THE Avalanche REVIEW

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The Human Factor

During a year with a deep-slab problem, the human factor manifests itself as backcountry users struggle to maintain patience and low-angle forebearance in the face of strong desire coupled with lingering, high-consequence uncertainty.

This slab was triggered intentionally by a snowboarder January 24, 2010, while skinning up the ridge along West Monitor Bowl, off the Park City ridgeline in the Wasatch. The skin track often lies far enough out into the shoulder that it would have been taken out by this event: According to observers Wendy Wagner, Drew Hardesty, Leigh Jones, and Brett Kobernik, the avalanche was 4-5' deep and 1500' wide. It failed on facets near the ground on the last day of a multi-day storm that left a foot of snow overnight, along with 50" of new snow and 4-5" of SWE in the previous six days. The weather history chart from the UAC *(left)* clearly shows the maturation of the deep-slab problem: cold shallow snow at the ground grows an icing of near-surface facets, then a series of warm windy storms explodes the deep-slab problem.

Photo by Jake Hutchinson, patrol director at the Canyons, on an avalanche sightseeing mission after the storm cleared

The Psychology of Backcountry Safety

Story by Mike Richardson

Backcountry Safety Systems

Originally, this was supposed to be an article about human factors and trip planning. Yet over the past few months, as I've had discussions with people in the industry and pored over materials on psychology and risk management, it's become increasingly clear to me that there is no separation between psychology and any specific element of backcountry safety. In light of this basic fact, it seems entirely reasonable to conclude that backcountry safety systems must be centered around tools for managing the risks that arise from our psychology and its connection to our physiology.

The first thing I'm going to propose is a catchphrase to describes risk management concepts. In this article I'll use the term "complete backcountry safety system" to foster an integrative view of the system composed of trip planning, travel techniques, and avalanche rescue. A complete backcountry safety system uses multiple overlapping elements in order to implement risk management in a variety of different places, which is the same concept as not putting all your eggs in one basket.

Second, on the advice of a clinical psychologist, I'm going to propose replacing the term "human factors" with "psychology." Just as the high concepts of risk management are not easy for most people to learn and apply in the field, using jargon such as human factors only serves to increase the difficulty in accounting for how individual psychology flows into group psychology and influences decisions.

See story continued on page 14 ➡

The Avalanche Review
P.O. Box 2831
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in this issue

To keep my comfort level with my skill in check, I remind myself of the Dunning–Kruger effect, a cognitive bias that suggests that unskilled people lack the skills to evaluate their performance and therefore overestimate their ability. In essence, the greater you think you are, the more likely you are to be clueless.

—Ron Simonhois, *Tale of an Avalanche*, pg 24

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from the executive director

The AAA Membership Directory is available to Professional and Affiliate Members. Email aaa@avalanche.org to request the jpg version. A very limited number of hard copies are available on a first-come, first-served basis.

It's barely past the middle of winter as I write this. Avalanches and the forecasting of them are still prime concerns. The days are getting longer and the temps warmer, but it is still winter.

I've been writing about this for a while; the Association is finally ready to implement some administrative improvements in order to become more efficient and effective. As our membership continues to grow, the administrative responsibilities are becoming more daunting. Our goal is to meet these challenges without increasing the membership fees. We want to direct your dues to membership benefits (like keeping TAR the first-class publication it has become and to be able to continue to sponsor and co-sponsor continuing professional development programs) rather than to administration.

First, the Membership Directory will be produced in an electronic format this year and in the future. This saves AAA production and postage costs as well as valuable natural resources.

Next, we will be going to an online membership management system this spring. Mailings will become a thing of the past. AAA will communicate with you regarding membership renewal, meeting announcements, election of officers, and special events and offers electronically. You will be able to manage your personal information and renew more efficiently. Rest assured that we will not ever sell or share your personal information.

Finally, we will also use a social media marketing tool called Constant Contact in order to stay in touch on a regular basis with you via email. This is much easier than printing and mailing for routine communications.

In order for all this to work, we need you to keep your contact information with us up to date – particularly your email. You will be able to do this easily when you log into the AAA membership database – changes will be immediate.

I expect there may be some bumps in the road, but these improvements will bring the administration of AAA into the 21st century. Thanks in advance for your help in making this all work.

This is our last issue before the summer, and I wish you all an enjoyable summer whether on snow or not. The fall of 2011 will mark the 25th anniversary of the founding of the American Avalanche Association. We hope to host a special get-together to honor the occasion. *—Mark Mueller*

Late January 2011:

"After 48 snow-free hours during January in the Tetons, crystals were already organizing and growing on the surface in protected zones near the Idaho/ Wyoming border."

Photo by Eric Balog

from the editor

As this final issue of *The Avalanche Review* for winter 2010/11 has come together, I have been thinking about the underlying and recurring theme of ritual that runs through each case study presented here. Conversations with a wide variety of people, from intuitive to analytical, have helped me to clarify the theme, highlighting variations in the backcountry rituals we practice. The incidents that lead to our case studies, for the most part, come about because we have shortchanged our ritual. In some stories we have been impatient and hurried; in others we are complacent or goal driven. In all these stories, the writers are lucky and self-aware enough to see what they missed and even why they missed it – and brave enough to share those lessons with TAR in the storytelling tradition; thank you. As humans we will continue to make mistakes in the front and backcountry; perhaps due to your courage in sharing your stories we will have enough perspective and memory to avoid repeating your mistakes.

In addition to the case studies, articles from thinkers in our snow community demonstrate that there is no "silver bullet" that gives instant clarity to our filters, just a slow facility over time and practice to achieve competence with tools such as a sense of humor, a reminder of connection to family or community, an acknowledgement of the complexity of human psychology, or a bow to the intuition of expertise. All these can become part of our own personal backcountry ritual for decision-making; it is the job of the mentor and teacher to ensure that each novice initially learns to practice a rule-based ritual. I think that Doug and Jill struck gold early on with the simple elegance of the Avalanche Triangle. Other checklists abound, but Ian McCammon's ALPTRUTh has become a favorite backcountry tool whose clarity has shown to be useful as a double-check for experts as well. See Mark Mueller's story, "When you Assume," on page 15 for a great example.

The practitioner, however, as the practice evolves, must mature the ritual and make it personal, address the distinct traps to which each of us is particularly susceptible. For me, I need to answer these questions: "What is the nature of today's avalanche problem, and how shall I approach the mountains with this in mind?" Even as I gain more experience, the concept of beginner's mind – open, eager, and without preconceptions – helps me develop a subtle pattern recognition that hopefully leads to clean, appropriate decision-making and an objective rear-view mirror.

And I'm curious – what's your ritual?

In order to grant space to the wealth of human-factor perspectives, we were forced to bump several articles that discuss avalanche center survey results. Watch for those along with the NAC season summaries this fall in TAR 30-1; deadline for article submissions: August 1.

Thanks to several people for helping with this human-factor issue: Drew Hardesty and Blase Reardon applied their considerable wordcrafting skills to editing the editorial, Mike Richardson's perspective on psychology and the ongoing skirmish between desire and uncertainty provided a powerful seed of insight for TAR and for my inquiry deeper into the human factor, and Janet Kellam will always be a source of clarity into my editorial quandaries.

Here in the Tetons we have a snowpack four meters deep; I'll be on skis through June, and teaching snow skills well into July. I hope you too have good adventures into new terrain that keeps your eyes open and your skis fast.

—Lynne Wolfe

Eric White working at 10,400' on Mt Shasta, May 2010.

Nick Meyers and Eric White of the Mt Shasta Avalanche Center study the crown of a large natural avalanche on December 22, 2010. The crown was 1–1.5 m deep and 1 km wide.

metamorphism

Mt Shasta Update

The Forest Service Mt Shasta Avalanche Center has undergone some recent staff developments.

From Eric White:

"I have accepted a position with the National Weather Service in Hilo, Hawaii, and will begin in mid-February. After 10 years at the Mt Shasta Avalanche Center and 13 years with the Forest Service on Mt Shasta, I have chosen some new challenges. I will miss working outside on the snow and the excitement of forecasting, but most of I'll miss all the great people of the avalanche community! I plan to keep my ears open and possibly return to avalanche work with an even stronger weather background.

From Kai Allen:

Eric White's knowledge and experience here at Mt Shasta will be seriously missed and we hope to fill in behind him as soon as possible (That's government-speak for, "Yah, right, good luck with that."). Stepping up to bat is self-avowed throttle-junkie **Nick Meyers** who we hired into a permanent position here last August as a climbing ranger and avalanche forecaster. Nick has worked at Mt Shasta as a ranger for 11 years, and he has a wealth of experience on the mountain. Lastly, **Kai Allen**, former USFS snow ranger and wilderness manager at Crested Butte, Colorado, has traded in his skis for a desk by accepting the Recreation/Wilderness/Special Uses staff position on the district. If he's lucky, the crew at the avalanche center will let him go outside once in a while, or at least dig him out from beneath the avalanche of paperwork cascading across his desk.

CAIC Update

The CAIC is proud to belatedly announce that **Brian Lazar** became the deputy director for the winter of 2010/11.

Wendy Wagner explores the cuisine in Talkeetna, Alaska.
Photo by Ashley Wagner

Chugach Update

We hired **Wendy Wagner** of Salt Lake City as our newest avalanche forecaster. Wendy comes to us from the Utah Avalanche Center, where she worked as an observer, instructor, and apprentice forecaster under Bruce Tremper and the rest of the UAC staff. She has also worked with the Utah DOT snow safety program, US Army Cold Regions Research and Environmental Laboratory, and the Utah Ski Weather Program. She has a masters in atmospheric sciences (with an emphasis on mountain weather and snow science) and has presented papers at ISSW and the Mountain Meteorological Conference. She was also the head Nordic ski coach at the University of Utah, a US Ski Team Nordic athlete from 1996-2006, and a two-time Nordic Olympian in 2002 and 2006. She has extensive backcountry skiing experience in Europe, Alaska, Utah, Montana, and Idaho.

Lisa Portune is busy trying to figure out the snowpack in Sandpoint, Idaho. We look for her future involvement in the Panhandle Forest Service Avalanche Center.

NWAC UPDATE: ¡La Niña, Hooray!

Story by John Stimberis

"How much snow would that be?" the plow driver asked, ducking in from the rain. The "how much" question is in response to yet another rainy day on Snoqualmie Pass. Do the readers from CO, UT, and MT ever ask that question? Probably not, but it is a question that is commonly heard here in the Pacific NorthWet. Yes, we officially dropped the "s" in "west," in case you didn't get the memo. "How much snow would that be?" is related to our penchant for rain and the ongoing saga of a yo-yoing snow level.

"What if it was all snow?" I used to ask that question when the storm ended and felt the mixture of frustration and dismay that comes when the storm, yet again, goes upside down. Not the low-density to higher-density snow that you're thinking about; I'm talking Costco style snow to rain – big and plenty. I don't feel that pain as much; I guess I've finally accepted the fact that it is what it is and there's nothing you can do about it. And yet, January 2011 delivered over 24" (610 mm) of precipitation, with 20" (500 mm) in the form of rain. If that 20" fell as snow at an average of 10% it would be 200" (500 cm), at 8% we would have received 250" (635 cm), at 6% we would have… See, it is pointless, especially when you consider our dismal 121 cm of snowfall. Don't even get started on the 75" of precipitation we have received since October 1. I started putting some figures together about snow, rain, etc., but have decided to wait it out. I'm not giving up on La Niña, but I am beginning to think we should put out an Amber Alert to find her.

Here are a few happenings from around my neighborhood:

Alpental hosted VertFest over the weekend of February 12-13. The event, sponsored by Outdoor Research and The Summit at Snoqualmie, is a fundraiser for the Northwest Weather and Avalanche Center (NWAC). VertFest was originally built around the Randonee Rally and included some gear demos. Last year saw a record 104 participants in the race. VertFest continues to grow, this year becoming a two-day event with a variety of backcountry-oriented clinics on Saturday and the randonee race on Sunday. A record 122 entered the randonee race and over $8,000 was raised for the NWAC. The weather was great, a few inches of new snow greeted the racers, and much gear was ready for the raffle at the after party. Unfortunately, the race was overshadowed by the loss of local backcountry skier Monika Johnson. Monika was well known throughout the Northwest backcountry crowd and she flat-out owned the women's portion of the randonee race. Monika was killed in a cornice fall avalanche on February 1. Her loss rippled through the community, and the response was amazing. Monika truly touched and inspired many people's lives. Take a look at the forum on Turns-All-Year.com.

The response at VertFest was overwhelming. Outdoor Research announced that the race will be renamed the Monika Johnson Memorial Randonee Rally at VertFest. Gregg Cronn organized a wonderful slide show of Monika that was played at the awards ceremony,

This photo from Kevin Grove shows Monika Johnson on an early morning recon from the Kokanee Glacier Lodge in British Columbia.

leaving few dry eyes in the room. Gregg also spoke of the effort to retrieve Monika's belongings from the top of Red Mountain (where she fell through the cornice) and the subsequent ski down with her gear. I'm sure the experience was steeped in heavy emotion, but I really enjoyed the quote he shared from Dan Helmstadtar: "Even with goggles full of tears, skiing is still f%*#ing fun!"

That really sums it up for me, about why we venture into the mountains and do what we do: because it's fun. Many people shared that fun with Monika, and her spirit will live on for many mountain adventures to come.

There have been quite a few avalanche courses happening in the Northwest. I'll highlight The David Pettigrew Memorial Foundation because the classes are free! (Full disclosure: I'm an instructor.) The Pettigrew Foundation offers courses in Mountain Safety Awareness, Avalanche Awareness, and Companion Rescue Workshops. A total of 19 classes were offered this winter at Alpental, Mission Ridge, and Stevens Pass. Kudos to all of the instructors for their time and energy in making these classes successful.

We have some great avalanche-related events coming up. The Northwest Forecaster's Meeting is scheduled for mid-March on Mt Hood. The meeting gathers many of the people involved with snow safety and avalanche control from ski areas, highways, NWAC, and a backcountry guiding operation. The group also includes members of The United States Avalanche Control Council (formerly Washington Avalanche Control Council). Issues related to avalanche control, snow safety, explosives, and explosive use are discussed.

Alpental BARK (Backcountry Avalanche Rescue K-9s) is hosting their annual fundraiser at Alpental on March 5. Alpental BARK was involved with the rescue/recovery efforts at the Red Mountain avalanche accident mentioned above.

Another great fundraiser for the NWAC is coming up on April 15: Snowball. A semi-formal, sit-down affair with a live auction, this event is a real good time. In addition to raising money for the avalanche center, it is a great opportunity to dust off the fine clothing. I'm thinking about busting out the tux this year.

What else am I missing? Lots I bet, but I let a deadline get past me and can't keep Lynne waiting any longer. Let me know what else happened around the Northwest; I'm excited to hear about the various classes, fundraisers, and avalanche-related events.

John Stimberis is vice-president of the AAA and seems to have a hand in every pie in the Pacific Northwest. He sent the tribute to Monika Johnson (at the top of the next page) written by her close friend Oyvind Henningsen, who played a key role in the recovery efforts.

IN MEMORIAM: Monika Johnson

Story by Oyvind Henningsen

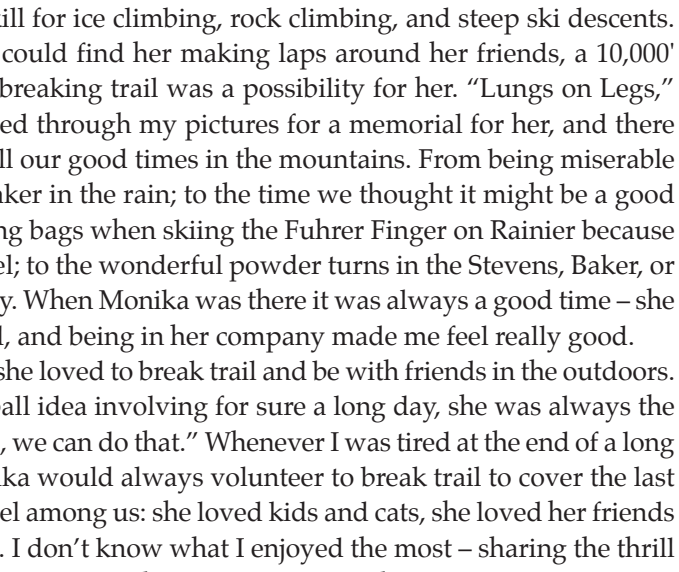
Monika was my closest and dearest female friend. She was such an incredibly strong, kind, naïve, supportive, and beautiful woman.

Monika was an experienced and well-rounded ski mountaineer and climber. She had the strength and skill for ice climbing, rock climbing, and steep ski descents. In the winter time you could find her making laps around her friends, a 10,000' day in new snow with breaking trail was a possibility for her. "Lungs on Legs," I called her. I have looked through my pictures for a memorial for her, and there are just so many from all our good times in the mountains. From being miserable on the north ridge of Baker in the rain; to the time we thought it might be a good idea to not bring sleeping bags when skiing the Fuhrer Finger on Rainier because of the high freezing level; to the wonderful powder turns in the Stevens, Baker, or Snoqualmie backcountry. When Monika was there it was always a good time – she was so fun to be around, and being in her company made me feel really good.

She loved to ski, and she loved to break trail and be with friends in the outdoors. Whenever I had a hairball idea involving for sure a long day, she was always the one to say, "No problem, we can do that." Whenever I was tired at the end of a long day in the saddle, Monika would always volunteer to break trail to cover the last vertical. She was an angel among us: she loved kids and cats, she loved her friends and being out in nature. I don't know what I enjoyed the most – sharing the thrill of skiing the Curtis Glacier on Mt Shuksan or cruising the Inspiration Glacier on Eldorado on a warm spring day after skiing Klawatti, Austera, and Eldorado in a day and getting back to the car before dinner. Being in the mountains felt effortless when she was around.

Countless hiking trips with cool scrambles in the North Cascades and beautiful trips through the Enchantments. If the guide books said two to three days was needed, we would cram it into a day. She was always willing and able to suck it up and squeeze in a couple of more thousand feet. With a smile, that is.

We have shared many trips together and she certainly had many partners that can attest to her skills and stamina on countless trips. Here are a few memorable ones for me:



Monika charges toward the north face of Mt Shuksan.

- Klawatti, Austera, Eldorado in a day
- Mt Logan from Easy Pass
- Mt Baker trifecta in a day – Colfax, Grant, Sherman Peaks
- Fuhrer Finger on Rainier
- Kautz Glacier on Rainier
- Chiwawa and Fortress
- St Helens for Mothers Day
- Shasta and Shastina in a day
- Curtis Glacier on Shuksan with the Hourglass for a bonus climb
- Colchuck and Dragontail ski in a day
- Mount Hood Sunshine Route
- Mt Hood Cooper Spur
- Mt Stuart ski

Our Dear Friend Monika

Story and Photos of Monika by Kevin Grove

My wife, Molly, and I first met Monika Johnson at the Alpental rando race a few years back and became fast friends. We connected after the race and I was surprised to learn how much Monika and Molly already knew about each other. They had been chatting during the race! Molly loves to chat and had become friends with Monika during the race. We skied afterward and made plans for future adventures.

Over the years we came to know Monika as a wonderful, caring, and kind person. Monika had legs of steel, a heart of gold, and a winning smile a mile wide. As I look back at all of my photos from the past few years, one thing clearly stands out. Monika always had a huge smile on her face. She loved being in the mountains and loved spending time in the snow with friends. Monika was always psyched. Early in the morning, late in the evening, after many miles on the trail – Monika was always psyched! I loved that about her. She was always positive and a pure joy to be around. Her infectious enthusiasm rubbed off on all skiing partners and friends around her. Though she was as strong as any of the guys she skied with, she loved to ski with guys and gals. She'd ask Molly for tips on being a princess. Molly tried to coach her on little things like letting the guys skin her skis, not breaking trail, etc., but princess just isn't a word to describe Monika. Queen is more fitting.

I have many wonderful memories of Monika charging hard, hanging back to chat with friends, breaking trail, following closely behind. Long days out in wild, amazing places were always more special because she was around. She was always fun to be with. The rivers of tears that have been shed are a testament to how much she meant to us.

We will miss you Monika – we'll miss your huge smile, your psyche, your trail breaking, and many more wonderful attributes you shared with us over the years. We have learned so much from you and will remember you always. The skin track and hut conversations won't be the same.

A-Basin Patroller Leif Borgeson Dies in Aspen

This article first appeared in the *Summit Daily News*, February 8, 2011.

Arapahoe Basin's snow safety director Leif Borgeson died Tuesday while hiking the ridge at the Aspen Highlands Bowl. According to a press release from A-Basin, Borgeson collapsed after the hike and was immediately attended to by Aspen Highlands patrol but was unable to be resuscitated.

Borgeson, 50, of Dillon, worked at A-Basin starting in 1990, joining the ski patrol after patrolling at Keystone for several years. He worked in various capacities including medical coordinator, paramedic, snow safety supervisor, and most recently as snow safety director. He has been instrumental in creating A-Basin's avalanche procedures and protocols and recognized nationally for his work on the study of avalanches – in particular wet slab avalanches. He was a long-time professional member of the American Avalanche Association.

Between 2001-2004, Borgeson worked for the National Ski Patrol as its training director. Before joining Keystone in the 1980s, Borgeson worked as a patroller in Arizona Snow Bowl and as a hot-shot forest firefighter in Flagstaff, Arizona. In addition, he served as a paramedic for Summit County Ambulance Service in the early 1990s.

