

AVALANCHE RISK REDUCTION IN THE CONTINENTAL CLIMATE: HOW TO IMPLEMENT AN EFFECTIVE BOOT PACKING PROGRAM

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**ABSTRACT:** Ski resorts in the continental climate are challenged with safely opening steep terrain early season. Providing a skiable product with timeliness correlates to increased revenue and maximizing profit. In the Rocky Mountains, a faceted, shallow snow cover prone to avalanching is typical. To retain snow, avalanche risk reduction methods such as boot packing are critical. Over the past 20 years, the Aspen Highlands Ski Area, located in central Colorado, has successfully developed a preseason program to address such problems. Implementing a boot compaction program improves both snow stability and quality of skiing. A successful packing operation requires extensive man hours and depends on outside assistance along with ski patrol personnel. This paper illustrates how other ski areas can benefit from a "Packing for Passes" program providing guidelines on organization, packer safety, logistics and cost.

**KEYWORDS:** Boot packer, shear plane disruption, avalanche risk reduction

## 1. INTRODUCTION

Ski areas in the continental climate are challenged with providing early season skiing in avalanche terrain. Maximizing profit is dependent on providing a skiable product with timeliness, both initially and during storm cycles. A faceted, shallow snow cover prone to avalanching is not ideal and must be addressed through effective risk reduction methods such as boot packing. At Aspen Highlands, located in the Colorado Rockies, at latitude ~39.9 degrees N, longitude of ~106.5 degrees W, and ranging in elevation from 2440 m to 3775 m HASL, an extensive, early season boot packing program has proven effective. Over the past 20 years, boot compaction has become a successful risk reduction tool, improving both snow stability and skiing quality.

Initially, boot packing was a method for adding strength to basal storm layers. Currently the program's main objective is shear

plane disruption. Because boot compaction interferes with propagation pathways, it reduces the probability of deep slab instabilities allowing risk reduction teams to operate with a higher level of confidence while providing a safer environment for the skiing public. Boot packing is a viable solution for offering steep skiing in mid December. The 48.5 hectares of Highland Bowl has become a primary packing focus. Slopes average 37 to 42 degrees with aspects ranging from north to south east. A 30 to 40 minute climb provides the recreational skier with a backcountry type experience. From a marketing perspective, it is critical to offer a quality product on opening day and for the subsequent holiday season. The Christmas revenue stream determines the financial outlook for the entire season. Maximizing skier numbers is dependent on snow retention with minimal avalanching. Paying guests do not want to look at closed terrain, avalanche debris or rocky bed surfaces.

## 2. METHODOLOGY

At Aspen Highlands, a successful packing operation is dependent on outside resources or additional man power requiring approximately 6,500 man hours per season. The packing crew includes both paid patrol and workers who pack for passes. The process begins well before the first snow fall as perspective packers inundate the snow safety office with calls and e-mails in hopes of securing a spot on the pro packer team. Due to the program's increasing popularity, a web site has been incorporated--"[bootpacker.com](http://bootpacker.com)"--allowing more efficiency with the sign up process and reducing office time. Those interested, can look

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up program requirements, scheduling, sign up procedures and view photos of boot packing. For the 2009-2010 season we had over 150 inquiries due to the poor job market and the financial challenge of purchasing a season pass. For exercise fanatics with flexible schedules, this is an economical and ideal way to earn a pass and condition for skiing.

By the third week of October, we have enough prospective packers to hold organizational meetings. Packers are briefed on the necessary gear requirements and compensation. It is mandatory that all packers have an avalanche transceiver and lug soled boots. All participants must sign a waiver and contract stating they are not covered by workman's compensation and that they understand the program rules and guidelines. Packer reimbursement is structured as follows; to earn a ski pass, packers must work an eight hour day in exchange for a \$100 credit. After five days, they have the option to cash in for any pass product, either paying the difference or working up to 15 days for the full season pass. In 2009, 80% of the packers did not pack the full fifteen days and opted for a pass product of lesser value due to the time commitment, scheduling or physical demands. There is also a small percentage of packers who volunteer or do not complete five days which results in bonus packing hours at no cost to the company.

Prior to bringing in packers, snow safety personnel spend time in the field assessing the early season snow cover and gathering data. Have the initial October storms turned to facets and become buried? Is there an overlying windslab? What is the long range forecast? Can we get to the packing site efficiently or will we spend more time traveling than actually packing? These are important questions which must be addressed in the decision process of when to bring in packers. Timing is critical in terms of efficiently using man power and effectively disturbing the snow layering. Beginning too early could mean having to repack terrain, starting too late could put the master plan behind schedule. Over the years, a 0.5 meter HS at the midway study plot has become the benchmark depth for beginning work. Greater depths make full penetration and disrupting all layers difficult. Preparations also include hauling and staging necessary gear to ensure packer and patroller safety. Explosives must be cached and twelve 180 meter ropes must be transported on foot to a staging area located at 3,696 m HASL. Each hauling lap takes approximately one hour round trip and climbs 236 vertical meters in two km. In 2009

packing set up required approximately 120 man hours.

