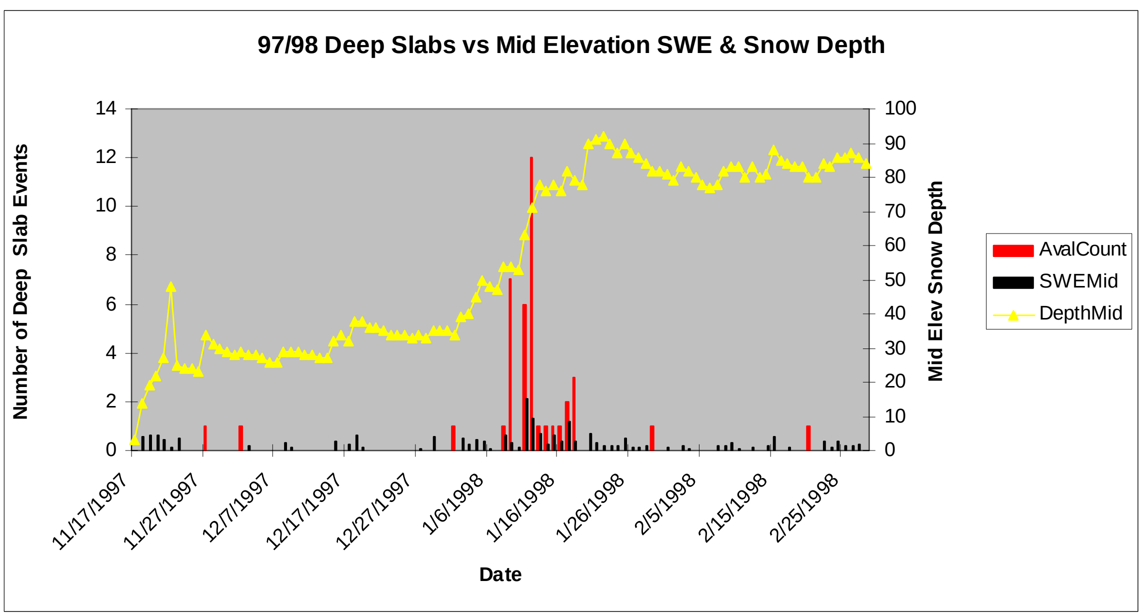

Figure 9: Graph of the 1997/98 season. A deep slab avalanche cycle occurred during this season from 1/9/98 to 1/19/98. These deep slabs failed on a December drought surface.

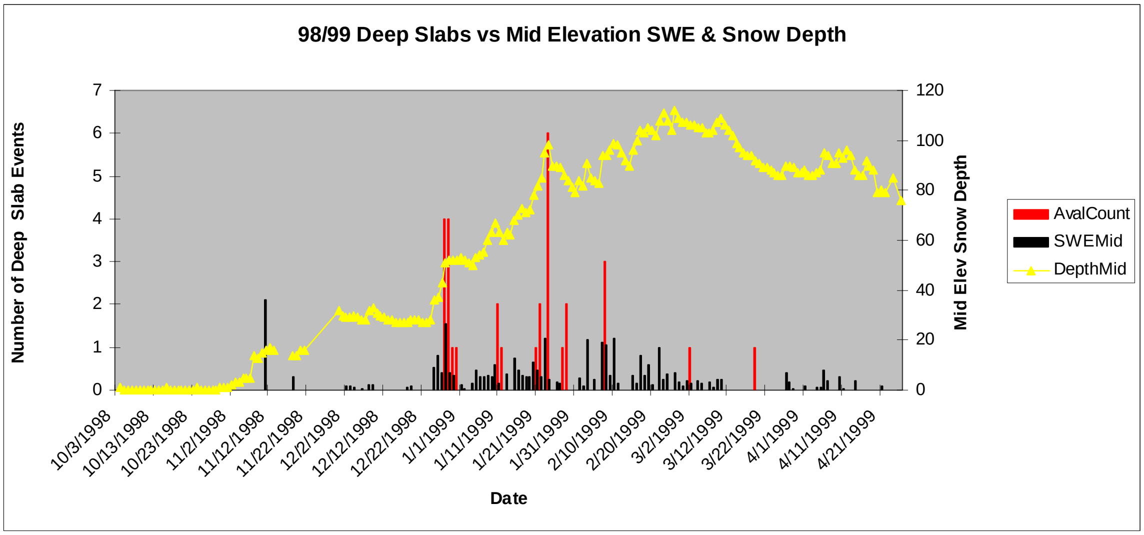

Figure 10: Graph of the 1998/99 season. Drought conditions in December 1998 created a bed surface for a January 1999 deep slab avalanche cycle.