Borgeson is survived by his wife, Denise Schmidt-Borgeson, his two sons Ian and Aidan Borgeson, his parents, and his brother.

corrections

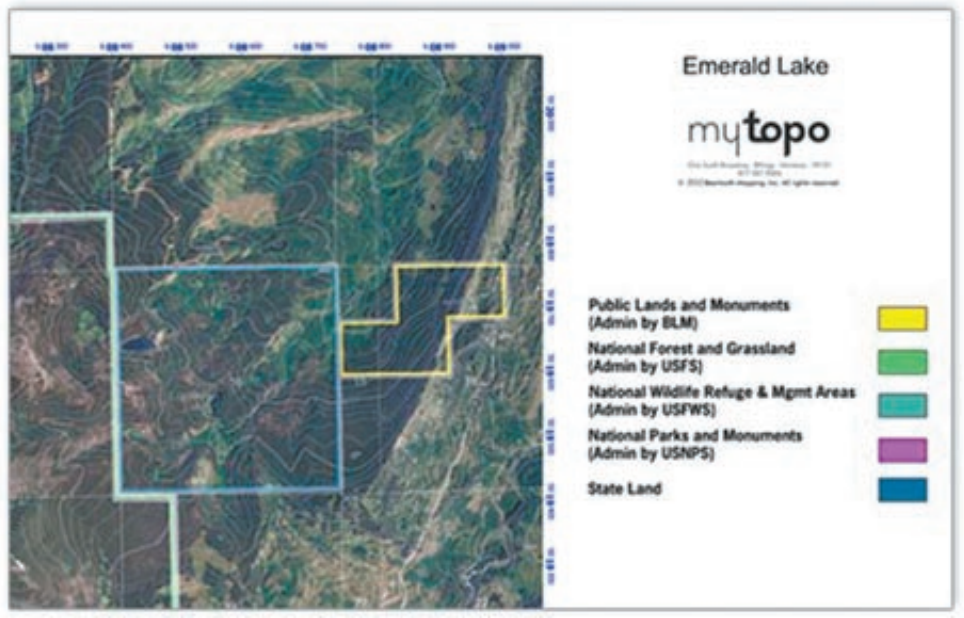
From Kevin Grove:

In my bio – just in case you are ever in our neighborhood – we live in Bend, Oregon, not Portland.

From Ron Simenhois:

In his article on ISSW, Richmond mentioned the paper, *The effect of changing slope angle on extended column test results: Can we dig pits in safer locations?* It was not clear that Karl Birkeland is the lead author of this paper (he also collected the data and was the driving force beyond this work). The wording in the article may lead some folks to mistakenly think that I am the lead author, while in fact I am just a lucky co-author.

what's new



MyTopo Adds Public Lands Boundary Layer To Its Mapping Products

Federal and State Public Lands Overlay Available for Download to GPS and Overlay on Printed Maps

MyTopo customers now have the option to overlay public land boundaries for the Western US on the company's popular service that allows customers to order topographic, aerial, or hybrid large-format maps that are printed and shipped within 24 hours. There is no additional charge for the public lands overlay. MyTopo Map Pass subscribers also now receive access to the public lands data layer as part of their $29.95 annual subscription fee. This service allows users to download maps to many Garmin GPS models.

The public lands data layer is available to overlay on all MyTopo base maps, including its fully-detailed USGS topographic maps, 1-meter aerial imagery maps and MyTopo's unique TopoPhoto maps (an aerial map with a topo overlay). The new public lands layer shades Bureau of Land Management (BLM)- managed lands in yellow, State-owned lands in blue, and other public land boundaries in the traditional colors founds on BLM topographic maps.

Subscribers to the MyTopo Map Pass who own the Garmin Colorado, Dakota, Oregon, or GPSMAP 62 units can download topos, aerials, or hybrid TopoPhoto maps – with the public lands overlay – into their devices as part of their $29.95 annual subscription. For more information, visit www.mytopo.com, www.facebook.com/mytopo, or call 877-587-9004.

Explosives Update

Story by Bill Williamson

In January, the National Ski Area Association's (NSAA) Explosive Committee met at Snowbird, Utah, and was updated on new issues, concerns, and progress in the ski areas' explosives community.

In 2003, a group of patrol directors and mountain managers, members of the National Ski Area Association Explosives User Committee, formed an ad hoc committee in order to fulfill an agreement with the International Manufacturers of Explosives (IME) and International Society of Explosives Engineers (ISEE) to address in-depth explosives training for ski area workers who perform avalanche control work. With help from the American Avalanche Association (AAA), the NSAA purchased the Canadian Avalanche Association's *Avalanche Control Blasting Manual* so that it could be adjusted to give proper guidance in the United States. The document was reviewed and through a somewhat agonizing process, was translated from Canadian to American.

The *Avalanche Blasting Resource Guide* was initially made available to US ski areas at the cost of $450. Several areas purchased the manual and were able to integrate it into their training programs. With the leadership of Geraldine Link of the NSAA and help from others, the resource guide was recently reviewed, updated, and made more accessible with a lower cost of $45.

The guide addresses new requirements for handling and storage of explosives under the federal Safe Explosives Act. It also covers explosives storage, explosives components, site control, communications, transport, hand charging, assembly, no-light procedures, cornice blasting, and more. The guide includes a step-by-step curriculum, with accompanying PowerPoint slides, to enable resorts to train relevant personnel on this important topic. Every resort that stores or uses explosives should purchase this state-of-the-art guide. The 100-page guide is available for NSAA and AAA members only. Please pass on the fact that this guide is available and, along with the NSAA Explosives Guidelines, will benefit all ski areas large and small. To purchase a copy contact NSAA at www.nsaa.org.

The "Billy, Larry, Woody, Corky, Dougy, Piney Show" at Jackson in 2003 putting together the original *Avalanche Blasting Resource Guide*. *Photo courtesy Doug Richmond*

In the last five years or so there has been a shift of some explosives manufacturers' opinions of the avalanche control world, and we have some support from major companies. But some members of the ISEE and IME still criticize our techniques, and any major accidents in the future may threaten our ability to use explosives in the ways we have historically practiced. Both the NSAA and AAA feel that proper training is the best way to avoid any future incidents and encourage all areas to use this guide as a tool to provide knowledgeable, safe, compliant practices in our industry.

At the meeting other topics included product issues (nothing major to report) and progress with our goal of building a better relationship with the Bureau of Alcohol, Tobacco & Firearms (BATF). The NSAA Explosives Committee is working with BATF on a national level to ensure consistency on regulations throughout our industry. There was also discussion on building a closer relationship with some IME members and having them advocate better acceptance of our practices. The meeting will reconvene in a year.

Bill Williamson (shown in the photo, at left) is the Ski Area Representative to the AAA board.

Avalanches and Related Subjects International Conference

The fourth annual Avalanches and Related Subjects International Conference will be held September 5-9, 2011, in Kirovsk, Murmansk region, Russia.

Topics will include: Snow Cover Stability, Avalanche Dynamics, Temporal and Spatial Avalanche Forecasting, Geography of Avalanches, History of Studies and Struggle Against Avalanches, Avalanche-Control Techniques, Avalanche Protection, Avalanche Awareness Education and Public Warning Systems, Avalanche Search and Rescue, Slushflows, Properties of Snow and Snow Cover Evolution, Snow Drift, Instrumentation, and Avalanche Safety During the Winter Olympic Games in Sochi 2014.

The conference will be held in Kirovsk, Russia, which is located in the Khibini Mountains in the middle of the Kola Peninsula. Registration is $200 for participants and $120 for accompanying persons. Commercial exhibit space is available for $350. For more information, go to http://cas.apatit.com

ISSW Steering Committee Looks to Future, Proceedings Available Online

Story by Rich Marriott

Although the ISSW Steering Committee (ISSWSC) has maintained a low profile over the past 28 years, it has helped to maintain the structure and philosophy of the workshops and provided continuity between meetings. The steering committee consists mostly of former chairs of ISSWs and several additional members to widen the regional balance.

In the past the committee only met every two years at ISSW, primarily to select the next location, but the growing size and importance of the workshops has increased the lead times for the meetings. Additionally, a growing demand for access to the workshop information has made it necessary to find a permanent Internet home for "all things ISSW."

As a result the ISSWSC had meetings over two days at ISSW 2010 to consider future plans. The committee made a decision to begin awarding future ISSWs at least four years in advance to give the local organizing committees sufficient time to reserve facilities and to prepare for meetings now approaching 1000 attendees (ISSW 2010 had over 920 registrants).

Future Workshops

ISSW 2012 was already awarded to Anchorage and is scheduled for September 16-21, 2012. Chairs Carl Skustad and Dave Hamre has the event Web site up at www.issw2012.com.

2014 is a Canadian year, and ISSW 2014 was awarded to Banff, Alberta, returning it there for the first time since 1996 (The original workshop in today's format also occurred there in 1976). Committee chairs will be Grant Statham and Rowan Harper with help from Chris Stetham and Bruce Jamieson – both former ISSW chairs. The exact dates are still to be decided.

Looking farther into future, ISSW 2016 was also considered and will probably be held in Colorado. A presentation was given for a return to Breckenridge (ISSW 1992), but a final decision has not been made yet.

The committee spent a long time debating the future of European ISSWs. After the great success of ISSW 2009 in Davos, many committee members were in favor of putting Europe into the regular ISSW rotation (two in the USA, one in Canada) but there were many questions about its effect on North American ISSWs and how to integrate the change into the rotation over the next six years. As a result the committee decided to postpone a permanent decision but in the interim to hold another off year ISSW in France in 2013. Several groups in France have already indicated an interest in hosting ISSW 2013, and these are being followed up on. The most likely locations at this time are Grenoble or Chamonix.

ISSW Proceedings Online

Beyond future ISSWs, the ISSWSC has been working on creating a permanent Internet presence for ISSW to maintain its history and to give access to information from previous ISSWs. A historical site has been online at www.issw.info for several years now with links to the proceedings of several recent ISSWs.

Thanks to the initiative of Professor Stephen Custer at Montana State University, the committee has embarked on a project with MSU's digital library to establish an online searchable database of all past ISSWs dating back to 1976. Preliminary design has already been done on the database, and it's hoped the dataset will be available by the end of this year. ISSWSC is submitting proposals this spring to AAA and to CAA to fund the cost of developing the database and scanning in the earlier proceedings. ISSWSC is interested in hearing from any other groups that would be interested in helping to fund the project (contact Rich Marriott, secretary, at isswsteering@yahoo.com).

A New Web Address

Finally, to make ISSW easier to access overall, the Web site will be moving to a new address in the next few months. Due to the generosity of Dan Judd, the site will soon be found at www.issw.net. Beyond containing all of the historical information about ISSW, it's envisioned that this will be the address for all future ISSW Web sites and information.

Conclusion

After 34 years of workshops, ISSW has grown into a major international forum for workers in the snow and avalanche field to meet and exchange information and experiences. It is the goal of the ISSWSC to document and make easily available the knowledge of earlier ISSWs to a broad audience, and to ensure that the workshops continue in the future maintaining the founding philosophy "the merging of theory and practice."

Rich Marriott, Seattle meteorologist extraordinaire and ISSW steering committee member, is dutiful about keeping us updated on ISSW news and La Niña.

Munitions in the Backcountry

Story by David George

In January, mountain guide Jean-Louis Lechène set out on a ski tour from the Pyrenean resort of Cauterets, climbing the west ridge of the Monné on crampons. During the climb he noticed the fins of an avalanche grenade sticking out of the snow. He decided to pass well below the charge, but as he drew level the detonator exploded, firing shrapnel into his face and hands. Fortunately he was able to contact the Cauterets piste patrol on his radio and was evacuated by helicopter to Toulouse where he has made a full recovery.

This is the fourth accident of its type in France, one of them fatal. It has raised public safety concerns about avalanche control work. Even if the failure rate for this kind of device is around 1 in 500, that is one failure every three to five years for the average ski resort.

According to the head of the Cauterets piste services all the charges fired in 2009 and 2010 exploded correctly. The grenade that injured Mr Lechène was fired during 2008. A second charge was fired 10 minutes later at the same spot, but this obviously was not effective in clearing the rogue device. The liquid explosive used in the charges becomes inactive within 24 hours – it is only the detonator, filled with 1 gram of Pentrite, that is dangerous. Avalanche grenades are often equipped with Recco reflectors by patrollers (some charges have them built in), but these can be lost in flight, finding charges in winter is difficult, and the area where charges fall is often difficult to access. A headache for the piste patrol.

Better communication may be one result of the police investigation of the Cauteret's incident. Signs on access trails could inform backcountry travelers of the potential danger. In any event, people should never approach any suspicious looking objects but rather inform the authorities with a clear location or GPS reference. Built-in powered RFID transmitters may also be more effective than Recco reflectors without a significant increase in costs.

David George runs the ski touring Web site www.pistehors.com. He is a dependable European correspondent for The Avalanche Review.

SWE Sensor Improves on Traditional Snow Pillows

Campbell Scientific, with over 35 years of world-class measurement experience, is pleased to announce the new GMON3 Snow Water Equivalency (SWE) sensor, produced by Campbell Scientific Canada and developed in collaboration with Hydro Québec. The innovative design of the GMON3 makes it an excellent sensor for non-contact SWE measurement applications.

The GMON3 obtains a measurement by monitoring gamma rays that are naturally emitted from the ground. As snow accumulates on top of the ground, the GMON3 measures an attenuation of the normal background radiation levels. The higher the water content, the higher the attenuation of the gamma radiation.

The new sensor measures with an accuracy of ±15 mm from 0-300 mm and ±15% from 300-600 mm, operating within temperatures from -40°C to +40°C. The GMON3 can output an RS-232 (1200 to 115200 BAUD) signal interface to Campbell Scientific dataloggers or other recording devices. It is effective with any type of snow or ice. Data can be transmitted in near real-time with the addition of a wireless communication option.

For more information about the GMON3 visit www.campbellsci.com/gmon3.

Campbell Scientific has designed and manufactured measurement and control instrumentation and related communications peripherals for over 35 years, specializing in versatile, programmable, stand-alone systems.

snow science

Is Your Beacon Ready to Retire?

Story by Jeff Lane

Do you know how old your beacon is? Do you know when you're finally going to put it out to pasture and buy yourself a new beacon? Have you even considered just how old your beacon needs to be before you really ought to retire it?

I hadn't considered that last question until this winter, when a search and rescue team we work with offered to give away their beacons to another team that had a higher likelihood of heading out for a rescue in avalanche terrain. These particular beacons had been sitting at home, unused for years except for sporadic practice sessions. They seem to be in perfect working order, but are they too old to give away?

I had assumed there was a standard that I just wasn't aware of, so I began asking around. I asked a variety of people: guides, avalanche forecasters, manufacturers, and professional rescuers. Quickly I learned that there was no industry standard, though as it turned out, plenty of common ground is shared on the topic among those I spoke to. Most people thought the question was one worth finding a good answer to and were interested in knowing the results.

One of the most common themes that came up again and again was that regular practice is the most important thing one can do. Stories abound about the crusty old veterans using ancient beacons who, in scenarios and contests, routinely put on a clinic for their younger colleagues. There's no secret to what they're doing; it comes down to familiarity with their equipment and solid fundamental search skills.

In addition to practicing, another common theme is the importance of taking care of your beacon. This includes good habits such as removing the batteries for long-term storage, protecting it when burying it for practice, and regularly inspecting your beacon thoroughly. As much as these themes came up often, the issue of beacon age and lifespan remained as elusive as an above-the-ankle powder day in New Hampshire.

If age were the only factor when considering when to retire a beacon, the question would have been answered long ago. As it is, complicating factors make every situation slightly different, and I believe this is part of the reason why no consensus exists within the avalanche industry. Beacons aren't used in a vacuum, so how the beacon is used and cared for plays an important role, as is the case with any electronic equipment regularly subjected to a harsh environment. Some beacons are used daily by professionals, while others are used only for a couple days each season. Others are used by an assortment of people throughout the season, making it impossible to truly know their history. They get strapped to sweaty bodies, left in cold backpacks, dried out indoors, and probed during practice sessions. Most people I spoke with agreed that how a beacon is used and cared for should have a significant impact on its service life.

In addition to the environmental and usage factors, technological advances are another prime motivator for people to purchase a new beacon. However, this still skirts the issue of what to do with the old beacon. Does it get fully retired, does it become a designated practice target, or do you sell it on eBay to an unsuspecting and self-righteous free-heeler?

Outside of all these factors that can drive a beacon into retirement, the next biggest problem is aging electronic components. Just how long one should put trust in old electronics is subject to debate. The quality of components used in electronic equipment definitely plays a strong role in their longevity. The companies that produce the components do guarantee their products to stay within specifications for a long time. One beacon manufacturer told me their suppliers guarantee components for 15-20 years, which is much longer than I would have guessed. But the components themselves are only a part of the larger picture.

Each manufacturer I spoke with had a different perspective on beacon lifespan. Since I was also interested in developing talking points for our avalanche center to use with visitors to our forecast area, this discrepancy complicated the task. Generally speaking, following the manufacturer's recommendations is a good idea. Unfortunately, the vast majority of people using avalanche terrain in New Hampshire's Presidential Range do not carry any avalanche safety gear. I would rather see a person using an older but well-cared-for beacon than using nothing at all, and I personally know a few of those crusty veterans with ancient beacons mentioned earlier. With that in mind, we want to offer people reliable information to help them make their own informed decisions. Ironically, this is similar to our philosophy of managing avalanche terrain – we provide information and analysis, but you make your own decisions.

Two of the four manufacturers I spoke with, Mammut and BCA, do not have a set age after which one should retire a beacon. Mammut recommends electronic diagnostic checks every three years for the Pulse and every two years for the Opto 3000. In addition, they recommend regular inspections and practice sessions specifically looking for any errant behaviors. BCA also recommended thorough inspections and scenarios, but did not specifically recommend sending a beacon in to them for a checkup. They feel that a comprehensive inspection is something that a beacon owner can do, and in doing so, he or she would be gaining a better working knowledge of the beacon as well as logging valuable practice time.

Ortovox had the strongest stance toward retirement. They warranty their products for five years (similar to others) and believe that after this time the beacon should be retired. (Find the date code for this warranty period inside the battery compartment.) Their position comes from the idea that aging electronics may not be detectable in a hands-on inspection or through an electronic diagnostic check. Since a beacon is a life-saving device requiring 100% reliability, the best way to ensure this is through replacement of the unit before it's too late.

Pieps stood on middle ground, stating that "no beacon should be older than 10 years," especially given the conditions under which beacons are used. Similar to the others, they say beacons should be thoroughly checked at the start of each season. They offer to do diagnostic checks, but with the caveat that diagnostics cannot extend the lifespan of the unit and can instead only prevent the use of a faulty beacon.

Regardless of which beacon you use, you should follow the manufacturer's guidance. After all, nobody knows their products better than they do, and nobody shoulders the weight of potential liability as much as they do, either. On top of the manufacturer's recommendations, one other common theme that came up multiple times was, "If in doubt, retire it." This seems like good advice to me.

If you're the type of person who never does any practice or never gives your beacon a thorough inspection, you might never have any doubts about its performance, and therefore you'll never see the need to retire it. If this describes you or your partner, read the next section carefully and follow these instructions on how to do a comprehensive examination of your beacon. Remember, you may not care whether your beacon is working properly or not, but I'd put good money down that your partners care quite a bit. When it's time to do the comprehensive exam, here's what you do:

1. Perform a check of initial signal acquisition range. This varies enormously among different models, so compare your results to an identical model. Start with your beacon in send mode well outside of its receive range. Then switch the beacon to search and walk at a moderate pace toward the target beacon. Note the distance, turn the beacon back to transmit, and repeat the test a couple times. How you position the two beacons relative to each other (the coupling position) will affect the distance, so be consistent when comparing different units.
2. Perform a check of transmission range. This range is very similar among different models, so just about any other beacon can work as a comparison unit provided you can orient the transmitting antennae identically. The simplest way to do this is to use an identical model as the comparison. Orient carefully when using beacons that have angled antennae or have the ability to switch to a different transmitting antenna. To do this check, simply repeat the prior test, but this time swap the transmit units, not the search units.
3. Inspect the beacon's casing and harness system for any physical damage such as cracks or loose switches.
4. Inspect the battery compartment for signs of corrosion or looseness, and for Pete's sake, take the batteries out if you're not using the beacon for any length of time. This will prevent battery leakage inside the compartment.
5. Inspect all the display components, including making sure the direction arrows function properly when in search mode.
6. Ensure the functionality of all buttons and switches. Do they do what they're supposed to do? Does the auto-revert function actually revert to send after the correct amount of time?
7. If you have access to another beacon with the capability, check for frequency drift. This is particularly important with older analog beacons, such as the F1 Focus, which may drift outside of the international standard for avalanche beacons: 457kHz ±80Hz. Unfortunately, you can't test for frequency drift with the range tests previously described, since different beacons have widely varying abilities to pick up a drifted transmission.
8. Run through a couple practice searches, looking for errant behaviors. Try it with single burials and with multiple burials; this is particularly important with modern beacons running fully digital software. Make sure the technology does what it is supposed to do. As an added benefit, you'll get some quality practice time.
9. If you are an avalanche professional responsible for a fleet of beacons, document your inspection findings. Should your organization be unfortunate enough to have an accident, you'll truly impress the OSHA inspectors when you pull out a file documenting years of regularly performed inspections.