Because packer safety is critical, avalanche control routes, stability tests and slope evaluation must be conducted prior to exposing workers to an unconsolidated snow pack. Initially, Highland Bowl resembles a backcountry scenario rather than a managed ski area. It is not uncommon to experience fracture/collapse and release of unstable pockets. Snow safety personnel choose to operate towards the lower limit of the operational risk band. The number of packers exposed is kept small, moving one at a time becomes protocol. Additional explosives are used on site in unconsolidated zones adjacent to packer tracks, and a spotter is strategically stationed and ready to respond.

To address potential slab release and working in technical terrain, a fixed anchor belay system was installed in 2000 (Figure 1). The system has proven effective for accessing steep, rocky areas and working in the higher risk alpine environment. All packers are issued a self belay device (Petzl Shunt) and harness, packing while self belaying on a 11.6 mm static rope when necessary (Figure 2,3). A rope team works ahead of the packing crew and coordinates with the packing team leader. Ideally all ropes are set and in place when needed (Figure 4). Good communication and being one step ahead is key and prevents packers from standing around or losing momentum. With 30 to 40 packers per day, it is important to have good group management, maximize packing time in the field, continually evaluate stability and follow proper safety protocols. The ideal patrol to pro packer ratio is 1 to 5.



Figure 1. Fixed anchor and cable



Figure 2. Petzl Shunt on fixed rope



Figure 3. Packers in alpine terrain descending and self belaying on fixed rope



Figure 4. Patroller setting initial packing line on belay

The technique developed over time is to form a 1 meter x 1 meter grid by walking vertically, in a down hill direction (Figure 5,6). The goal is to penetrate all snow layers reaching the ground or basal layer. Patrol monitors and instructs packers looking for adequate compliance and proper spacing. Full boot penetration 80% of the time is achieved and

considered sufficient. All paths are meticulously packed, side to side and top to bottom (Figure 7). This technique avoids missing areas and affects the perimeters which pose potential stability problems if not addressed. Packing in between trees, even where spacing is tight, must not be overlooked. This process ensures that steep pockets are thoroughly packed and do not get skipped.



Figure 5. Packing vertically downhill



Figure 6. 1 meter x 1 meter grid



Figure 7. Thoroughly boot packed terrain

In the case of hard slab, packers are instructed to give at least three hops. If the slab is impenetrable, a patroller is alerted and marks the area with carpenter chalk. An explosive team will later place several 1 kg explosive rounds around the designated markings in order to break up areas which boot compaction could not affect. This technique is the precursor to SAE (Systematic Application of Explosives). At Aspen Highlands, SAE has become an alternative shear plane disruption method when boot packing is not feasible (Carvelli, 2008).

Once the packing phase is complete and all layers have been disrupted, continual follow up and addressing each additional storm layer is the protocol; methods include standard avalanche risk reduction routes, skier compaction, hasty and full data pits and random distribution of explosives over space and time. In addition, large explosive tests using at least 15 kg ANFO rounds are systematically conducted at intervals to ensure both thoroughness and redundancy. The goal is to never let a shear plane become contiguous or uninterrupted.

Skier compaction is a necessary tool and often a challenge before the operational season. Because AH does not open until mid December, the "Powder Posse" method is utilized when the public is not an available resource. The technique involves recruiting local skiers to assist with follow up compaction on new storm layers or wind slab that has buried boot packer tracks. At this time of year when open ski terrain is limited, it is not uncommon to have over 300 skiers participate. Although chaotic, there is a method to the madness. Patrol strategically directs, controls and monitors specific areas which require skier compaction.

Boot packers must be compensated for their time and hard work. All packer days are tracked, tallied and submitted to Aspen Skiing Company administration. Once information is processed and in the computer system, packers are eligible to redeem credits and obtain a ski pass product. In 2009, earned packer credit was \$88,700, with a total of 87 pro packers cashing in, the largest number yet. This dollar amount is a soft cost, it is debatable whether or not packers would have purchased a season pass at the non discounted, high season price. Without the packing program, it is likely that members of this specific group would seek other options such as working for the company, race crew or even foregoing lift served skiing. This segment of the skiing community is in search of discounts and alternative methods to purchasing

a non-restricted season pass at the ticket window.

### 3. DISCUSSION

Operating an extensive packing program has become complex due to the increase in packer numbers. In 2009, approximately 6,500 total man hours were required to pack the Highland Bowl and other slopes exceeding 30 degrees. This includes both paid staff and those working for passes. Certain factors may double packing time. Packing varies with snow conditions, current weather, terrain and pro packer fitness and experience. Under typical conditions, a 0.5 meter snow depth, soft slab and a 30 degree slope, it requires 7.0 man hours to boot pack 0.4 hectares. Travel time must also be accounted for in a work day and usually amounts to two or more hours.