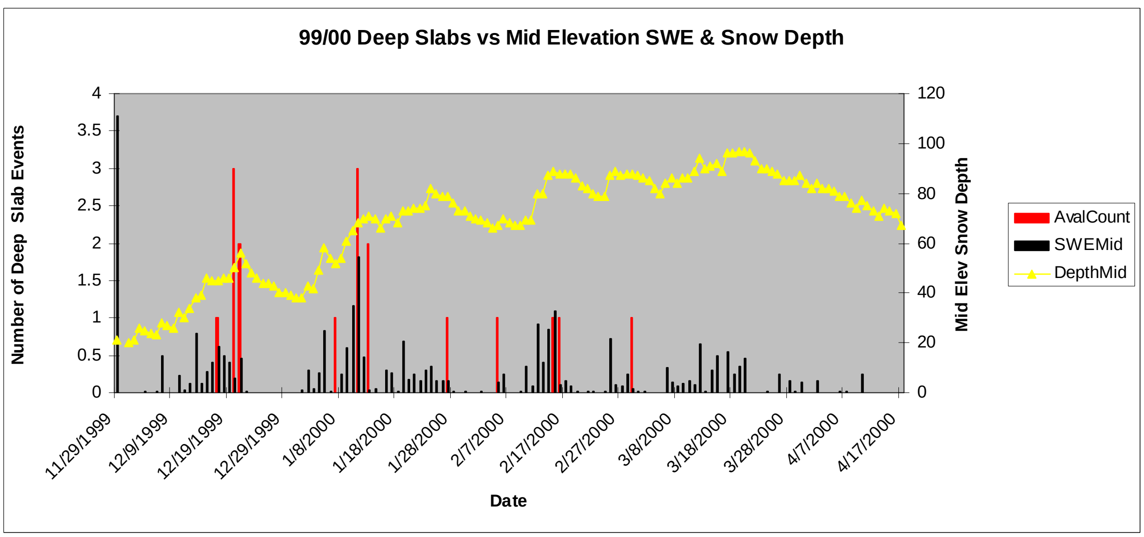

Figure 11: Graph of the 1999/2000 season. A shallow snowpack in November and an extended dry period in late December and early January set the stage for deep slab avalanche cycles in December and January.

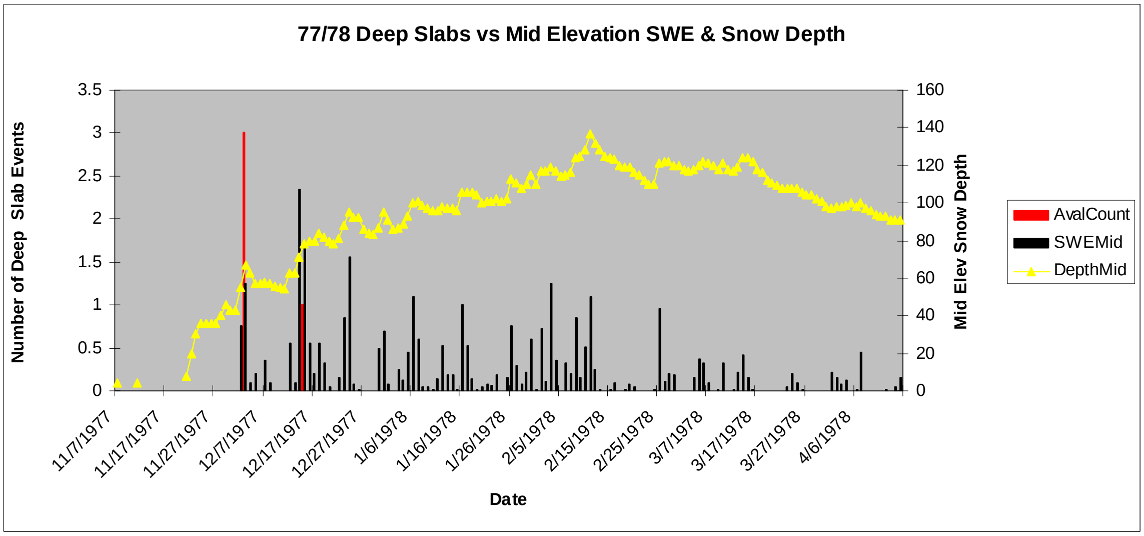

Figure 12: Graph of the 1977/79 season. This season had the lowest number of deep slab avalanche events (4) in the 33 year database.