If any of the points above lead you to question the functionality of your beacon, you've got a few options. You could play it conservatively and use the "when in doubt, retire it" piece of advice, relegating it to a practice target (if its transmission is still okay). After going through all that work, don't you deserve to treat yourself to a shiny new beacon? You could also send it in to the manufacturer for a checkup. This might make you feel better, but isn't this line of reasoning the same as someone who hopes their compression test results are good enough to make them ignore that large natural avalanche that just took place on another slope? If you've already got evidence that the beacon may have a problem, you don't need a second opinion to tell you to retire it.

The ideas presented here represent a lot of people's opinions and personal statements, all of which have been filtered through my interpretation and writing ability. There is a lot of subjectivity, not the least of which is related to how the beacon gets used during its lifespan. Always consider a beacon's history, and when in doubt, retire it.

Jeff Lane works as a snow ranger for the Mount Washington Avalanche Center. He is both a snowboarder and a humble telemarker, and he enjoys a good debate over which is more fun.

AVALANCHE MITIGATION *in the* CONTINENTAL CLIMATE

Guide to an effective boot-packing program

Story by Karen Sahn

Ski areas 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.

Thoroughly boot-packed terrain is achieved with Aspen Highlands' innovative "Packing for Passes" program. *Photo by Karen Sahn*

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, Aspen Highlands ski area – located in central Colorado at latitude ~39.9° N, longitude ~106.5° W, and ranging in elevation from 2440 m to 3775 m HASL – has successfully developed a preseason program to stabilize the snowpack. This boot-compaction program improves both snow stability and skiing quality. A successful packing operation requires extensive man hours and depends on outside assistance along with ski patrol personnel. This article outlines the benefits of a "Packing for Passes" program, with guidelines on organization, packer safety, logistics, and cost.

Initially, boot packing was implemented as a method to add strength to basal storm layers. The program's current main objective has become 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 southeast. 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 through 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.

At Aspen Highlands, a successful packing operation is dependent on outside resources or additional man power, requiring approximately 8900 man hours per season. The packing crew includes both paid patrol and workers who pack for passes. The process begins well before the first snowfall as prospective packers inundate the snow-safety office with calls and emails. Due to the program's increasing popularity, a Web site was established at bootpacker.com, allowing more efficiency with the sign-up process and reducing office time. Those interested can look up program requirements, scheduling, and sign-up procedures, as well as view photos of boot packing. For the 2009/10 ski season we had over 150 inquiries due to the financial challenge of purchasing a season pass during a poor job market. For exercise fanatics with flexible schedules, this is an ideal way to simultaneously earn a pass and condition for skiing.

Boot-Packing Program Initiation

By the third week of October, we have enough prospective packers to hold organizational meetings. Packers are briefed on gear requirements and compensation. All packers must have an avalanche transceiver and lug-soled boots. Participants sign a waiver and contract stating they are not covered by workman's compensation and that they understand the program rules and guidelines. Packers must work an eight-hour day in exchange for a $100 credit toward a ski pass. After five days they have the option to cash in their credit for any pass product, either paying the difference or working another 15 days for the full season pass. In 2009, 80% of the packers did not pack the full 15 days and opted for a pass product of lesser value due to the time commitment, scheduling issues, or physical demands.

Prior to bringing in packers, snow-safety personnel go into the field to assess 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 that must be addressed while deciding when to bring in packers. Timing is critical in terms of efficiently utilizing 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.

Safety Protocol and Packing Methods

Packer safety is critical – avalanche-control routes, stability tests, and slope evaluation must be conducted prior to exposing workers to an unconsolidated snow pack. Preseason, 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 toward the lower limit of the operational risk band. The number of packers exposed is kept small, and 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 *(Figures 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 staying one step ahead are key ways to prevent 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 1:5.

The technique developed over time is to form a 1 m x 1 m grid by walking vertically, downhill *(Figure 5)*. 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 considered sufficient. All paths are meticulously packed, side-to-side and top-to-bottom *(see photo above)*. This technique avoids missing areas and affects the perimeters that pose potential stability problems if not addressed. Packing in between trees, even where spacing is tight, must not be overlooked to ensure that steep pockets are thoroughly packed and not skipped.

In the case of hard slab, packers are instructed to give at least three hops. If the slab is impenetrable, a patroller is alerted who then 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 that boot compaction could not impact. This technique is the precursor to Systematic Application of Explosives (SAE). 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 additional storm layers is 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.

Program Cost and Considerations

Boot packers must be compensated for their time and hard work. All packer days are tracked, tallied, and

Anchor System Costs

Materials	Quantity	Cost	Total
Wire, Rope, & Hardware	1,212 m	$600/303m	$2400
Anchors	30	$20	$600
Labor	120 hrs	$20/hr	$2400
TOTAL			**$5400**

Fig 1: Fixed anchor and cable. *Photo by Colleen Carvelli*

Fig 2: Petzl Shunt on fixed rope. *Photo by Tim Grogan*

Fig 3: Packers in alpine terrain descend while self-belaying on fixed rope. *Photo by Maureen Fox*

Fig 4: Patrollers set initial packing line. *Photo by Tim Grogan*

Fig 5: 1m x 1 m grid. *Photo by Karen Sahn*

submitted to Aspen Skiing Company administration. Once information is processed, packers are eligible to redeem credits and obtain a ski pass product. In 2009, earned packer credit totaled $88,700 with 87 pro packers cashing in – the largest number to date. This dollar amount is a soft cost, and it's debatable whether packers would have purchased a season pass at the non-discounted, high-season price. Without the packing program, it's 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.

Operating an extensive packing program has become increasingly complex as participant numbers grow. In 2009, approximately 8900 total man hours were required to pack Highland Bowl and other slopes exceeding 30 degrees. Certain factors may double packing time. Packing varies with snow conditions, current weather, terrain, and pro packer fitness level and experience. Under typical conditions – 0.5-meter snow depth with soft slab and a 30-degree slope – seven man hours are required to boot pack 0.4 hectares. Travel time must also be accounted for, which 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 the following charts:

Boot Packing Effectiveness

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 and time consuming, while possibly decreasing pass sales. But 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.

When digging pits throughout the season, packer tracks are easily recognizable with densities averaging 300 kg / m3 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, Highland Bowl has been open 98% of ski area operational days. Bottom line: the company cannot afford to eliminate Aspen Highland's boot-packing program – avalanches are bad business.

Ski area marketing and upper management believe that the program's benefit outweighs the cost and alternatives. The Aspen Skiing Company expects steep skiing at Aspen Highlands on opening day and for the holiday clientele. From a business standpoint, 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 Highlands ridge are featured in magazines, brochures, and on Web sites. The local uphill culture is an important tool in the company's advertising campaigns.

Conclusions

When performing avalanche risk reduction work, the number one priority is safety for 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." 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 stay 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."

At Aspen Highlands, a simple technique commonly utilized at ski areas in the continental climate has evolved to a higher level – expanded and implemented into a systematic outside-assistance program. Results of the program include personnel and guest safety, exhilarating skiing for recreationists, 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)*.

Acknowledgements

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References

R. Burkley, Aspen Skiing Company VP Mountain Operations, personal communication, 2010.

Carvelli, P. 2008: *Boot Packing and "Systematic Application of Explosives": Shear Plane Disruption Technique in the Continental Climate*. Proceedings, ISSW, Whistler, B.C., Canada.

LaChapelle, E.R., Atwater, M.M., 1961. *The Climax Avalanche: A Study in Case Histories*. U.S. Department of Agriculture, Forest Service.

McClung, D.M., Schaerer, P., 2006. *The Avalanche Handbook*. The Mountaineers Books, Seattle, WA, USA, 150-152.

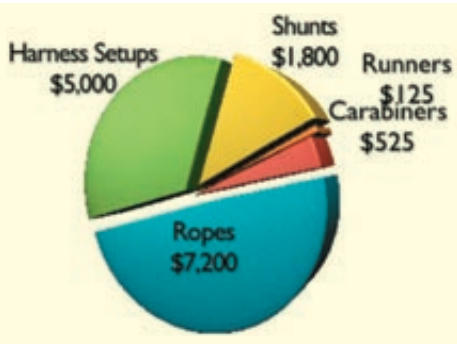
Aspen Highlands, 1978-2008. Avalanche occurrence records on file.

Karen Sahn spends her winters at Aspen Highlands ski area as a snow-safety worker and boot-packing specialist.

Initial Program Costs

ROPES:	12 ropes, 180 meter, 11.6 m static @ $600 ea
HARNESSES:	50 harnesses and shunt setups @ $100 ea
SHUNTS:	30 Petzl shunts @ $600 ea
RUNNERS:	25 runners @ $600 ea
CARABINERS:	75 carabiners @ $600 ea

Total Initial Cost
$10,150



Annual Program Costs

EXPLOSIVES:	500 kg @ $20/round
LABOR:	2400 hours @ $20/hour
SUPPLIES:	
Duct Tape:	100 rolls @ $7/roll
Carpenter Chalk:	20 liters @ $50/liter

Total Annual Cost
$58,750

Fig 1: Summer photo of one of the slopes studied. This slope is covered with Sitka alder trees up to 4 m tall, the same underlying vegetation on 16 of the 18 slopes where we observed glide avalanches.

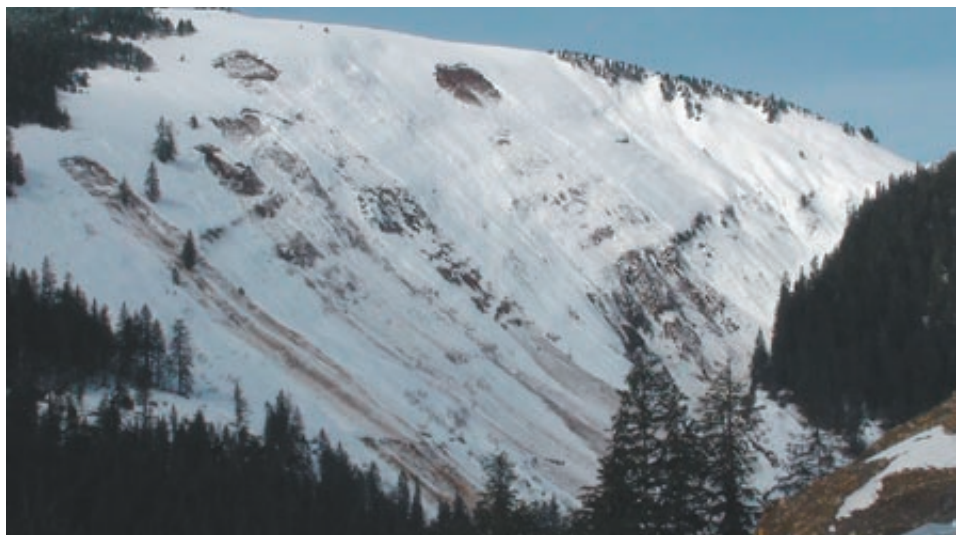


Fig 2: Same slope with glide avalanche activity. This photo was taken on April 1, 2010.

GLIDE AVALANCHES:
Forecasting & Mitigation Challenges

Story by Ron Simenhois and Karl Birkeland

Glide avalanches present a serious challenge to avalanche programs. They can be very destructive as they often mobilize large volumes of snow. They are hard to forecast and difficult to artificially trigger. *The Avalanche Handbook (McClung and Schaerer, 2006)* loosely characterizes glide avalanches as wet slides. However, we have also seen glide avalanches where the snowpack consisted almost entirely of dry snow. Glide avalanches typically start in specific start zones within a mountain range and their location is highly dependent on topography.

Dave McClung and others *(1994)* concluded that liquid water at the interface between the snowpack and the ground has a greater effect on glide velocity than varying snow properties. Past research hypothesized the existence of a critical glide rate that when exceeded, results in glide-avalanche release *(der Gand and Zupanièiè, 1966)*. However, other studies find no clear relationship between glide rates and glide-avalanche release *(McClung et al., 1994; Clarke and McClung, 1999)*. It has been suggested that glide-avalanche release may best correlate with periods of increased glide acceleration, rather than increased glide rates. This hypothesis is supported by a recent study in the Pacific Northwest where a dramatic increase in glide rates was observed within 30 minutes before glide-avalanche release *(Stimberis and Rubin, 2009)*. Thus, though measurements of glide rates show some promise for predicting glide avalanches, such measurements are currently costly, largely unreliable, and extremely difficult to conduct in multiple paths.

This article highlights the challenges in forecasting glide avalanches with a review of three glide-avalanche cycles during the winter of 2009/10 in Johnson Creek in the Coastal Range of southeast Alaska.

STUDY AREA

Johnson Creek Basin is situated 70 km (43 miles) north of Juneau, Alaska. The majority of the glide avalanches we observed were on an east-facing slope. Start zone elevations range from 300m (1000') to 800 m (2600') above sea level, while slope angles are between 45° and 55°. Although many slopes in the area are steep enough for glide avalanches and we observed glide crack development on many of them throughout the winter, glide avalanches occurred on only 18 slopes. The ground cover in 16 of the 18 start zones consists of Sitka alder trees up to 4 m (12') tall *(Figures 1, 2 & 3)*. The remaining two start zones are underlain by rock slabs.

NOVEMBER/ DECEMBER CYCLE

Our first glide-avalanche cycle was on November 30 and December 1, 2009. It consisted of five avalanches. The largest avalanche of this cycle was an R2/D3 avalanche on November 30.

The weather leading to the cycle consisted of warmer-than-average temperatures for the first half of November. The warm temperatures likely kept the ground from freezing before the first big snowfall of the season. This snowfall of over 3' occurred on November 7. These warm temperatures set the stage for a relatively warm ground–snowpack interface. The warm early November was followed by a cooling trend with well-below-average temperatures leading up to the avalanche cycle *(Figure 4)*. Average temperatures were below freezing until a few days before the avalanches, and then they increased up to about +2° C (37° F). At the time of the avalanche cycle, temperatures were below freezing and falling.

The snowpack leading up to late November differed significantly from the snowpack associated with the latter two cycles *(Figures 5 & 6)*. Contrary to what is usually expected for glide avalanches, this snowpack consisted of mostly dry snow of decomposed fragments with a warm snow–ground interface where the snow was wet. The generally dry snow leads us to believe that the wet basal layer of wet snow was not due to surface melting or rain, but from a warm ground that melted a small amount of the basal layer. Interestingly, we did not observe any glide cracks or other signs of gliding before the first avalanche of the cycle.

Streamflow data from Johnson Creek shows a sharp flow increase immediately following the last avalanche day. We cannot explain this short spike in the streamflow as we did not observe surface melting or rain during this time period. After that, streamflow declined sharply for two days and kept declining for the next two weeks *(Figure 4)*.

JANUARY / FEBRUARY CYCLE

The second avalanche cycle of the season took place from January 28 through February 7, 2010. We had avalanches on six of those 11 days, with most (four) occurring on February 6. The largest avalanche of this cycle was R2/D3 and occurred on January 29.

Above freezing temperatures with eight rain events before January 21 caused the snowpack to go through a melting process. The snow developed water channels to discharge free water and was relatively strong. Prior to this cycle, as in all the glide cracks we investigated throughout the winter, the bottom of the snowpack had no or minimal contact with the ground below. Snow depth by late January varied between 0.5 (20") and 2.5 m (98"). Up to a foot of new dry snow existed above elevations of 760 m (2500 ft). Areas with the newer dry surface snow layers avalanched about five days later than areas without new snow layers. It is unclear whether the later avalanche activity at those locations was related to the new snow or to the higher elevations of those starting zones.

Glide cracks and other signs of increase gliding rate started to appear in early January. However, no new signs of gliding appeared, and old signs stopped expanding about a week before the first avalanche

Fig 3: Glide crack resulting from basal sliding of the snowpack.

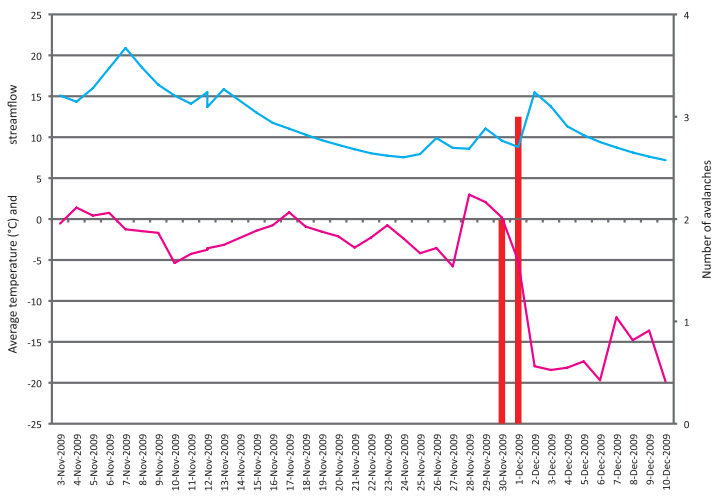


Fig 4: 24-hour average temperatures (pink), streamflow (blue) and avalanche occurrences (red) during November and December 2009. Temperature and streamflow are on the left axis.

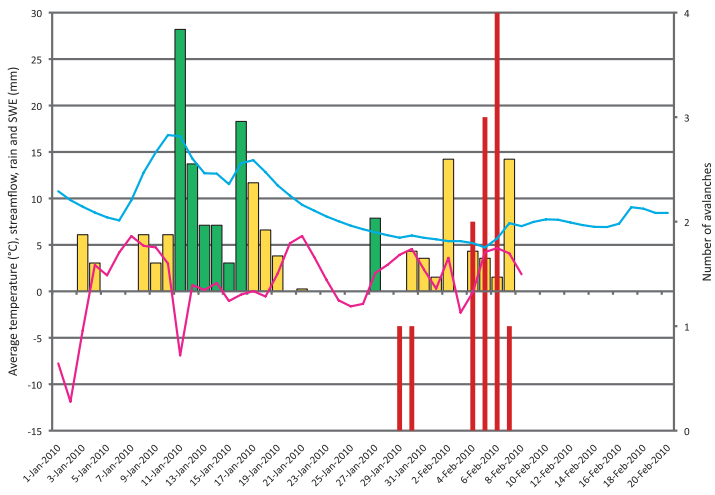


Fig 5: 24-hour average temperatures (pink), streamflow (blue), avalanche occurrences (red), mm of rain (orange) and mm of SWE (green) during January and February 2010. Temperature, streamflow, rain and SWE are on the left axis and avalanche occurrences are on the right axis.

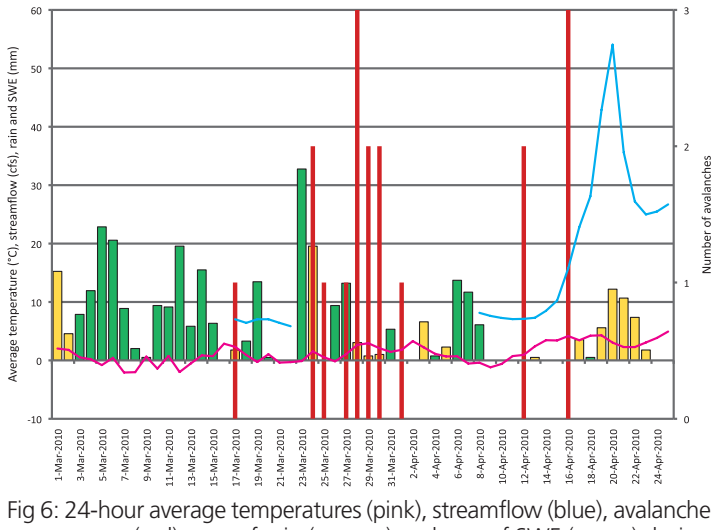


Fig 6: 24-hour average temperatures (pink), streamflow (blue), avalanche occurrences (red), mm of rain (orange) and mm of SWE (green) during March and April 2010. Temperature, streamflow, rain and SWE are on the left axis and avalanche occurrences are in the right axis.

Fig 7: Snow creep around trees. The photo on the right was taken on 5 February and the photo on the left is from 7 February. The opening diameter downhill from the tree expanded from 41 cm to 57 cm during those two days. Slope angle is 35°, elevation is 580 m (1900 ft) asl.

Fig 8: "Glide ripples" under a glide crack at 13:10, 29 March 2010. This piece of snow avalanched at 16:45 on the same day.

on January 28. Thus, we did not observe any obvious visual signs that glide avalanching was imminent prior to these avalanches until the last days of the cycle when gliding was clearly evident again *(Figure 6)*.

In contrast to the first cycle, streamflow continued to decrease after the first two avalanches of this cycle. A day after the second part of the cycle began (February 5), streamflow began to increase, ultimately decreasing after the cycle ended. We observed some relationship between streamflow and glide avalanching, but that relationship does not always hold, as evidenced by the first two avalanches of this cycle. Further, when they occur, streamflow changes are typically after the onset of avalanching and, therefore, are not useful for forecasting purposes.

MARCH / APRIL CYCLE

The third glide-avalanche cycle was also the most extensive. It took place from March 17 through April 16, 2010. This cycle consisted of 18 avalanches occurring on 10 of the 31 days in this period *(Figure 6)*. The largest avalanche of the cycle was an R2/D3 observed on March 28.