In addition, materials, climbing gear and labor must be factored into the budget. Program expenses are depicted in tables 1-3:

**Table 1. Annual Costs**

Materials/ Labor	Quantity	Cost	Total
Explosives	500 kg	\$20/ round	\$10,000
Labor	2,400 hours	\$20/ hour	\$48,000
Duct tape	100 rolls	\$7/roll	\$700
Carpenter Chalk	20 liters	\$50	\$50
<b>Total</b>			<b>\$58,750</b>

**Table 2. Anchor System**

Materials	Quantity	Cost	Total
Wire Rope & Hardware	1,212 m	\$600/303m	\$2,400
Anchors	30	\$20	\$600
Labor	120 hrs	\$20/hr	\$2,400
<b>Total</b>			<b>\$5,400</b>

**Table 3. Initial Costs**

Climbing Gear	Quantity	Cost	Total
180 meter, 11.6 mm static rope	12	\$600	\$7,200
Harness/shunt set-ups	50	\$100	\$500
Additional Petzl Shunts (for patrol)	30	\$60	\$1,800
Runners	25	\$5	\$125
Carabiners	75	\$7	\$525
<b>Total</b>			<b>\$10,150</b>

Boot packing is a critical tool for both improved snow stability and ski quality throughout the operational season. It can be debated that the program has become too costly, time consuming and possibly decreases pass sales. At this time, eliminating the "Packing for Passes" program is not an option. Shear plane disruption through boot compaction has proven an effective risk reduction method at Aspen Highlands.

From 2007-2009, December storm cycles have seen some of the highest early season SWE totals in over 20 years with two storms exceeding 150 mm per storm. During the past three early seasons, there has been no significant avalanching (according to avalanche occurrence records) in boot packed terrain. In contrast, undisturbed, steep terrain below tree line in December 2009 was avalanching to the ground both during and following the storm cycle

(091214). Initially, packing was not feasible at lower elevations due to the shallow or nonexistent snow cover. Several of these ski runs were not opened until mid season and remained rocky and of poor skiing quality throughout the winter. To have this scenario in the Highland Bowl and other signature terrain would not be favorable for increasing revenue and skier numbers.

When digging pits throughout the season, packer tracks are easily recognizable with densities averaging 300 kg/m<sup>3</sup> or greater in the track. Since the program's inception in 1988, avalanche occurrence records (AH 2009) and personal observation indicate no avalanches initiating in or penetrating into dry boot packed layers (Carvelli, 2008). These statistics do not apply to wet snow. In boot packed terrain, there have been no avalanche incidents involving patrol or public. This statistic alone is invaluable as safety in avalanche prone terrain outweighs all other factors. Over the past decade, the Highland Bowl has been open 98% of ski area operational days. Bottom line, the company cannot afford to eliminate the Aspen Highland's boot packing program, avalanches are bad business.

According to marketing and upper management, the benefit outweighs the cost and alternatives. The Aspen Skiing Company has come to expect steep skiing at Aspen Highlands on opening day and for the holiday clientele. From a business standpoint, the Highland Bowl is considered an asset and worth the investment in a boot packing program. Because of the program, the Company has the ability to meet its open acreage goals of a 95% target yield. Powder day lines of hikers ascending the Highlands ridge are seen in magazines, brochures and on web sites. For the 2010 season, the Company has chosen this image for the season pass. The uphill culture that is unique locally is an important tool in the Company's advertising campaign.

The Company is also trying to capitalize on an extended season. Traditionally, the Highland's operational season ends in early April, however the Company's goal is to offer steep skiing into May. With Highland Bowl's north facing terrain above 3,300 meters, the Company now has the confidence to add more skier days to its calendar which will increase ticket revenue. Upper management views the Highland Bowl as a, "powerful symbol and the iconic foundation of a collective four mountain ski package" (Burkley, Rich, Aspen Skiing Company VP Mountain Operations), marketed both in the US and internationally. Some of these attributes represent qualities which are part of the Company's core values and cannot be plugged into a formula or given a numerical value.

#### 4. CONCLUSION

When performing avalanche risk reduction work, the number one priority is safety of ourselves, our team and our guests. The mission of the Aspen Highlands Snow Safety Department is to, "open avalanche terrain in a safe and timely fashion for the use of our skiing guests." (2009) Over the past two decades boot compaction has made these goals a reality. The "Packing for Passes" program has become early season protocol, setting the foundation for the entire operational season. In this industry nothing is certain, the possibility of deep slab instabilities must be kept in the thinking process at all times.

The boot compaction technique can be traced back half a century as cited in Monty Atwater and Ed La Chapelle's, *The Climax Avalanche*. "In anticipation of trouble from this weak snow layer, artificial compaction by ski and foot was undertaken in (Alta, Utah) Peruvian Bowl and on the Stonecrusher and Lone Pine slide paths." (1961)

At AH, a simple technique, commonly utilized at ski areas in the continental climate, has evolved to a higher level, been expanded and implemented in a systematic outside assistance program. Results of the program include personnel and guest safety, exhilarating skiing for recreationalists and the achievement of a positive cost benefit ratio for the Company. Minimizing uncertainty enables personnel to work confidently within the operational risk band nearing the upper limit when appropriate (McClung & Schaerer, 2006).

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