Temperatures for the first half of March were below freezing most of the time, with 12 days of snowfall. The first avalanche in March occurred after two days with average temperatures above freezing. The cycle itself really started on March 24 with 12 avalanches in eight days. It started after 16" of snow (34 mm SWE) fell on March 23, followed by 17 mm of rain on March 24. Average temperatures throughout the eight days were above freezing with a decreasing trend and three more snow days leading to the second phase of the cycle. Temperatures increased to around freezing at the beginning of the second phase and to about 3.5° C (38° F) on the last day of the cycle on April 16.

The snowpack during the cycle was similar to the February snowpack, i.e., melt forms with a dry surface layer at higher elevations. We also observed a similar trend as the previous cycle where areas with dry upper snowpack layers avalanched on average nine days after slopes in areas where the snowpack consisted of entirely melt forms.

Like the previous cycles, we didn't see new signs of gliding in the first half of March. In fact, the first clear sign of increased gliding was the March 17 avalanche. In two cases (on March 29 and April 13) we saw "glide ripples" developing downslope of glide cracks on concave slopes *(Figure 8)*. In the first case an avalanche occurred within six to 12 hours after the ripples started to form. The second case was smaller and avalanched three days after the initial ripples development. In both cases, the glide cracks above the "rippled" area developed weeks before the avalanches occurred.

CONCLUSIONS

Forecasting:

Our observations demonstrate the difficulty in forecasting glide avalanches. Despite data from three weather stations; regular snowpack observations; and regular observations of glide activity like glide cracks, snow around trees, rippling, and streamflow data, it was not possible to definitively predict the onset of glide-avalanche activity. Our experience is consistent with the experience of other avalanche programs.

In terms of weather observations, our data suggests that any single weather event by itself is insufficient for glide-avalanche forecasting. Avalanches were running after four days of sub-freezing temperatures as well as in above-freezing temperatures. We also saw no clear relationship between precipitation and glide-avalanche activity. Further, the heaviest glide-avalanche day of the season on February 7 (four avalanches) occurred after eight days of no rain and 12 days with no snow. Our experience suggests that our weather observations were not a reliable tool for glide-avalanche forecasting. However, our data does not include extreme events like prolonged periods of heavy rain.

Snowpack structure varied greatly between mostly dry snow in the first cycle and wet snow in the latter two cycles. However, in all three cycles we saw no persistent weak layers in the snowpack. Also, in all three cycles the bottom layer of the snowpack was wet. Another consistent observation throughout the winter was that, in all the glide cracks we investigated, the bottom of the snowpack had no or minimal contact with the ground below. Still, we observed snowpacks similar to those that avalanched on other slopes that did not avalanche during all three cycles.

Glide avalanches are usually accompanied by cracks and other clear signs of increasing glide rate. However, glide-crack formation (or lack of glide-crack formation) also proved to be an unreliable indicator for approaching glide-avalanche occurrences. In fact, in all our avalanche cycles, we observed avalanching before new glide cracks or other fresh signs of increasing glide rate were observed, and in many cases we observed glide-crack formation without any avalanche activity.

Avalanche control and hazard mitigation:

We typically mitigate avalanche danger through forecasting and active control work. However, glide avalanches are difficult to forecast, and we are only aware of one method for successfully triggering glide avalanches. This method is costly as it involves placing large explosive charges (25 kg (55 lb)) at the bottom part of the gliding snow section using helicopters *(Wayne Carran, Milford Road New Zealand, personal communication)*. Although glide avalanches are difficult to control, there are ways beyond passive defense structures that can minimize the risk they pose. An active approach that we took involved identifying slopes prone to glide avalanches. We then minimized the avalanche size potential on those slopes by diligently triggering small avalanches throughout the season, thereby reducing the volume of snow on suspect slopes. Since small avalanches present less danger, maintaining a shallower snowpack can reduce the avalanche danger.

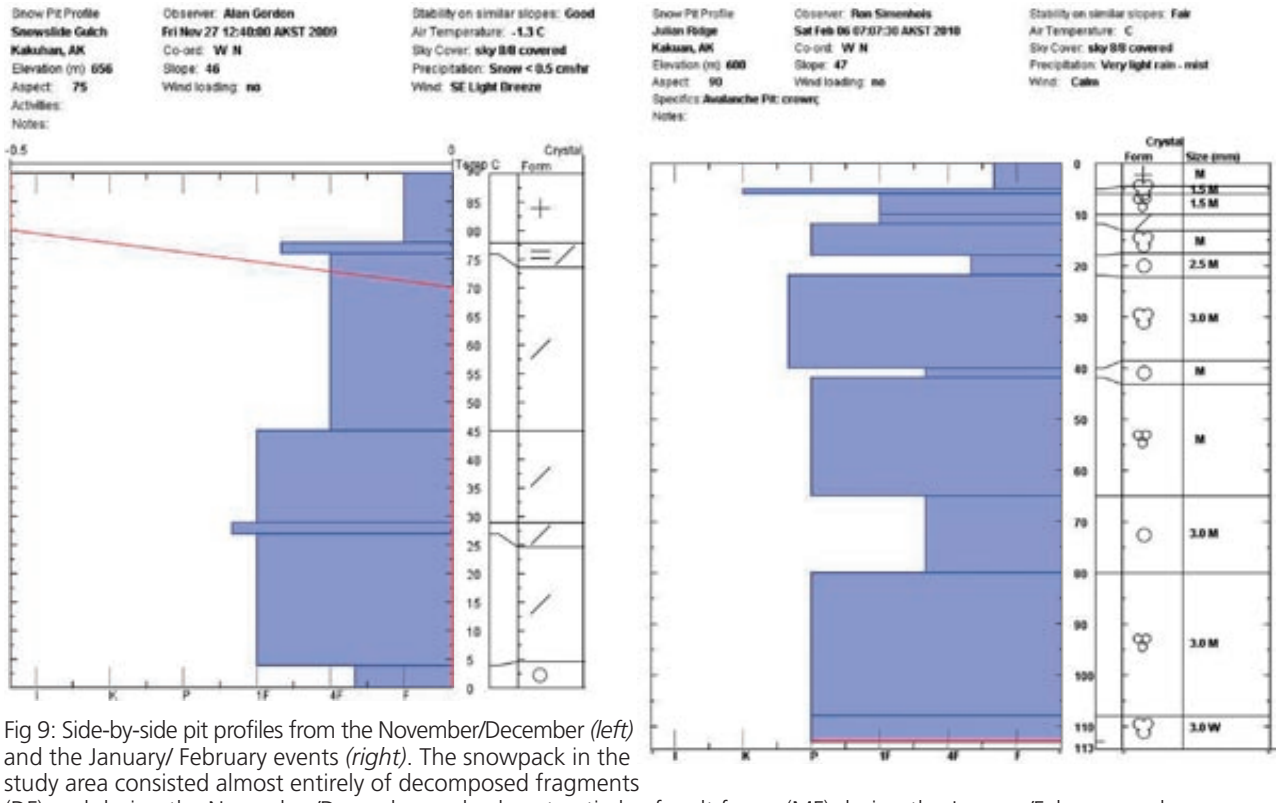


Fig 9: Side-by-side pit profiles from the November/December *(left)* and the January/ February events *(right)*. The snowpack in the study area consisted almost entirely of decomposed fragments (DF) and during the November/December cycle almost entirely of melt forms (MF) during the January/February cycle.

ACKNOWLEDGEMENTS

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REFERENCES & ADDITIONAL READING

Clark, J. and D.M. McClung. 1999. Full-depth avalanche occurrences caused by snow gliding, Coquihalla, British Columbia, Canada. *Journal of Glaciology*, 45(150), 539-546.

Hendrikx J., Peitzsch E. and Fagre, D.B., 2010. *A practitioner's tool for assessing glide avalanche activity*, Proceedings of the 2010 International Snow Science Workshop, Squaw Valley, CA.

Jones, A. 2004. Review of glide processes and glide avalanche release. *Avalanche News* 69.Canadian Avalanche Association, Revelstoke, B.C. (69) 53-60.

Lackinger, B. 1987. Stability and fracture of the snow pack for glide avalanches. *International Association of Hydrological Sciences Publication* 162 (Symposium at Davos 1986) – Avalanche Formation, Movement and Effects, 229-240.

McClung, D.M. 1980. Creep and glide processes in mountain snowpacks. *National Hydrology Research Institute (NHRI) Paper No. 6*, Ottawa, 66 pp.

McClung, D.M., S. Walker and W. Golley. 1994. Characteristics of snow gliding on rock. *Annals of Glaciology*, 19, 97-103.

McClung, D.M. and P.A. Schaerer. 1993. T*he Avalanche Handbook*. Seattle, WA, The Mountaineers, 271 pp.

Peitzsch E., J. Hendrikx D.B. Fagre, and B. Reardon, 2010, *Characterizing wet slab and glide slab avalanche occurrence along the Going-to-the-Sun Road*, Glacier National Park, Montana, USA. Proceedings of the International Snow Science Workshop, Squaw Valley, CA, 2010

Sharaf, D., B. Glude, and M. Janes, 2008. Juneau Avalanche, *The Avalanche Review*, 27(2), December 2008.

Stimberis, J. and C. Rubin, 2009. *Glide avalanche response to an extreme rain-on-snow event, Snowqualmie Pass, Washington, USA*. Proceedings of the 2009 International Snow Science Workshop, Davos, Switzerland, 301-305.

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decision·making

The Human Factor

THE PSYCHOLOGY OF BACKCOUNTRY SAFETY

Story by Mike Richardson

continued from cover

From the perspective of contemporary psychology, "bad decisions" can be described as negative outcomes associated with our reactions to stress. It's tempting to say that our reactions to stress have very bad consequences in the backcountry, as if these reactions are benign everywhere else, but poor coping skills have bad consequences in the rest of our lives as well. How, then, can we teach recreational backcountry skiers to manage the psychological stress associated with backcountry outings? The answer, in large part, depends on what we believe is really at the center of backcountry safety.

Cognitive behavioral therapy is one approach to teaching us effective proactive and reactive techniques for managing our state of mind. Proactive techniques help us learn how to recognize certain psychological pitfalls in order to avoid them in the first place, and reactive techniques help us clean up afterwards if avoidance is impossible. Bruce Tremper makes the point quite succinctly when he writes, "See a therapist. Character flaws might provide your friends with good gossip, but in the mountains they will kill you."

Ian McCammon has published some very interesting and oft-cited research. He was curious about why people with avalanche training were killed by avalanches when obvious signs of instability were present. This just begs the question: what was the state of mind of the individual for whom this sign of instability was allegedly obvious?

The deeper answer to McCammon's original query is of course very clear: people ignored obvious signs of instability because their state of mind allowed them to do so. When it comes right down to it, psychology is critically important because it refers to our state of mind, and, naturally, our state of mind plays a central role in our choices. Including the choice to travel in avalanche terrain when the snow is unstable.

Why Does This Happen?

Psychological equilibrium is important to us, and it is perhaps related to the body's drive to maintain biological homeostasis. Psychology is a very complex domain, so there isn't enough room to discuss the subject in great detail here. However, despite the complexities, systems-thinking and the careful use of framing techniques allow us to produce powerful generalizations from which it is possible to construct simple, highly effective teaching materials.

In order to develop a systems-thinking approach to psychology as it relates to avalanches, we need to identify broader themes, and we can do this by searching the literature. To do this, I reviewed nonfiction works, avalanche research, and contemporary psychological research. In addition, there were several key conversations with clinical psychologists and the editor of this publication. The review process, and the associated synthesis, identified several very specific themes that comprehensively "frame" several major variables of the human element as it relates to avalanches: desire, uncertainty, stress, and trouble.

What do you think happens inside a mind beset with unmanaged desire? We rationalize in order to justify our desires. We think that the rules don't apply today because the snow is mostly stable. What do you think happens inside a mind fraught with unmanaged uncertainty? We speculate and construct "facts" in order to fulfill our desire for clarity. We simply ignore our uncertainty or try to explain it away.

In short, desire and uncertainty – alone or in combination – create stress. In turn, we react, and it is the nature of this reaction in the context of the current situation that determines whether or not we get into trouble. The basic neurochemistry of this response is well understood. Chemicals such as norepinephrine and cortisol shortcut our decision-making and interfere with memory use. Sensory perception is routed directly from the thalamus to amygdala, bypassing the cortex altogether. Collectively, even the most basic facts suggest that it is very important to manage our psychological response to stress in order to prevent the psychological-physiological stress cascade from pulling the wool over our eyes.

Given the ever-present and dynamic nature of our psychology – including its basis in, and effects on, our biology – instead of presenting psychology as yet another element of a complete backcountry safety system, it might be very useful to acknowledge that a complete backcountry safety system revolves around managing our psychology. Managing implies actions, and we can sort these into proactions and reactions. Since managing our psychology is of central importance to safe backountry travel, then it certainly could be useful to think about how complete backcountry safety systems help us choose proactions and reactions appropriate for the current situation.

The Planning Cascade

In my experience, which may be relevant only to the Cascade Range in Washington state, many recreational backcountry skiers prefer to go light on the trip planning. In the hands of undisciplined skiers, poorly planned trips can easily become disorganized, stressful affairs. How does this stress arise? Well, it's quite simple actually: if you don't plan, you might not know something. Not knowing something creates uncertainty. It's perfectly possible to desire something even if you're uncertain, and this creates the psychological discomfort which can trigger a physical stress response. When this happens, the stress response may be significant enough to induce behavior that compromises the application of travel techniques.

As a result of compromised planning, including its effects on the application of travel techniques, additional pressure is put onto the avalanche rescue component of the dismantled backcountry safety system. Unfortunately, the avalanche rescue component of a complete backcountry safety system is designed only to give you a chance at live recovery in the event of a complete burial. At this point, in the event of an avalanche, successful avalanche rescue is the only thing that stands between the party and total disaster.

Trip planning plays a prominent role in managing our psychology. Planning allows us to condition our state of mind in a safe, low-stress situation. We can gather information by performing simulations of the trip, and even determine key decision points beforehand. In this sense, trip planning helps us establish a healthy state of mind that can serve as a highly effective replacement for our default psychological habits and responses, while also reducing stress and helping us manage expectations.

> DON'T TEACH decision-making BEFORE you teach the basic psychology of desire, uncertainty, and stress. Students must proactively manage their state of mind before educators can expect their students to make good decisions. Otherwise, our mind will unconsciously self-manage and create conditions suitable for accident formation.

Good habits are essential to high performance in most areas of life, and backcountry skiing is certainly no exception. Mountain professionals, many of whom possess a high degree of experience and skill, already realize that safety and psychology are, in fact, inseparable. They also know that managing psychology requires proactive and reactive techniques, and they get into the habit of applying the right technique at the right time.

It's really quite remarkable how the psychological-physiological stress cascade leads directly to a similar cascade of failures in a complete backcountry safety system. On the other hand, it is not remarkable at all when you consider that a complete backcountry safety system is composed of human beings.

Check your transceiver before you leave home. Check yourself as well.

Additional Food for Thought

- Accident formation is an appropriate technical term for the basic psychological and physiological processes that lead to avalanche involvement, and it may be useful to present trip planning, travel technique, and rescue skills as basic activities that are highly related to stress management and state of mind.
- McCammon and others, such as Albi Sole, have noted that many avalanche victims had some degree of formal avalanche training. It would be interesting to know whether or not any of the victims had psychological training, and if so, how much.
- Psychology is the ring that rules and binds all these concepts.
- Good individual decisions flow from healthy individual psychology.
- Good group decisions flow from balanced group psychology.
- Poor group decisions flow from individual imbalances that manifest as collective imbalances in group psychology as a whole.
- Dangerous psychological conditions occur when individual numbers for desire, uncertainty, and stress are uniformly high; or when there are large differences in these variables among group members. Uniformly high numbers or large variances are a sign to regroup and recenter. Accident formation is possible under these conditions; likelihood of accident formation is harder to discern and probably highly correlated to current instability. Stated simply, psychological conditions suitable for accident formation may develop on a regular basis, but the snowpack is usually stable…and you usually get away with it.
- Sloppy backcountry trips can quickly become highly stressful affairs during which we become susceptible to dangerous psychological conditions at level of individual and group.
- Uncertainty stimulates information-seeking behavior in most people. Data sampling has a strong influence on perception of instability, and we must manage our state of mind in order to minimize unwarranted influences on our beliefs about instability.
- Trip planning is a powerful, proactive method of managing desire and uncertainty.
- Differences in primary cognitive style can also serve as a source of instability

during conflict resolution. People should strive to make decisions using a mix of cognitive styles, or a neutral style should be used.

- People who are "doers" may have more problems with desire.
- People who are "planners" may have more problems with uncertainty.
- People in the middle of the spectrum may have a mix of problems with desire and uncertainty.
- You can manage your state of mind quite effectively by evaluating desire, uncertainty, and keeping an eye out for stress, including stress that may arise in others.
- Educators should explicitly teach students that psychological stress, and our response to it, creates conditions suitable for accident formation.
- Don't teach decision-making before you teach the basic psychology of desire, uncertainty, and stress. Students must proactively manage their state of mind before educators can expect their students to make good decisions. Otherwise, our mind will unconsciously self-manage and create conditions suitable for accident formation.
- Cognitive behavioral model = Desire, Uncertainty, Stress, Trouble (DUST). This field doesn't need "yet another acronym," but I think this is a good tactic for memorization.
- Recreational backcountry enthusiasts must be taught how to negotiate with each other in order to sharpen their conflict resolution skills. This is an important area for future work.
- There are outliers for whom these techniques will not be effective.
- Finally, any techniques used must be compatible with realistic human behavior.

References

Lynne Wolfe. Personal Communication.

Dan Otter. Personal Communication.

Uncertainty: The lack of certainty, A state of having limited knowledge where it is impossible to exactly describe existing state or future outcome, more than one possible outcome. Definition from en.wikipedia.org/wiki/Uncertainty. Retrieved February 16, 2011, 12:11 am.

Desire. Desire is a sense of longing for a person or object or hoping for an outcome. Desire is the fire that sets action aflame. The same sense is expressed by emotions such as "craving" or "hankering". When a person desires something or someone, their sense of longing is excited by the enjoyment or the thought of the item or person, and they want to take actions to obtain their goal. The motivational aspect of desire has long been noted by philosophers; Hobbes (1588–1679) asserted that human desire is the fundamental motivation of all human action. Definition from en.wikipedia.org/wiki/Desire_(emotion). Retrieved February 16, 2011, 12:19 am.

Desire is not an emotion. Desire is a feeling. Emotions originate from the limbic system in the brain; whereas, feelings originate from the cerebral cortex.

Cognitive Dissonance. Cognitive dissonance is an uncomfortable feeling caused by holding conflicting ideas simultaneously. The theory of cognitive dissonance proposes that people have a motivational drive to reduce dissonance. They do this by changing their attitudes, beliefs, and actions.[2] Dissonance is also reduced by justifying, blaming, and denying. It is one of the most influential and extensively studied theories in social psychology. Definition from en.wikipedia.org/wiki/Cognitive_dissonance. Retrieved November 16, 2010, 1:16 pm.

Cognitive behavioral therapy (or cognitive behavioral therapies or CBT) is a psychotherapeutic approach, a talking therapy, that aims to solve problems concerning dysfunctional emotions, behaviors and cognitions through a goal-oriented, systematic procedure. The title is used in diverse ways to designate behavior therapy, cognitive therapy, and to refer to therapy based upon a combination of basic behavioral and cognitive research. [1] en.wikipedia.org/wiki/Cognitive_behavioral_therapy. Retrieved January 4, 2011 2:23 pm.

Cognitive Styles of Forest Service Scientists and Managers in the Pacific Northwest. Andrew B. Carey. United States Forest Service. 1997

Biological Homeostasis. The tendency of an organism or a cell to regulate its internal conditions, usually by a system of feedback controls, so as to stabilize health and functioning, regardless of the outside changing conditions (2) The ability of the body or a cell to seek and maintain a condition of equilibrium or stability within its internal environment when dealing with external changes. Definition from www.biology-online.org/dictionary/Homeostasis. Retrieved December 9, 2010, 4:24 pm.

A Systems Approach To Human Factors And Expert Decision-Making Within Canadian Avalanche Phenomena. Laura Adams. MSc Thesis. 2005

The emotional/analytical conflict. *Deep Survival*. Laurance Gonzales. Norton, W. W. & Company, Inc. October 2004.

What does your gut say and should you listen? The intuitive-analytical decision making continuum in mechanized ski guiding. Iain Stewart-Patterson. Proceedings of ISSW 2010.

Elements of Avalanche Education. Mike Richardson. *The Avalanche Review*. December 2009.

Uncertainty In Nature, Cognitive Dissonance, and the Perceptual Distortion of Environmental Information: Weather Forecasts and New England Beach Trips. Robert L. A. Adams at University of New Hampshire. *Economic Geography*. 1973

Choices, Values, and Frames. Daniel Kahneman and Amos Tversky. *American Psychologist*. 1984

Sex, Drugs, And The White Death. Ian McCammon. Proceedings of ISSW 2004.

The Role of Belief In Avalanche Decision-Making. N.J. DiGiacomo. *The Avalanche Review*. February 2007

Heuristic Traps in Recreational Avalanche Accidents: Evidence And Implications. Ian McCammon. *Avalanche News*. Volume 68.

Working with Emotional Intelligence. Daniel Goleman. Bantam Books. 1998

Influence: The Psychology of Persuasion. Robert Cialdini. Collins. 1998

The Avalanche Handbook Volume 3. Dave M. McClung, Peter Schaerer. Mountaineers Books. 2006

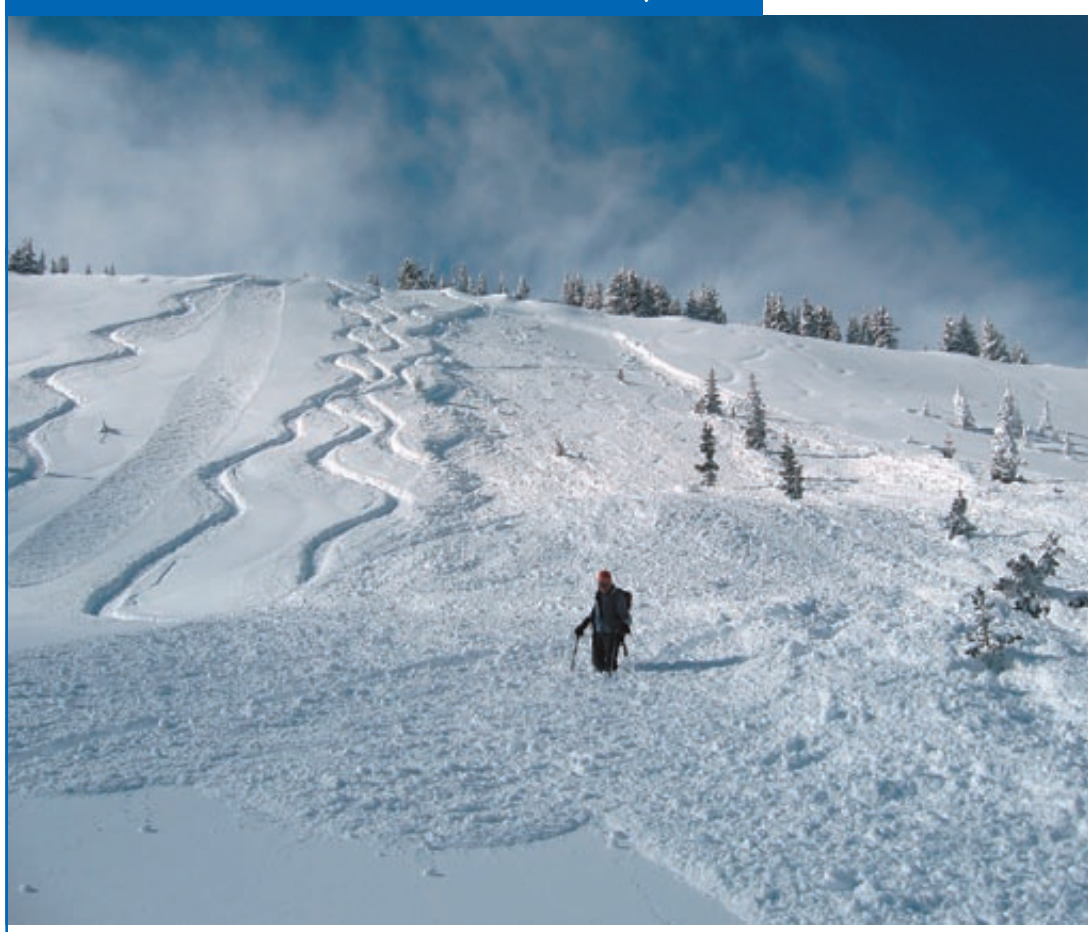
Staying Alive In Avalanche Terrain. Bruce Tremper. Mountaineers Books. 2003

The Role of Belief In Avalanche Decision-Making. N.J. DiGiacomo. *The Avalanche Review*. February 2007

AUTHOR'S NOTE: This article arises from some discussions I've had over the last few months with Lynne Wolfe and Dan Otter. They deserve an equal share of credit for many of the ideas contained herein.

Mike Richardson is a software developer based in Seattle. He likes cookies and real life happy dogs. You can contact him at mike@scenomics.com.

Human Factor Case Study #1



A two-foot slab on surface hoar was predictable but low in consequences. Photographer and trigger Mark Mueller ponders Complacency vs Uncertainty. *Photo by Mark Mueller*

When you Assume...

Story by Mark Mueller

The photo above shows an avalanche I triggered on February 1, 2007. The winter wasn't particularly snowy – about average up to that date. A brief two-day storm brought 16" of new snow with 0.7" of water content at the study plot about 700 vertical feet below the avalanche path. Temperatures were below 0° F and southwest winds averaged in the teens with some stronger gusts in the 40s. Skies were mostly clear.

The broad path is short, about 200 vertical feet, but wide and a common place for me to do some ski testing. I didn't visit this slope the day before, during the storm, but others did and numerous day-old tracks were visible, as was a very small slab not visible in the photo, but just to the left of the avalanche.

We were a group of three: myself, my wife Sandy – a very experienced avalanche person and owner/operator of Wolf Creek Backcountry and the Wolf Creek Avalanche School, and DJ – a friend, very experienced backcountry skier, and avalanche enthusiast. We were out for an early morning powder run before I had to head up to Monarch Pass for highway forecasting responsibilities.

I can't really remember my exact thoughts about the day's events, but I did a ski cut across the most avalanche prone part of the wide path and got a small, but long-running, dry loose-snow avalanche *(pictured above, looker's left of soft slab)*. Things seemed okay, so I just pointed 'em downhill and enjoyed some sweet powder turns. Sandy and DJ did the same and we climbed back up to make some more turns. Sandy had to leave, and DJ and I made our fourth run on the slope. I was the fifth skier; on my second turn the slope broke out, and I easily skied out of the narrow slide. The slide gained speed, but DJ was easily able to move out of its path. The crown was about 2' deep and ran on buried surface hoar.

Was I surprised? Yes. We did some things right. Ski testing and we skied one at a time – that's about it. What did I ignore or assume? The previous day's activity (small, but fresh): ignored. My familiarity with the slope led to complacency – I often assume (that is *used* to assume) that this portion of the slope is less avalanche prone. The light-density snow would not be so slabby – assumed.

After this incident I remembered a decision-making aid from ISSW 2006 to make my work/play decisions more objective. At ISSW 2006 in Telluride, I was honored to be able to introduce Pascal Haegeli and Ian McCammon who both gave interesting talks about the ALPTRUTh (Obvious Clues) method of hazard assessment. I use this routinely to be able to take a quick step back and carefully think about what I'm doing or what I'm about to do. It's quick, it's easy, and I think it covers most of the important bases. ALPTRUTh has taken some hits over the last couple of years, but I think it is a very valuable tool. I do a lot of my work alone and I think it gives me an objective foundation any time during my workday – during the ascent or top of a slope. Anytime I have three yeses I try to kick into a more conservative mode.

A brief epilogue: the first avalanche fatality in 20 years at this end of the San Juan mountains occurred three days later about nine miles to the east when a snowmobiler was caught, buried, and killed by a large slide triggered by a companion. Without additional snowfall, strong northwest winds loaded a southeast-facing slope.

In addition to being AAA's executive director and a forecaster for CAIC/ CDOT, Mark Mueller is an avid backcountry skier.

Intuition in Expert Decision-Making

Story by Iain Stewart-Patterson

Helicopters and expectant guests put a lot of pressu
and article author Iain Stewart-Patterson stands at
level to ski below the cornice pictured above, in a
BC. This choice turned out to be a Good Day, no

Standing at the top of a pristine wilderness peak, a ski guide prepares a group of guests for the rewards of a 4000' descent through deep, untracked powder. Weather, snowpack, and terrain usage data have been gathered throughout the winter, enabling the guide to carefully analyze the present hazard according to well-developed industry standards. As the guide slides over to the edge of the slope, a feeling emerges from somewhere within the guide. It is a bad feeling. He cannot figure out the source of the feeling, only that something is not right. With the guests looking to him for a decision and eager to ski the slope, his intuition tells him something is wrong. What should he do?

Decision-making in avalanche terrain is a complex process, so professional backcountry ski guides need well-developed strategies to help them navigate through the challenges. Guides are charged with the role of conducting guests through a constantly changing, hazardous, wilderness environment with the goal of maximizing the guests' rewards (deep powder skiing) within a risk envelope that does not eliminate the potential for a fatality.

The judgment and decision-making literature has suggested that decision-making has two components, analysis and intuition, which contribute toward a final decision solution. Analysis is the product of careful thought and reflection, whereas intuition is the product of learned experiences or expertise. Expertise ranges along a continuum and is generated through the depth and breadth of experiences. Rapid pattern recognition comes from these many and varied experiences and can generate a sense of confidence. However, misleading environmental feedback can complicate the perception of decision quality. When nothing bad happens, poor decisions can masquerade as good ones. This notion of non-event feedback has the potential to support the development of a faulty pattern recognition process with a corresponding negative effect on the quality of future intuitive responses.

The Study

This study was a qualitative analysis of data contributed by 31 ski guides who operated in British Columbia from 2008 to 2011. Eighty-nine Good Day reports and Near Miss reports were collected over two winters, 2008/09 and 2009/10. The primary criterion for a Good Day report was challenging decision-making. These winters were described by avalanche professionals as being particularly challenging due to the persistent nature of numerous weak layers within the snowpack and the high consequence of potential avalanches. It was an unforgiving environment, and the results of the study would likely have been different in more lenient years.

Results

Several themes emerged from the descriptions provided by the participants. These themes were: Environment, Decision Process, Uncertainty, Complexities, Outcomes, and Future Decisions. The environment theme was dominated by the acknowledgement that the winters were outside of the expected norms. These winters were different from previous norms, and research participants described how "normal had been redefined."

The challenge of forecasting the snow stability in this different environment was central to the stress experienced by practitioners. Previous research indicated that ski guides are highly skilled when it comes to forecasting storm-snow instabilities, but they have greater trouble when it comes to forecasting the stability of persistent weak layers. The challenge, as described by one participant, comes from trying to determine whether "a deep instability was ripe for triggering." On a Good Day report, another participant stated, "The most important decision of the day was to open up a number of ski runs for guiding that had been closed to guiding for some time due to persistent instabilities."

The decision process is dependent on an intimate knowledge of the qualities of the snowpack and the intricacies of the terrain, which influence the generation of intuitive and analytical responses. Safe skiing terrain is chosen based not only on the shape of the terrain, but also the guide's understanding of how the snowpack has developed over the season on that terrain.

"I felt that I was on a safe terrain feature, and there was little risk for me to investigate the ski line. I misjudged the spatial variability of the SH [surface hoar] layer thinking it was not in this wind-exposed location, and in any case, did not think the bench I was on was steep enough to slide."

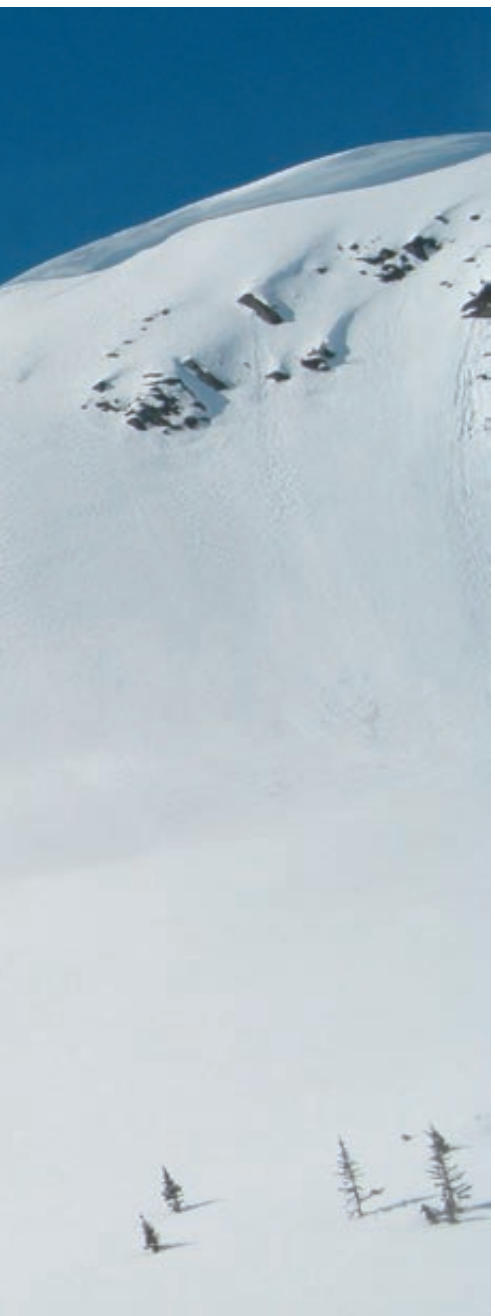
An overriding trend from the data was the intermingling of the intuitive and analytical processes. Occasionally a decision was attributed to a fully intuitive process, and more rarely, a decision was attributed solely to a fully analytical process. The majority of the time, the two processes were used together. The ultimate goal of the decision process was the selection of challenging yet safe terrain. Striving to achieve an optimal balance between maximum challenge and acceptable risk was a constant battle. Safe skiing options were typically constrained by a context specific margin of error. "This was so great because I actually got an answer to the 'safety margin/decision-making process' we do every day."

Summary

Previous research indicated that confidence based on an immediate intuitive response had a strong influence on the decision process. Ski guide participants in my study reported an increased feeling of confidence based on an absence of class one stability factors. In the Near Miss reports, these class one factors of natural and skier-triggered avalanches provided immediate and tangible feedback to the decision process. However, on Good Day reports, intuitive confidence increased when guides gradually stepped out and skied bigger lines, in the absence of direct environmental feedback, even though the hazard still existed.

"I was the kind of wondering at the time if we would get that awful surprise. We weren't seeing anything…For a long time we were worried about remotely triggering things. We were avoiding that kind of terrain for so long. We kept saying caution shallow areas, but we were not seeing it. We were building confidence on that. Maybe it's not as bad as we think. I was wondering, 'Are we going to get caught with our pants down?'"

Guides appear to use a combination of analysis and intuition in their decision process, particularly with



ure on the mechanized guide. The photographer t the bottom, mentally exploring the confidence n unnamed location in the Selkirks of southern t a Near Miss. *Photo by Iain Stewart-Patterson*

shifting understandings of what is normal. However, formalized decision training for guides centers around the development of sophisticated analytical processes. Far less has been done to foster the development of intuitive responses. This may be because analytical decision-making is easier to teach. Some might even say that intuition can only be learned experientially. But small groups have a powerful tool at their disposal, which can cultivate more sophisticated intuitive responses. Peer feedback will enhance not only the development of a broader range of pattern recognition, but also more accurate decisions. Intuitive responses can become more accurate through open and honest feedback solicited from a peer. The evening guides' meeting, typical within the heli and snowcat skiing industry, is an excellent venue for this forum.

Iain Stewart-Patterson is a UIAGM Mountain Guide and coordinates the climbing and avalanche courses in the Adventure Diploma at Thompson Rivers University in Kamloops, BC. He has been teaching in the Adventure Department since 1992 and has spent his professional development time working as a heliski guide for Coast Range, Northern Escape, Mike Wiegele, and Canadian Mountain Holidays. In 2006 he began a PhD at the University of Edinburgh investigating the role of intuition in the decision-making process of ski guides. ❄

Human Factor Case Study #2

Garan Mangan-Dimuzio marked the line of the hourglass couloir where he was caught in the Nellie and e-Ticket zones of Bear Creek, Telluride backcountry. *Photo by Brett Schreckengost*

A Telluride Tale:
Letting My Guard Down

Story by Garan Mangan-Dimuzio

On January 26, 2010, I was caught in a slide in the Bear Creek sidecountry of Telluride, Colorado. I was on my third lap of the day with a fellow off-duty ski patroller when I triggered a soft slab 2' deep and 500' wide that ran nearly full track at 900' vertical. I met the question, "What would happen if the slope slides?" first hand as I was swept through a cheese-grater boulder garden and over several substantial cliffs. There is no question: I am lucky to be alive. Although the injuries I sustained were serious, I am grateful to be alive and learn from my mistakes, and this is what I have taken away from my accident.

The conditions that day warranted careful mitigation: over 10" of new snow with moderate winds deposited less than 72 hours prior, our east-facing lee slope was appropriately rated considerable. The day was overcast and relatively cold (20-degree high) with a light wind out of the southwest. We were skiing in the Nellie and e-Ticket zones of Bear Creek: a plethora of small terrain traps, gullies, cliffs, convexities, and slope angles between 35 and 50 degrees. Earlier in the day, my partner and I had been skiing a ridgeline that borders a large path that had recently slid within the old snowpack. We were well aware of the implications – a recently avalanched path meant that the hazard was very real. However, with careful mitigation of the ridge and a very large "safe" zone (the recent slide path) to which we could retreat, we felt that we could successfully manage the well-known terrain. Which was true – until I deviated from that logic on my third lap. Instead of careful mitigation, I chose to go skiing.

My partner and I were merely a quarter of the way down the slope, taking a break at a safe bench and discussing the next section. My partner opted for a similar approach to our previous laps, but my eyes grew wide at a new temptation. We agreed to meet under a nearby cliff band (within verbal contact), and my friend went first, made some sweet turns, and hollered for me to proceed. I threw one fast ski cut in the top of an hourglass-shaped gully, waited a moment, and feeling confident (more in my skiing than the conditions), dropped in.

On my second arc I hit the sweet spot – a shallow area close to some rocks near the edge of the hourglass – when I felt the slope crumble. With the speed I had, I attempted to ski to the side of the hourglass, but I was near the edge of the slab and facing the wrong way. Almost immediately, the volume of snow from above pitched my head downhill. It turns out that I was at the front (and fastest) part of the slab. After choking on snow for a moment, I inserted my AvaLung, breathed one clean breath, and then catapulted into the first of many large boulders. This initial impact tore my backpack (Avalung included) from my body and the struggling, survival phase of being caught in a slide commenced. After numerous insults throughout the rock-strewn slide, I felt the snow start to slow, and I fought like hell to reach the surface. All said and done, I was on top. Broken, bloody, and bruised, but on top.

My experience is no new story. In fact I can only support all the evidence for contributing factors toward an avalanche. I am a 27-year-old male with intermediate avalanche experience, an expert skier on the last lap of the day with nothing but success and pleasure in the two previous runs out the gate. So why did I push the limits of the terrain on that given day? Why, with all the evidence and personal knowledge of the subject, indulge my hungry attitude for a bigger line? I can isolate part of the answer within two heuristic traps as proposed by Ian McCammon *(Avalanche News, No. 68, Spring 2004)*. Heuristics deals with the rules of thumb that unconsciously guide us through everyday life but can also give us a "grossly inaccurate perception of a hazard," *(McCammon, 2004)*, especially in avalanche terrain. Although I probably exhibited behaviors indicative of almost every heuristic trap, the two that I was most susceptible to were familiarity and consistency.

Bear Creek is my backyard. I have taken great pride and pleasure in learning the intricacies of this massive playground. However, this knowledge causes me to continue to venture into more obscure and admittedly dangerous areas. There is absolutely no way that I would have chosen this particular line on that particular day without being so familiar with the terrain.

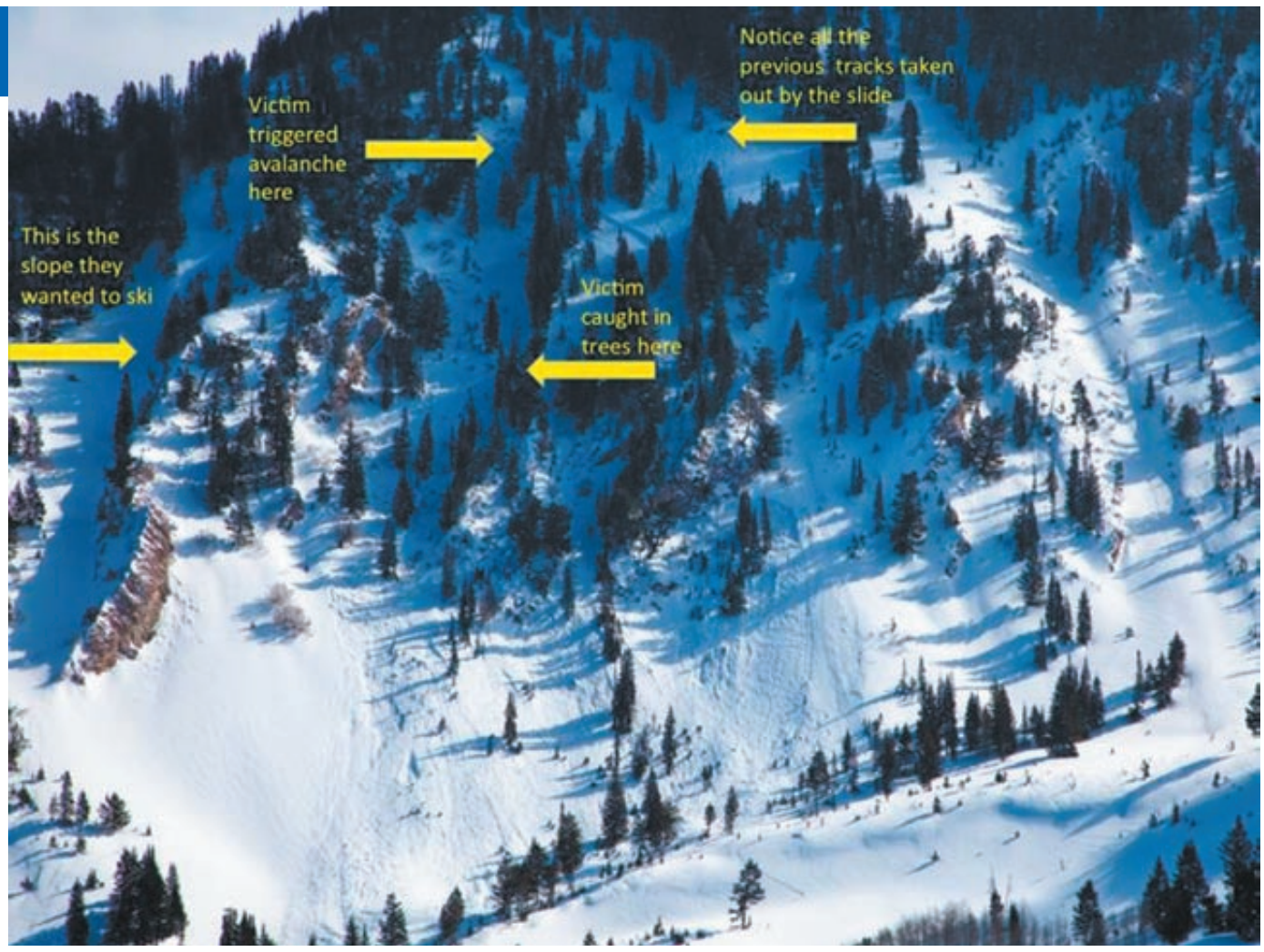
The consistency heuristic is probably the most compelling argument to my mistake that day. As mentioned earlier, we had been skiing near my fateful line all day and nothing happened, right? This is proof of the total unconscious, illogical nature of heuristics: If you had asked me just before my accident if I considered the slope in question to be safe merely because our previous two runs were uneventful, I would have laughed and said, "No way!" But here is exactly the point of heuristics. No one asked me that question – not my friends on the hill, not my partner, and most importantly, not myself. The question was absent from my consciousness and therefore a critical evaluation was overlooked, almost costing me my life. I let my guard down, and I know many people will continue to do the same. But if you are traveling in suspect terrain, don't worry about what to ask, just remember that there are important questions to ask.

Garan Mangan-Dimuzio, originally from Vermont, has worked for the Telluride ski patrol for the past five years. Garan also serves as an EMT for the town of Telluride when he is not ski touring around the San Juans. ❄

Human Factor Case Study #3

Rough Day in Alexander Basin

Story by Matthew Knotts



Steep, rocky, high-consequence terrain in Alexander Basin made rescue difficult. Matthew Knotts is grateful to Wasatch Backcountry Rescue, especially Brandon Dodge, for their exceptional efforts. *Photo by Bruce Tremper*

We met at the Porter Fork trailhead in Millcreek Canyon on Sunday morning around 9:30 am on February 7, 2010. John, Clay, and I had talked earlier in the morning after reviewing the avalanche forecast and discussed our options for the day. The avalanche forecast was calling for a moderate danger with pockets of considerable danger existing on upper-elevation north aspects that had a shallow snowpack. The weather report was calling for mild temperatures with cloud cover and the possibility of a few snow flurries. Winds were projected to be light to moderate coming out of the east. Temperatures were estimated to be in the mid-30s at 8,000' and mid to upper 20s along the ridges.

Given the conditions, we decided to go for a long walkabout tour, and Millcreek has excellent terrain for this. The trailhead starts at 6,200' and we headed up and over Gobbler's Knob, which tops out at 10,400'. It had not snowed in over a week, so there was no trail breaking to speak of. We were more interested in being out in the mountains than skiing any particular line. We reached the summit of Gobbler's Knob around 12:30 pm. The views of the central Wasatch were spectacular.

The winter of 2009/10 was shaping up to be a pretty miserable season for touring in the Wasatch. Early season snow and cold temperatures produced large pockets of depth hoar throughout the central Wasatch. Coverage was thin at best at lower elevations. A large avalanche cycle towards the end of January produced impressive slides, and the first backcountry skier fatality in the central Wasatch occurred on January 27. We were acutely aware of the conditions. The thin snowpack was evident as we worked our way up and over Gobbler's Knob.

I had toured in the area that we were headed toward the day before. I had a strong urge to go back and look around in order to find a clean line into Alexander Basin from the adjoining ridge to the east. As we approached Wilson Peak, we discussed our options. I knew there was good snow in the glades off of the summit. The Wilson Chutes had not been skied, but given the conditions, they were out of the question. We had agreed to go on a walkabout and skiing the chutes did not fit our plan for the day. We opted to ski a run in the glades. This terrain is quite fun, as the slope angle is moderate in the mid to low 30-degree range with old growth trees spaced throughout. At the bottom of the run we ate lunch, put on our skins, and headed back to the peak. We noticed an avalanche on the western edge of the glades as we skinned, but did not give it too much attention as it was triggered over two weeks earlier.

As we regrouped on the peak, we had a decision to make: what to ski next? We chatted briefly with a group of skiers that had come up the ridge from the east by way of Big Cottonwood Canyon. I pushed for the option to explore the upper ridge of Alexander Basin. I framed it as an opportunity to poke around and explore an area that I had been in before, but which does not easily give up the clean lines that can be skied. Clay and John were not overly excited about the idea. I continued my pitch: there's a clean shot that we can ski that will put us in Alexander Basin, and we can either ski out to the car from the bottom or skin up the ridge to the west and climb back up and over Gobbler's Knob one more time. I explained that I did not come across any obvious signs of instability the day before: no cracking, collapse, whumpfing, or slides were noticed. I knew this was not a definitive way to determine that the area was safe to ski, but I felt we could ski it safely if we broke it down into small pieces and skied from one area of relative safety to the next.

Clay and John ultimately deferred to me on this one. This terrain is a bit more aggressive than the glades that we had just skied. We talked about the need to go one at time, find islands of safety to ski to, and keep each other in sight.

It did not take long before the terrain unveiled its more interesting aspects. As we worked our way across the slope, staying high at approximately 9,500', I skied onto an exposed cliff band. Clay watched me from a safe spot as I side stepped up and around the rocks. We looked at each other and knew the consequences would be serious if we ended up in the wrong spot on this slope.

Clay was familiar with this terrain. In the summer and fall he runs on the trail that winds through Alexander Basin up to Gobbler's Knob. He knew that there was not an easy way into the basin, but decided not to voice his objections or push me for clarification on where exactly I was going. John on the other the hand was concerned, but did not want to speak up and voice his gut instinct about being nervous of the area. We were really good friends after all, and our friendship had been created out of our love of ski touring over many years. John explained later that he did not want to bring up any conflicting thoughts about the route selection at that point in the day. Everything had been going in our favor so far.

At this point, we had come too far across the slope to make any easy retreat. We did not discuss putting on our skins and climbing out; it just did not seem practical. We counted seven sets of ski tracks on the slope as we were poking around. Three of those were from the group that I was with the day before. We regrouped at around 1:45 pm. Clay and I stood together by a small group of trees; John was below, off to skier's left on the slope. Clay mentioned his uneasiness with the slope, but I quickly responded, "It's gonna be fine." He went first and made about a dozen turns before he was out of sight. John recounted later that he was quite uneasy with the spot where Clay and I stopped, but did not say anything. John went next. I waited several minutes until I thought he would be clear of the slope. With John and Clay below, it was my turn to go.

Avalanche!

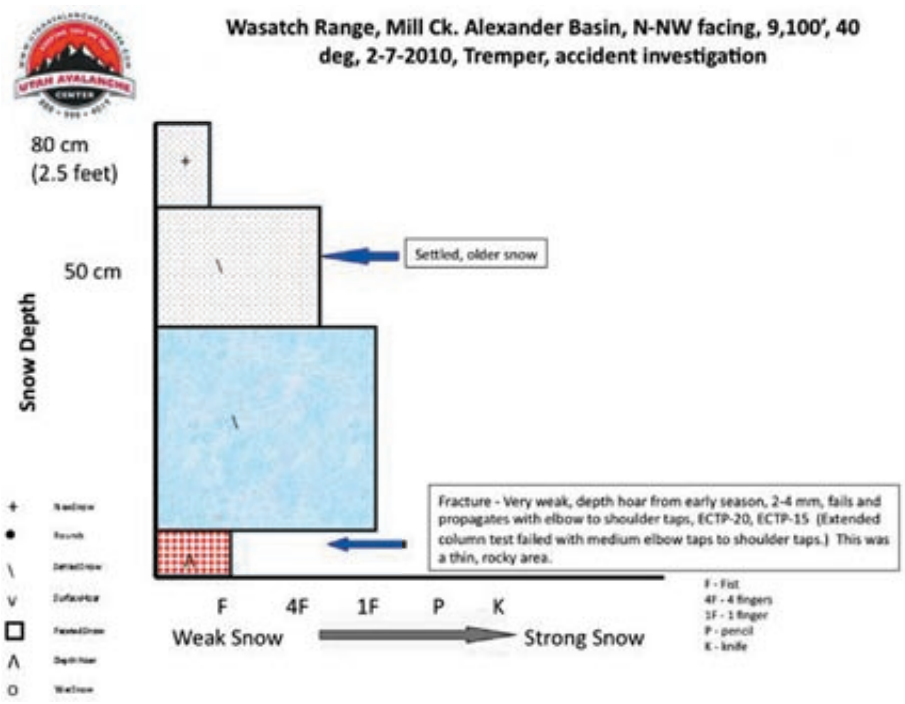
My life changed in an instant. I took a turn to the left and watched the slope crack out in front of me. I immediately yelled "Avalanche!" I was completely focused on the spot just in front of my ski tips – it was as if my vision had narrowed to just a few feet in front of me. I could see the fracture line, and it was not particularly deep, perhaps a foot deep at most. I worked with all my might trying to side step off the slab, but could not get free. My momentum carried me across the slope and into a cluster of trees. I reached out and grabbed a branch, but I could not hold onto it. I felt the branch slip through my hands. As I was carried down slope, I fought to keep my mouth free of snow. At this point everything was moving as if in slow motion. This did not last for long as all at once everything accelerated. The speed was unreal. I hit a group of trees with such force that it tore both of my legs apart. It felt like I was being beaten with baseball bats at full swing.

Clay and John were able to get out of the way of the slide. Clay got to me first and helped me sit up. I was completely wrapped around a tree, and both legs had compound fractures and were bleeding. I knew immediately that the only way I was getting out of there alive was by AirMed. John made a platform for me to sit on several feet down slope. The bed surface was slick and we were perched on a 40-degree slope about 500' above the basin floor. Clay lowered me to John and then began the process of calling for help. Cellphone coverage is not great in Millcreek, but we were lucky. Clay was able to get through to 911, and after about 20 minutes he was able to speak with the sheriff's office that coordinated the search and rescue. This was not a quick process at all, as the various agencies were sorting out who had what responsibilities for the rescue. All this was happening as the cell coverage would lapse, and Clay would lose his signal and have to start all over again.

Once I realized the extent of my injuries – broken tib/fib on my right leg that was open and bleeding, broken left femur, and completely shattered left tib/fib – I did not think I was going to live for very long. With blood everywhere, I thought for certain that I had severed my femoral artery and would bleed to death in a matter of minutes.

John helped me wrap my left thigh with one of my climbing skins. He gathered up our extra clothes and bundled me up. John gave me a huge bear hug to keep me warm and to prevent me from going into shock. He held on to me until AirMed arrived, which was over two hours. It took several fly overs before AirMed located us. Wasatch Backcountry Rescue and AirMed arrived on the scene and

Brett Kobernik, UAC forecaster, examines the weak layer in the flank fracture. This photo shows the deepest section which was about 3' deep – the majority of the fracture was around 1.5' deep. *Photo by Bruce Tremper*



packed me up and lowered me to the waiting helicopter. They were fast and efficient, and as they were setting up the anchors for the litter to lower me, I was administered morphine, which provided immediate relief, and I had a sense that I might survive.

Hindsight

In hindsight, the human factors that contributed to this accident are quite clear. John and Clay had a gut instinct that the area was not safe to ski. Our friendship provided a level of deference to me, since I had been in the area the day before without incident. There was also a feeling of not needing to question or ask for clarification on exactly what we were planning to ski, as things were going smoothly up to that point. We read and understood the forecast, but did not apply it to the terrain in Alexander Basin. The terrain had all of the suspicious characteristics: it was an upper-elevation slope, it was steep with slope angles over 40 degrees, and the snowpack was thin – less than 4' deep in the spot where I triggered the slide. I saw the terrain as something that could be managed, but failed to see the consequences of what could happen if a slide occurred. No blatant signs of instability were present, which allowed us to enter the area, but the terrain did not allow for a course correction once we got in there. My curiosity to figure out the terrain was just too strong. I had been reinforced just enough on the tour in the same area the day before to go back and try it again.

Clearly this accident could have been prevented. The area can be skied safely, but not in low-snow years or during times of considerable instability. Knowing when an area can be skied safely takes time and a great deal of patience to develop. We missed a lot of cues on that day. The terrain and the snowpack provides the information for us to interpret when we are determining where and when to ski; it's up to us to get it right.

Matt has been skiing the Wasatch backcountry since the early '90s. He has completed a Wilderness EMT program and a level II avalanche training course through the American Avalanche Institute. He lives in Salt Lake City with his wife Jennifer and their two cats. He currently spends his time relearning how to walk after breaking both his legs (see xrays, right).

Xrays taken February 7, 2010, reveal Matt's right tib/fib break and left broken femur.

Beyond the Human Factor:
A Matter of Semantics?

Story by Ian McCammon

I used to think the words we used for it didn't matter.

Human factors, human error, the human factor – what we called it didn't seem important. What did seem important was how otherwise smart people could be lured into believing a slope was safe when it clearly wasn't. And what mattered was figuring out how to prevent it.

But as I explored this problem in my research and my teaching, I began to suspect that the words we use actually *do* matter. Like an iceberg on the ocean surface, words are often clues to unseen assumptions that lie beneath. Those assumptions can limit our understanding of problems and handicap well-intended solutions in ways we don't always understand.

For example, the very term "human factor" anchors us in at least two subtle but important assumptions. The first is a value judgment courtesy of the late industrial revolution, when the term first came into usage. The human factor almost invariably referred to the unpredictability of humans as a barrier to an otherwise logical and orderly manufacturing process. The human factor was an undesirable influence to be minimized and, if possible, eliminated.

In the avalanche world, this assumption was enshrined in the common belief that if only we could keep our emotions in check and be rational enough, we would make better decisions in the face of avalanche danger. The problem with this belief, as we now know, is that emotional engagement and intuitive insight are often essential to effective decision-making involving complex risks.

The second assumption is that the term "human factor" frames the decision to enter an avalanche slope as a convergence of independent and relatively static elements: physical factors such as terrain, snowpack, and weather contrasted against psychological factors that act on the individual or the group.

This approach certainly has appeal from an educational perspective, judging by the longevity of teaching devices like the Avalanche Triangle introduced by Jill Fredston and Doug Fesler in the 1980s. As a conceptual tool for novices, it's handy to simply file the (very) long list of human delusions, weaknesses, and biases under the human factor.

But deconstructing a problem is not the same as solving it, and simply naming the ways in which a decision can go awry does little to prevent it. This is in part because deconstruction typically overlooks interactions between factors, and thus provides no insights for failed decisions that were more than just the sum of their parts. As the Greek philosophers used to say, you can divide a cat into parts and study each of them, but when you put them all back together, well, you don't get the same cat back.

The factor interaction problem is easily appreciated by anyone who has ever tried to fix a warped bicycle wheel. The quick fix is to crank up the tension in one spoke so that it pulls the wheel more or less true. This solves the problem in the near term, but when the overstressed spoke eventually snaps, you're worse off than before. By focusing on the human factor alone as the source of our problems in avalanche terrain, I suspect we are setting ourselves up for the expectation of a quick fix – an expectation with a rather rich history of disappointment and disaster.

Fortunately, there is another perspective on the human-factor problem. Starting in the 1970s, and coincidental with the rise of systems engineering, some avalanche researchers and practitioners have advocated a more holistic view of how avalanches and humans interact. This perspective encompasses not only individual factors but also includes factor interactions and their dynamics.

As is typical of our field, many fascinating research questions are just waiting to be explored using relatively simple methods. For example, the four factors of humans, terrain, snowpack, and weather combine in at least 11 ways. Which interactions have received the most study and why (a potential metastudy)? How do these interactions commonly manifest themselves (quantitative/qualitative analysis)? Which interactions are most prevalent in accidents (data mining) and how can those interactions be addressed (cognitive ergonomics design)? Ah, to be a master's student again.

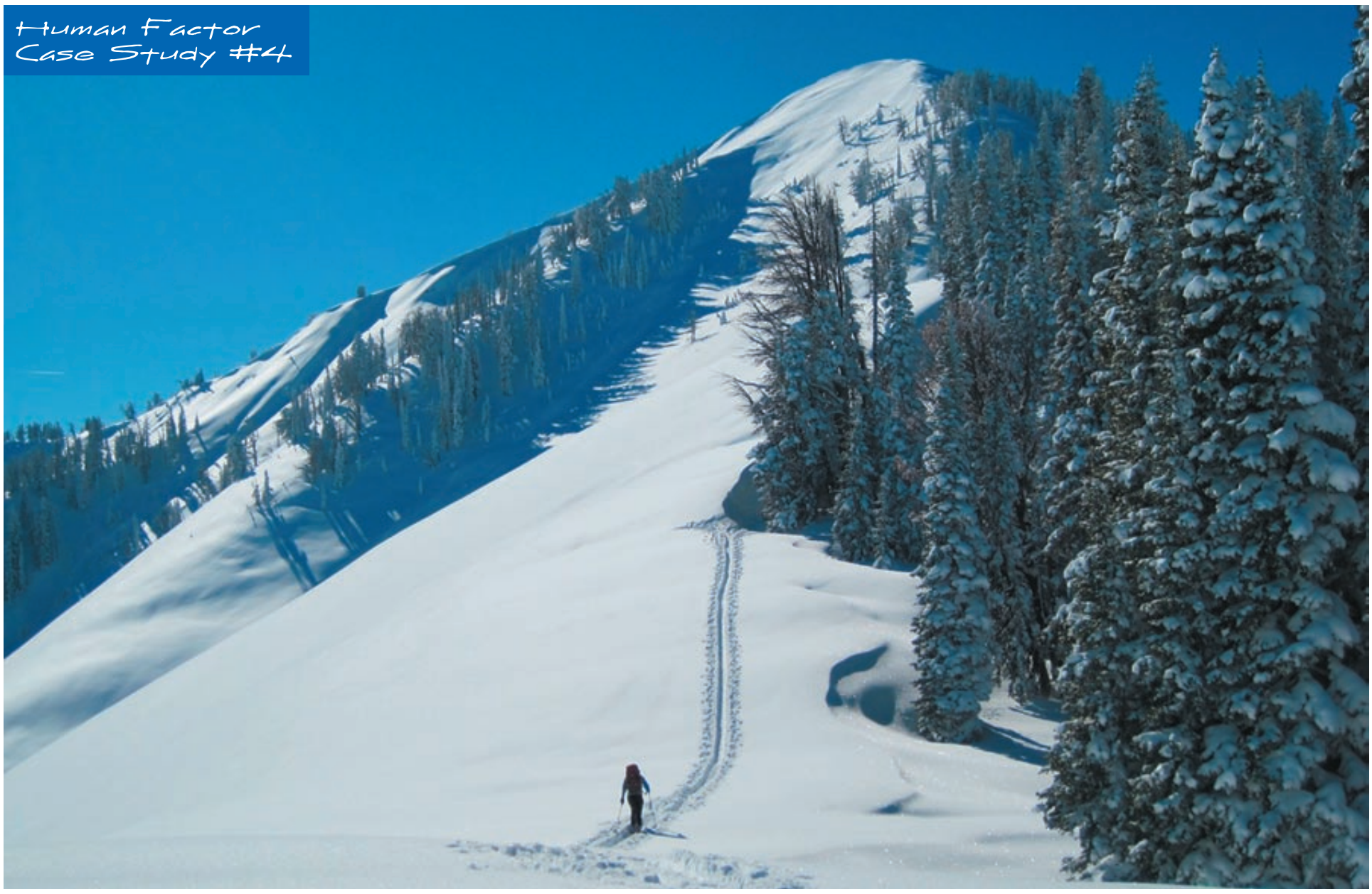
An even more extensive toolbox of research methods exists in systems engineering and cognitive systems research. In fields as diverse as emergency medicine, aviation, and tactical command, tools such as cognitive work analysis and system optimization have brought about significant advances in human performance in the face of risk. And it is worth noting that these successes are occurring in fields where the term "human factor" as a working explanation for accidents was retired long ago.

We're not likely to solve the avalanche problem overnight, but I suspect that a worthwhile first step might be freeing ourselves from assumptions and paradigms that have hindered our efforts in the past. The research tools already lie before us, and with a little creativity and hard work they can be adapted to help us make better decisions in avalanche terrain.

So perhaps words do matter. If nothing else, they are a good place to start.

Ian McCammon is a researcher living in Salt Lake City. He believes that humans are pretty good at making risky decisions, especially when compared to the alternative. He is deeply indebted to his students, colleagues, and mountain partners who continue to provide deeper insights into how good decisions can be made better.

Human Factor
Case Study #4



Thompson Peak with skin track. Just another pretty face in eastern Idaho.
Photo by Pat Kearney

Close Call in the Palisades

Story by Pat Kearney and Drew Leemon

On January 28, 2010, a group of five on a National Outdoor Leadership School (NOLS) instructor training seminar unintentionally and remotely triggered a R4, D 3.5 avalanche on an ESE-ENE aspect of Thompson Peak in the Palisade Range of Idaho/Wyoming, southwest of Teton Pass. The group had decided to ski the slope and were taking skins off when the avalanche ripped to the valley floor in front of them *(see photo, top of next page)*. No one was caught or injured. Ultimately the decision to ski the slope was based on a misperception of snowpack conditions and has provided useful insight into avalanche training and supervision for the school and other educational services.

Each winter NOLS runs a series of seminars designed to train current instructors interested in working in the program for the school. Participants already lead courses for NOLS (hiking, climbing, etc) and are required to have prior backcountry skiing experience. This seminar is called the winter instructor seminar (WIS) and is preceded by a mandatory five-day professional avalanche level 1 (AVT) seminar taught in the Teton Pass area. The WIS is a 10-day backcountry-based seminar of 12 participants and three instructors. This WIS was traversing the Palisade range. The avalanche occurred on day five of the seminar. I was one of three instructors teaching the seminar.

Weather and Snowpack

The 2009/10 winter in the Tetons had a relatively slow start, creating a shallow weak snowpack. The resulting depth hoar had been the primary avalanche threat thus far in the season. From January 19-28, the Tetons received 69" of snow with 4.7" snow water equivalent. The last significant avalanche cycle had occurred on January 6.

On January 28, skies were clear and observed temperatures were between -10º and -2º C. The local avalanche center recorded a max temp of 2.2º C at 9500'.

Day Plan & Assessment Process

Our plan for the day was to ascend Thompson Peak as one group and from the summit split into three smaller groups to assess and ski higher elevation terrain. On the way up we intentionally dropped a cornice onto a steep east-facing avalanche path, but did not cause an avalanche. The ridge leading up to Thompson is low angle and broad until the last 500 feet where it gets significantly steeper *(see main photo, above)*. At the base of the peak we observed a recent natural avalanche *(see photo, middle of next page)*, and the large group decided not to go to the summit. As a group we verbalized and acknowledged all of the components of the ALPTRUTh decision-making model, and the instructors spoke of "erupting red lights" and bulls-eye data that they were perceiving, influencing them to urge conservative choices for the day.

Avalanches – Recent: *Yes.*
Loading: *Yes, storm cycle ended the previous evening.*
Path: *Yes.*
Terrain Traps: *Yes.*
Rating: *Was unavailable to us, but we estimated it to be considerable.*
Unstable Snow Signs: *Yes, whumphing was observed while skiing to the base of the peak.*
Thaw Instability: *Yes, observed water dripping from trees and warm temperatures.*

At about 1pm we broke into three groups, participant-led and coached by an instructor, to travel onto lower angle and lower elevation slopes. I was with group 1 and a second instructor was with group 2. These two groups traveled back down the ridge to ski and assess east- and northeast-facing slopes. These groups did not experience any signs of instability and skied on low-angle terrain. Group 3 was initially headed to west-facing treed slopes when one of the participants suggested skiing an open, mostly east-facing broad ridge. The instructor thought it looked reasonable to assess and communicated the change of plan to group 2. Group 3 then split into two teams of two to assess the ENE and ESE aspects of their new objective while the instructor supervised by skiing back and forth to the groups performing "test + pits."

Stability & Test Findings of the Two Pit Locations

Pit 1 dug and observed by two participants:
E, 33-degree slope angle, elevation 8600', HS=100cm
CT9 Q1 down 25cm
CT9 Q2 down 80cm
ECTP14 Q2 down 65cm on facets
Summary of pit results: low strength, mod-high energy, poor structure (assessed stability rating: POOR)

Pit 2 dug and observed by two other participants:
ENE, 31-degree slope angle, elevation 8600', HS=160cm
CT 24 Q3, down 50cm
CT 29 Q2, down 80 cm
ECTX
Summary of pit results: high strength, low-mod energy, good structure (assessed stability rating: FAIR)

Group 3 then came together to discuss stability findings and make a plan. They shared pit observations and decided not to ski on the E/ESE aspect and to ski the ENE aspect. A participant led the decision-making process with the instructor fielding and facilitating additional questions. One of the participants asked about the whumphing experienced earlier and how that related to their intended line. The instructor thought that collapsing was less likely in the thicker snowpack on the ENE especially with the apparent lack of energy in the snowpack. The group went down to a slight rollover to get a view of the entire slope and identified a safe zone down slope to ski to. The group then skinned back up to a flat area (10-degree slope; after the slide this area was probed and found to be 50 cm deep) to begin the descent. The plan was to ski one at time on the ridge to the safe zone. As the last person joined them in a tight huddle there was a massive collapse of the snowpack; it seemed to have initiated on the more southerly aspect and propagated to the ENE aspect, down the group's intended descent and below both pits.

Aftermath

The group spent the rest of the day investigating the slide. Crown height varied from 15-80 cm and the avalanche was ~300 m wide and ran ~300 m on a 31-degree slope at 8600'. The instructor was belayed into the crown and dug on the crown face with the following results:
CT 8 Q1,
CT 11 Q2,
ECTP 12 Q1

All failures were 55cm down on 2-3 mm facets above a 2-3 mm ice crust, slab hardness was 4-Finger. Assessed stability: poor/very poor.

The instructor then dug within 10 m of pit 2 with the following results (compare to initial findings):
CT 13 Q1 down 95 cm on 2 mm facets
CT 11 Q1 on the same layer
ECTP21 Q1 on the same layer
High energy, Poor structure (5 lemons at the weak layer), and moderate-weak strength, Poor stability

Analysis

The Risk Potential Diagram provides a framework to both assess risk when faced with a risk-management decision in the field and as a method for organizing a risk analysis when seeking to identify the contributing factors that were at play in a specific incident. The risk potential increases or decreases based on the interplay of three main categories of factors:

Objective or Environmental – the condition of the environment. These are factors we cannot change.
Subjective or Human Factors – the condition of the people involved affecting perceptions and responses.
Program Factors – aspects of the program that may influence decisions and set the stage for the level of risk that is accepted.

Objective Factors

The avalanche occurred on a slope that averaged 31 degrees. We classified this as yellow light terrain *(see "NOLS Avalanche Terrain Definitions," TAR 27-3, p17)*.

The weak layer that the avalanche slid on appears to have been a buried rain crust. The instructor felt this crust with his saw, but the participant who dug pit 2 did not feel the crust.

There was a broad ridge between pits 1 and 2 along which the group planned to ski. The avalanche ran across the ridge and the terrain was structurally connected by the snowpack. The incident occurred after an extensive storm on a day with clear sunny skies and warming temperatures.

Subjective Factors

All participants and instructors observed all ALPTRUTh factors, and these were clearly communicated to everyone. The clear weather allowed everyone to see the natural avalanches that occurred during the storm cycle.

In assessing the slope they wanted to ski and when considering the bull's-eye data observed during the day, the group decided snowpits were necessary before making a decision to ski. They had conflicting snowpit assessments: pit 1 indicated poor stability while pit 2 indicated fair stability.

There was not a strong desire among the group to ski the slope. They had backed down from one objective earlier in the day, summiting Thompson Peak, and a decision not to ski this slope would likely have been readily accepted.

The instructor supervised the participants while they assessed the snowpack; he did not do his own independent snowpack assessment. The instructor's assessment (post-avalanche) of snowpack stability near pit 2 differed from what the participants in pit 2 concluded. The instructor determined the snowpack had poor stability.

Program Factors

The intention of this instructor-training seminar is to have participants get as much hands-on experience as possible assessing snowpack conditions and making decisions. This influences the risk tolerance for this program as we are allowing professional leaders (though they are novice avalanche forecasters), to make decisions and learn from the results of those decisions. The instructor in this setting becomes more of a facilitator than a teacher, but one who has veto power over the participants' decisions.

The participants had completed an intensive five-day avalanche course just prior to the backcountry expedition. They had dug numerous snowpits.Accuracy and efficiency in digging snowpits and interpreting the snowpack is a desired outcome of NOLS avalanche training.

Discussion

The different assessments of pit 2 by the participants pre-avalanche and the instructor post-avalanche may speak to spatial variability across a slope and/or the subjective nature of interpreting stability tests – especially by novices. Spatial variability is a known factor in snowpack assessment; what may not be as well understood is the subjective nature of how people of varying experience interpret snowpit test results. This incident indicates that there are times when more experienced practitioners should consider digging pits independent of the people they are supervising in order to confirm stability assessments.

The decision to ski the slope seems to have been based on the participant's assessment of pit 2. The ALPTRUTh factors and the "erupting red lights" that the seminar instructors had perceived and discussed earlier do not seem to have influenced the decision to ski the slope. Decisions need to be made based on the entire information available and not just on one element.

The participants claim they were not being complacent in their assessment, but they did say that the process was taking a long time. It is hard to know if this influenced their decision.

The ridge did not provide a safe ski route as anticipated. The instability traversed the ridge, and perhaps the ridge was not distinct enough to offer an appropriate ski route.

The warming temperatures during the day following a storm seem to be a significant factor in creating snowpack instability. The slope on which a cornice was dropped in the morning did not avalanche then, but did avalanche in the afternoon between 4-5 pm. This avalanche was remotely triggered by a group of five snowmobilers. *(see photo, bottom right)*

Conclusion

This incident provides a great opportunity to reflect and learn about the NOLS avalanche curriculum, how we teach stability assessment and avalanche forecasting, and how we supervise and facilitate these experiences. Avalanches are unusual events on NOLS courses, and this incident will be useful to our faculty and students in illustrating the complexities and potential consequences of traveling in avalanche terrain. The valuable learning that can come from an incident of this type cannot be underestimated. We appreciate the willingness of the instructor and participants to discuss this incident openly.

We are seeking ways to simplify the process of stability assessment to improve how our students and staff understand and interpret snowpack analysis and do so in an efficient way. We question if switching back and forth between the hazard rating (low-extreme) and stability rating (very good-very poor) is confusing for novices. We have also begun teaching "The Seven Common Avalanche Problems" and are finding it to be helpful in simplifying the complexities of avalanches.

The lessons derived from this incident will have far-reaching and beneficial implications for the NOLS avalanche education program.


The avalanche under discussion. Some of the participants can be seen on the ridgeline above the crown. The rain crust was elevation-specific but irrespective of aspect.


Final ridge to summit with natural avalanche on right side in the shade.


Avalanche remotely triggered by snowmachines late in the day, the same slope we dropped a cornice on early in the day without results. *All photos by Pat Kearney*

Pat Kearney *is a NOLS field instructor and program supervisor based in Victor, Idaho, in the winter and Lander, Wyoming, in the summer. He enjoys skiing in the Tetons and riding bikes in the Winds.* ***Drew Leemon*** *is the risk management director for NOLS and lives in Lander, Wyoming, where he still loves to powder ski.*

Luck beats skill any day.

—*Coot Nelson*

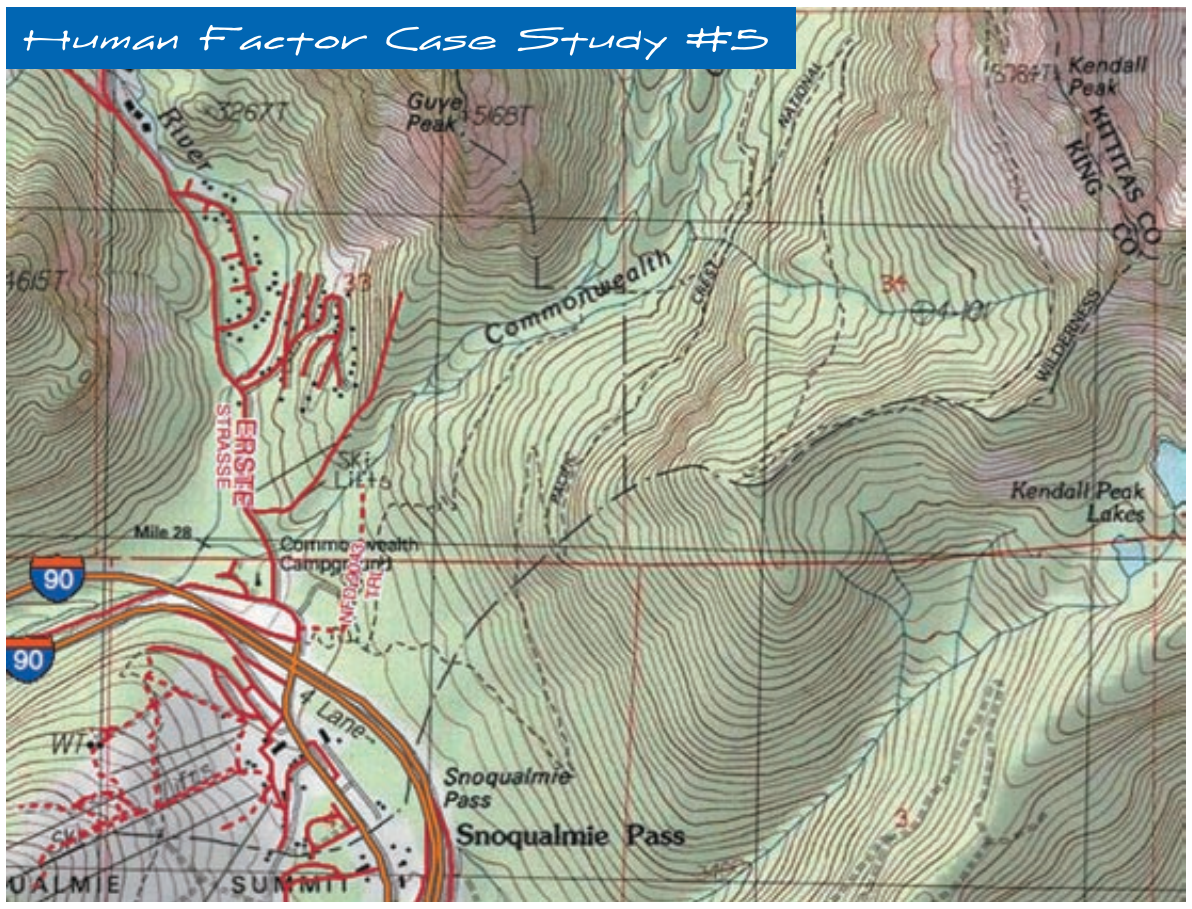
Luck favors the prepared.

—*Louis Pasteur*

When Things Go Wrong

Story by Dan Otter

Human Factor Case Study #5



Dan Otter's avalanche occurred in a wide treed gully to the southwest of Kendall Peak, in the upper right corner of the map, just left of the "P" in Kendall Peak.

On April 9, 2010, I was caught in an avalanche while backcountry skiing with three good friends near Snoqualmie Pass. My friend, Liz, and I were strained through trees and partially buried. Liz suffered minor chest injuries. I sustained massive trauma and nearly died. Statistically, I should be dead right now. But through a combination of experienced partners, rapid Search and Rescue response, and a healthy dose of luck, I beat the odds and will be back enjoying the snowy mountains of Washington this winter.

Good Powder Day Gone Wrong

The 2009/10 winter was defined by pretty meager snowfall in the Pacific Northwest. This made for great ski mountaineering conditions, which allowed me and my friends to ski several big lines in the Cascades. When a series of storm systems came through in early April, we were eager to ski some powder. However, our time skiing in bigger terrain may have skewed our perception of risk in smaller terrain.

My touring partners – Tom, Liz, Arthur – and I had all worked together ski patrolling and all had professional level avalanche and first aid training (OEC and EMT), as well as significant experience traveling in backcountry avalanche terrain. We made plans to go for a tour near Snoqualmie Pass, looking to make the most of the late-season dump.

The Northwest Avalanche Center had forecasted the avalanche danger as high for elevations above 5,000' for the day. The region had seen 20-30" of snow accompanied by backing NW to S winds in the past two days. The precipitation and winds had decreased overnight, and there remained only a low cloud deck that was slowly beginning to clear as we left the parking lot.

We abandoned our initial tour plan after observing fresh avalanche debris and headed to some lower angle, lower elevation trees below Kendall Peak. This option seemed safer given the snow conditions. At the top of the trees, we became enticed by a wide, treed gully that led to a notch above us. As we ascended, we did some quick tests to assess the instability and found easy hand shears within the soft storm snow. Higher up in the trees, the snow had been scoured by wind that had been funneled up through the gully. At the ridge, we cut a cornice onto the wind-loaded east face (we had just ascended a west-facing feature) and saw no results.

Our confidence in the snow conditions bolstered by our tests and observations, Tom and Arthur expressed interest in traversing north to a face we had seen from below. Liz and I opted to ski through the trees we had just ascended. We failed to make any kind of plan concerning how our two groups would communicate or how and when we would travel. This would prove to be a crucial mistake.

Slipping Into Darkness

As Tom began traversing onto a southwesterly face, I descended into the trees, followed by Liz. Just as Liz pulled up to where I had stopped, we heard a yell from above: "Avalanche!" I had just enough time to look up and see the powder cloud barreling toward us before I was thrown downhill like a rag doll. I was wrapped around a tree like a horseshoe, my head and arms on one side and legs on the other. The snow was moving past me at this point, each forceful wave crushing me against the tree. As my stomach contents were forced out of me, I imagined that my internal organs had just exploded out of my mouth.

This was the moment that I had the silent and calm realization that I was going to die. I remember how easily I accepted the fact as I slipped into darkness.

Apparently some part of me was not ready to give up, because I continued to wave my arm, which was above the snow and visible. Tom and Arthur saw the movement as they followed our tracks through the trees to investigate. They found Liz and me only inches apart, wrapped around separate trees, and quickly exposed our airways. Liz told them she was okay, but it was clear that my situation was more serious.

As I was being excavated, I lost consciousness and my respirations ceased. After being repositioned, I spontaneously began breathing again and came to. I was very confused, and it took me a minute of repetitive questioning to confirm that what was happening was real. As I began taking stock and self-assessing, I found that I was having trouble breathing lying down. Tom repositioned me to be more upright and I found some relief. Because of the force of impact, we were concerned about potential spinal injury. I had no neurological deficits and no pain on spinal palpation, so we decided that maintaining an upright position to help me breathe and initiating evacuation would take priority over spinal immobilization.

We had cell phone coverage, and Arthur began making calls to organize a helicopter evacuation. Eventually his battery died and he had to use my phone. He was able to give our precise location using his GPS. He was also able to give the medical team an accurate picture of my condition.

Tom covered me in his emergency bivy sack and got to work creating an improvised sled by lashing my skis and poles together with rubber ski straps and a cordelette. Using my backpack turned upside down, he was able to stabilize my C-spine by wrapping the hip strap around my forehead. I was secured to the sled using parachute cord I had in my repair kit.

A guide who was in the area with a client came up from the basin below to help. He offered hot tea and large mittens to help keep me warm. He and Tom hauled the sled down 400 vertical feet to the clearing below us that appeared to be a good landing zone for the helicopter. Despite the 30-degree pitch, they had a difficult time moving me through the deep snow.

A King County Sheriff helicopter equipped with a hauling winch arrived about an hour after King County Search and Rescue received their initial dispatch at 1335. It took another hour for two medics and a flight tech to package and fly me to the parking lot at Snoqualmie Pass ski area to a waiting ambulance. From there it was another 45 minutes to the hospital. All told, it took an estimated 3-3.5 hours from the time of the accident to when I arrived at Harborview's ER. My extremity pulses were barely palpable by the time I received a massive blood transfusion. I probably had another 1-2 hours to live.

I spent about 20 days in the hospital and a skilled nursing facility. My list of injuries included: broken pelvis, collapsed lung (hemothorax), lacerated kidney and spleen, broken ribs, ruptured ACL, L5-S1 spinal fracture. I have spent nearly nine months recovering, and I ran my first 5K in 26:58 a few days ago. Though I will most likely develop early arthritis, and I lost 85% function of one of my kidneys, I consider my recovery to be nearly 100%.

While not as easily defined or described, Tom, Arthur, and Liz also suffered the psychological trauma of watching their friend nearly die in front of them. The experience of rescuers is often disregarded and wrongly so. Everyone involved in an accident is a victim.

What Went Wrong?

Overconfidence: We ventured into avalanche terrain in high-hazard conditions because we felt like we had the experience and skill to manage our risk. However, we got sloppy and took some shortcuts that ultimately ended in catastrophe.

Poor Communication/Poor Travel Technique: After deciding to split into two groups, we did not discuss how the groups would travel, communicate, or interact.

Limited Terrain Analysis: Low clouds limited visibility when we were assessing the terrain from below. Our position in the terrain did not allow us to see and assess the culprit slope from below. From the upper ridge, we failed to recognize how the terrain interacted – specifically that the slope Tom traversed onto would run right into the gully if it slid.

Overvalued Observations Indicating Snow Stability: Our observations were accurate for specific slopes.

Two different perspectives on the Kendall slide. The left view shows the crown, where the other two members of the party triggered the slide. The right view shows the runout of the slide; Dan and his partner lodged against the lower trees in the slide path. *Photos by Charles Hagedorn*

However, we extrapolated our observations to slopes that were configured differently. The slope that slid was uniquely configured in that it was on the leeward side of a small rib/ridgeline. The wind that scoured the snow in the treed gully had deposited a slab of snow just below the ridge. This shows that snowpack and stability can vary greatly between aspects and elevations. Wind loading can be hard to predict and recognize because it is highly dependent on micro-terrain features.

What Went Right?

Proper Training: The level of emergency medicine training in our group allowed us to make the judgment call to prioritize breathing and evacuation over complete spinal immobilization. The level of rescue training of the group led to rapid excavation of the victims. The level of rescue training also enabled Tom to build a sled and Arthur to effectively communicate with rescue crews.

Proper Gear: Carrying two cell phones made our communication system redundant (carrying multiple batteries would be another option). An emergency bivy sack provided me with crucial warmth. Ski straps and other gear allowed Tom to build a sled. Arthur's GPS allowed him to give rescuers our precise location.

Lots of Luck: We were lucky to only have one patient, rather than two. We were lucky to have cell phone service. We were lucky that the clouds had cleared enough to let the SAR helicopter fly. We were lucky a guide was in the area and volunteered to help us. We were lucky to be so close to Harborview, a level 1 trauma center.

The Bottom Line

We had enough experience and skill to get ourselves into a bad situation, and we had just enough experience, skill, and luck to get us out. By entering challenging avalanche terrain in high-hazard avalanche conditions, we pushed the envelope to a point that allowed few mistakes. And we made enough mistakes to result in catastrophe.

Note: The names in this report have been changed to respect the privacy of those involved.

Dan is a guide and former ski patroller currently residing in Seattle, WA. He is looking forward to starting nursing school this summer at the UW. One day he hopes to have a job that will allow him to afford to guide and teach avalanche courses in his free time. He is back on skis this winter and has been learning to enjoy skinning for the sake of exercise and skiing low-angle powder. ❄

Will the Gladiators Take Over?

Story by Tony Daranyi, AVPRO 2009

A vendor booth at the recent 2010 ISSW in Lake Tahoe displayed an eye-stopping mannequin of a skier. Except that this wasn't your ordinary skier. The mannequin displayed a person who looked more prepared for motocross than skiing. The skier was decked out with the latest and greatest protective gear imaginable, with a full-face helmet, shoulder pads, chest protection, an AvaLung, a RECCO tab, an avalanche balloon system backpack, and, of course, an avalanche transceiver, probe, and shovel. My first thought was to turn away from this image. To be honest, it troubled me.

I wondered, is this really where skiing is headed? What happened to the days of freeriding, where less was more, where the freedom and exhilaration of letting skis or snowboards glide down a slope pulled by gravity resulted in one of the greatest sensations known to mankind? Are helmets and chest protection and AvaLungs and all the rest the new normal for a sport that seemed so simple and free?

Mid-season into the winter of 2010/11, that image is still haunting me. I'm still trying to come to terms with the prospects of what is undoubtedly the continued evolution in the sport. In particular, how do the additions of all this safety equipment fit into our risk homeostasis and heuristics profiles for decision-making in the avalanche-prone backcountry or off-piste terrain that we manage within our own ski areas? As skiers and riders, will we increasingly base decisions on whether to ski a particular slope by what safety equipment we have onboard? Those questions are probably best answered by the snow scientists who actually study this sort of thing (Ian McCammon and company).

But the truth of the matter is that there is a change taking place. We can't deny that. Two years ago, an avalanche resulted in serious injuries for a skier in Bear Creek, the vast backcountry terrain accessed by backcountry gates off Telluride Ski Resort *(see avalanche.state.co.us/acc/accidents_co.php?accident=20090129).* The rider triggered a hard-slab avalanche (R2/D3, 3'-4'x240'x1400') on a dangerous line under dangerous conditions. He was lucky to have survived. The reason for his survival? All the body protection he was wearing. He was equipped with the same shoulder pads and chest protection, etc., as that ISSW mannequin. The doctors said he broke every rib that didn't have protection. His helmet displayed cracks and scratches from the violent ride he took through rock bands as he was swept some 1400 vertical feet down the slope.

As a ski patroller, I'm slowly seeing the same safety equipment starting to infiltrate our profession. I'm an avalanche technician for Telluride Ski Area and a long-time backcountry ski enthusiast. Sure, we've always had beacons, probes, and shovels. But this season, the ski company invested in Snowpulse avalanche balloon packs. And we're now required to wear helmets under certain conditions. ABS packs were already a part of our uniform at the ski area in the French Alps where I worked for a season back in 2005/06.

My concern is this: as professionals, will the decisions we make when determining whether a slope is ready to open for the public be influenced by the equipment that the public is outfitted with? Might we begin determining a slope "safe" for the public based not on sound science and avalanche mitigation work, but more on what the skier/rider is outfitted with? I hope not.

Alternatively, will top management and ski area CEOs expect more risk-taking from their avalanche professionals and ski patrol staff because they've been outfitted in the latest safety garb? That sounds ominous.

In the end, I'm still a believer in common sense when traveling through dangerous backcountry terrain. The acronyms ALPTRUTh and FACETS still seem to be very apropos and the basis of any sound decision-making. The challenge and beauty of route selection and snow-stability assessment cannot be replaced by whatever technology or equipment we throw at our sport.

Or can it? What does the future look like? How will the "human factor" in avalanche country be influenced by changes in the equipment we're outfitted with?

Tony Daranyi is an avalanche technician for Telluride ski area. When not assessing the snowpack in the winter for stability, he assesses the snowpack in the spring and summer to determine what kind of an irrigation season to expect for Indian Ridge Farm & Bakery in Norwood, Colorado, his home, where he and his wife farm organically. ❄

Tale of an Avalanche

…and the personal journey that followed

Story by Ron Simenhois

Some time back I got caught in an avalanche. It can be classified as a near miss. It wasn't especially big nor did it leave me bruised. It wasn't the first time I have gotten caught. It only caught the tip of my skis, pulled me in, and dragged me for about 20' before I managed to dig into the bed surface and remain behind. But it stuck in my mind like a sore thumb, maybe because this time there was no question about the snowpack; this time it was all decision-making.

I knew I was likely to trigger avalanches after reading the weather forecast the day before. I reconfirmed my suspicions that morning when I saw over 40 cm (16") of new snow overnight with winds loading the start zones. If that wasn't enough, we were triggering avalanches as we were descending the slope. In fact, the only pieces of snow that didn't whumpf, crack, or avalanche when we touched it had already failed on approach from a distance. Still I found myself doing the wrong thing in the wrong place. This article describes the incident and my personal journey to turn this experience into an opportunity for improvements.

In touchy conditions with bad visibility, Ron kept edging out into the adjacent avalanche path in order to position the next shot when the slab released. Likelihood was high, consequences low, but Ron learned a lot from his decisions leading up to the avalanche. *Photo courtesy Ron Simenhois*

The Tale of the Day

That morning, my route partner and I got dropped on the ridge. We were about a mile north of where we needed to be to start our route. We skinned for over an hour, negotiating snowy, windy weather through snow up to our waist for the majority of the way. By the time we started the route we were wet, cold, and tired. We triggered avalanches on every start zone on our way down to a lower set of start zones. These start zones are divided into two areas: northerly (higher) and southerly (lower). In addition, we have a weather station above the southerly start zones that rimed up during the storm.

The northerly area is comprised of a slope divided into three poorly defined avalanche paths. Up to that day of the season, those paths had avalanched only once, after a substantial loading event. Poor planning and communication led us both to the weather station and, therefore, too low to control the northern paths from above. Moving toward the face to the north, I found that the first path had already avalanched. I triggered an avalanche on the second path by throwing a charge across from the first path then proceeded to the third path. I skied across a rocky rib toward the third path to find out that the slope was still intact. I backed out a couple of meters (6-7'), and as I stomped on my skis getting ready to take another charge out of my pack, I triggered an avalanche that ran in front of me, grabbed the tip of my skis, and pulled me in. I didn't go very far; I dug into the bed surface and came to a stop in less than 10 m (30') as the avalanche continued down the slope .

Reflection

Personally, I don't like to get caught in avalanches. It is cold, can make you sore, leaves a taste of failure in your mouth, and overall creates a feeling of physical discomfort. Hence, letting an avalanche incident (or any incident) "slide" without debriefing it – digging into it and trying to investigate every possible aspect of it – would be a horrible waste. I had to take full responsibility. After all, the only thing I can change is myself and my decision-making; everything else is out of my control. Furthermore, I am always worried that by not seriously acknowledging the incident, I may be inviting a cognitive-dissonance process *(Tavris and Aronson, 2007)* to manifest itself and eventually open the door to more incidents. Making the best of every incident is something I owe to myself, my co-workers, my friends, but most of all to my family – my wife and kids.

Looking Deeper

The 5-Whys is a commonly used query method to uncover the underlining conditions permitting poor decision-making. Recognizing and minimizing these conditions may help to safely negotiate wider range situations. Applying the 5-Whys method includes repeatedly asking why a situation occurred and repeatedly asking why to the answer of the previous why until the root causes are exposed.

Clearly, it may take more than five whys to uncover the root causes; however, typically five iterations are sufficient. For example: I got caught in an avalanche. *Why?* The snowpack was unstable and I stood in the wrong place. *Why?* There was excessive loading in the last 24 hours; I wanted to see if the slope already avalanched; I approached the slope from the wrong place; I misjudged the interaction between the snowpack and the terrain… *Why?* And so on.

In the end of the process I found that I didn't stop, plan, and communicate because of environmental distractions. I was cold, wet, and hungry, and I wanted to be done instead of stopping and talking it over. In addition, I failed to communicate because my priorities were out of order. I was working with a new partner in an area new to me, and I didn't want to come across as bossy or possibly insult my partner. In addition, getting carried away by the situation and forgetting what was really important allowed my curiosity to cloud my judgment and lure me too deep into the avalanche path. During the early parts of the storm I was closely following the effect of additional loading on ECT results and avalanche activity; I wanted to see if it already avalanched or not. Finally, I was applying personal experience to the wrong situation.

What next?

Identifying the basic causes gave me a road map to better decision-making. I needed to find ways to keep my priorities in order, to use my experience to stop me rather than push me forward in the wrong direction, and to try and minimize environmental distractions. Clearly, simplifying the task of improving decision-making by breaking it into basic causes does not guarantee optimal decisions. Nevertheless, it's likely to help and therefore worth doing. To help me rely on my experience in a safer manner, I seek people who challenge and question my decisions, and I try to encourage others to do so when going into the field. Questioning one's decisions in avalanche terrain is no different than checking your climbing partner's harness and ropes before starting to climb.

To keep my comfort level with my skill in check, I like to remind myself of the Dunning–Kruger effect *(Kruger and Dunnig, 1999)*, a cognitive bias that suggests that unskilled people lack the skills to evaluate their performance and therefore overestimate their ability. In essence, the greater you think you are, the more likely you are to be clueless.

Many things are close to my heart; however, my family is by far the most important of them all. To reduce the chance of losing perspective, I now have pictures of my wife and kids in my office, and I try to talk to my wife before I head out to the field; her input often helps me rethink my actions.

Environmental distractions can be partly reduced by better equipment. In addition, we installed a shelter in a strategic area where we can regroup, change into dry clothing, and talk.

Are these actions enough? Clearly not; my decision-making is far from perfect. There may very well be better ways to go about it, and it is possibly that there is nothing I can do that is enough. What I *can* do is to take ownership of my mistakes and keep seriously reviewing incidents to try and keep them as continually fresh reminders.

References

Kruger, Justin; David Dunning (1999). "Unskilled and Unaware of It: How Difficulties in Recognizing One's Own Incompetence Lead to Inflated Self-Assessments". *Journal of Personality and Social Psychology* 77 (6): 1121–34.doi:10.1037/0022-3514.77.6.1121. PMID 10626367

Tavris, C. and Aronson, E. 2007. *Mistakes Were Made (But Not by Me): Why We Justify Foolish Beliefs, Bad Decisions, and Hurtful Acts*. Harcourt Inc., Orlando, FL.

Ron is an avalanche forecaster in southeast Alaska. He is interested in all snow and avalanche related topics. If you have any insight into snow, avalanche, decision-making, hazard communication, or how to get your kids to sleep all night he is happy to buy you a beer in exchange for knowledge.

education

WHO SAYS You Can't Assign L1 Avy Students Pre-Course Homework?

Story by Jonathan S. Shefftz

So who says you can't assign pre-course homework to Level 1 avalanche safety course students?

Well, pretty much everyone I asked. At my AIARE Instructor Training Course, I was told that some students do request reading materials in advance and arrive with marked-up and highlighted texts and detailed questions. But most students would never complete any sort of pre-course assignments. And a prominent National Ski Patrol (NSP) instructor even told me that a draft outline for my proposed approach was not permissible as an NSP course.

I responded to that definitive rejection with dejection, but had I been motivated to investigate more thoroughly, I would have noticed that the NSP *Avalanche Instructor Manual* explicitly allows for extensive assignments outside of in-person course time. Instead, I spent the next few years teaching traditional courses, at which students arrive with no pre-course preparation and are then subjected to a series of PowerPoint presentations upon arrival in an attempt to convey a basic technical foundation.

Such a typical format is especially painful in New England. Almost all Level 1 courses are taught at the base of Mt Washington, requiring at least a three-hour drive for most students – and much longer for many more students – only to spend prime winter hours in an indoors classroom when an outdoor classroom of 4260 feet of vertical relief is directly above them.

Granted, book learning and other forms of "distance learning" educational resources have their limits. But a major goal of any Level 1 avalanche safety course is for students to learn some basic science. Readily available materials can achieve this effectively, and requiring students to acquire this knowledge ahead of time allows the in-person course time to be used for topics and activities that are better suited for that format. Besides, just what kind of school courses did you take that entailed no preparation or assignments outside of just showing up and vaguely nodding along?

Fortunately the NSP Eastern Division avalanche program supervisor was very supportive of my revised outline once I attempted to reinvigorate my prior attempt at teaching a course with a significant "distance learning" component. The specific format and assignments can be viewed at avycourse.blogspot.com. (Note that although I used blogging software, I structured the blog as a regular Web site. Were I to have to create this all over again, I probably would have used the new free Web site feature from Google, which even supplies an educational course template.) The course schedule entails a [very] full day of classroom activities and outdoor beacon practice in the fall, then a full weekend of winter touring combined with early morning and evening discussions.

The core assignment was to read the Tremper and Volken books, which many students had already read anyway on their own, despite the lack of a Level 1 course or any other formal avalanche safety education. (In fact, I suspect that the widely available and highly readable Tremper book may indeed deter some students from undertaking traditional avalanche courses, since they are reluctant to subject themselves to indoor lectures during the ski season on information they already know to some extent.) Students then completed a review quiz of over 20 pages, which in turn was the basis for an extended discussion at the very beginning of the class. After the fall classroom session, but before the winter touring weekend, students had to extrapolate from the local forecast center's bulletin for its two ravines to another nearby ravine, prepare a touring plan for any Western locale of their choice, and outline an avalanche rescue plan for their favorite New England resort that had been magically transformed to become 10 degrees steeper and with more bountiful natural snow. (Since this is a National Ski Patrol course, the rescue component is far more extensive than a typical Level 1 geared toward recreationalists, although the enrollment for this season ended up with only a single patroller.)

The advantages to this approach were two-fold. First and foremost, my goal was to allow more time during the fall classroom session for discussion and group exercises. We even had time for a fitness-assessment hike with full winter packs, along with an item-by-item inspection of those packs. Then in the winter we had time for a full weekend of touring, along with early-morning and evening discussions of the winter remote-learning assignments. Second, and entirely unanticipated by me, was how much more knowledgeable and informed the students were as a result of their pre-course assignments. From an instructor viewpoint, teaching Level 1 topics to students who have some basic Level 1 knowledge – and have been forced to think about it too – is a much more satisfying experience than the typical lecturing! Plus I noted that most students clearly relished presenting their touring and rescue plans to the group: remember, many of our avalanche-course "students" aren't kids accustomed to being talked at all day, but are instead accomplished professionals who often present to others.

Some of the disadvantages are obvious, although some others took me by surprise. First, this approach limits itself to only the most motivated students who also have extra time to devote to the assignments, so this is hardly the ideal model for a commercial provider trying to put through as many students as possible, or even many NSP volunteer providers who aim

During the Fall Session pack inspection, Jonathan goes through his emergency kit for a student who wanted *all* the details. Jonathan is holding a back-up pole basket, attached to which is accessory cord to replace a Dynafit TLT5 buckle bail, and inside of which is a screw rivet to lock the boot cuff into ski mode in case the upper buckle should ever break off.

Photo by fellow instructor Mark Renson (Mad River Glen and Mount Washington ski patrols)

for widespread dissemination. (I did notice that in addition to backcountry newcomers who wanted to start off with a thorough education, we picked up some very experienced backcountry skiers – I was astonished that these skiers had never taken an avalanche course, but then again this just shows how such a format can allow providers to sign up students who might never take a typical course.)

Second, although getting the students to complete all the assignments in advance of the course dates was easy – "Do it or else don't even bother showing up!" – getting them to do it sufficiently in advance for instructor review was more challenging, although the "reminder" emails eventually worked.

Third, and most surprising, was just how much instructor time and effort was necessary to keep track of completed assignments, review them, and forward them to my fellow instructors. I knew that the students would be spending a majority of their course time outside of the in-person course dates, but I didn't anticipate that the same would be true of me. For a commercial course provider that pays its instructors by the day or hour, the cost for such a course format would be significantly higher.

Fourth, although relying on other organizations' online resources has obvious appeal, outside links or even entire courses can change, be significantly modified, or disappear entirely.

Fifth, my goal had been an enrollment of eight students, but I set the cap at 10, thinking two might drop out, which is indeed what actually happened. Eight students turned out to be the maximum for this format, whether for reviewing homework assignments, touring in the field (I had one other instructor in the field for a 4:1 ratio), or checking all the student presentations on touring and rescue plans. As of press time, the 2011/12 season course is already about to exceed its maximum pre-registration number of eight students.

Feedback on the course Web site and all of this is welcome; also, anyone can copy the ideas and materials from the course Web site. Feel free to give me credit, or just claim it all as your original innovation – either way, as long as the material helps students to learn to be safer, I'll be happy!

Jonathan S. Shefftz patrols at Northfield Mountain and at Mt Greylock (with its historic CCC-era Thunderbolt backcountry ski trail). When he is not patrolling, teaching, or organizing the nascent Northeast Rando Race Series (check us out on Facebook!), he is a financial economics consultant and has been qualified as an expert witness in state and federal courts. He can be reached at JShefftz@post.harvard.edu.

crown profiles

Avalanche Forecasting for an Untouchable Snowpack

A meteorological analysis of the events leading to the June 5 avalanche that buried 11 on Mount Rainier's Ingraham Glacier.

Story & Photos by Kevin Hammonds

This photo of the Ingraham glacier avalanche was taken from a Chinook helicopter in the post-avalanche rescue efforts. A savvy climber can combine 2.76" of SWE in four days from the Paradise Snotel with relative humidity and temp readings from the Camp Muir weather station (10,080', photo below), add in 600 mb pressure levels, and finally, take a quick look at the closest stew-T diagrams to come up with a reasonably accurate interpolation of the snowpack on the upper mountain. This extended June storm in 2010 created dangerous avalanche conditions that impatient climbers were loathe to acknowledge.

The RMI mountain guides who saved 10 of the 11 avalanche victims:

Mark Falender

Adam & Caroline George

Tyler Jones

The phone rang at dawn. The report involved a disastrous avalanche on the upper slopes of Mount Rainier with multiple people buried. On my way to the heli-base, I got my first glimpse of the sleeping giant in what seemed like an eternity – the unrelenting cloud cover had finally moved on. The flanks and rock ribs were blanketed with a fresh coat of snow and shimmered iridescently in the early morning light. Against a deep blue sky there were no visible plumes of snow blowing off the summit like most spring days, hinting at relatively calm winds at the higher elevations. It was obvious that conditions were going to be in favor of a helicopter rescue, probably with the Chinook.

In 2010, summer arrived late to the upper slopes of Mount Rainier. June had turned into "Junuary," and even the marmots seemed keen for summer. The freezing level did not rise above 9000' for any real amount of time until the first week of July, and storm snow accumulations continued to be measured on a scale of feet. Climbers stumbled in and out of the high camps, but few were granted an opportunity for a summit attempt. In stark contrast to the previous summer, when May and June had brought countless summits and ski descents, this not-so-unusual delay of normal spring-like climbing conditions had created a problem that was two-fold. For most climbers, one part was an excessive summit yearning, and the other was a seemingly indignant attitude toward the need for continuing to evaluate a winter snowpack. Although a certain amount of tenacity can often lend itself well to mountaineering in general, this mind-set does not circumvent the abundance of objective hazards on Mount Rainier.

Arriving at the heli-base, we were briefed with the details of the rescue mission: 11 climbers in all had been caught and either fully or partially buried in a dry, soft-slab avalanche. The slide was estimated to have broken out four to six feet deep, run approximately 2000 vertical feet, and scraped clean the entirety of the popular Ingraham Direct climbing route. We were to fly out the most critically injured patients who had already been located and stabilized.

Mountain guides from Rainier Mountaineering, Inc., who witnessed the avalanche from an adjacent area, were the first on scene. Although they were leading a summit climb, they had wisely elected to give their clients some avalanche education in lieu of a summit attempt due to the rising avalanche concern. These guides (named here, as they are unlikely to receive any other formal recognition for their heroism) were Tyler Jones, Mark Falender, Adam George, and Caroline George. Together, they scrambled up the debris pile from below, tugging on every inch of exposed climbing rope they came across in hopes of finding someone attached to the other end. This proved to be an effective tactic, since it turned out that no one was wearing avalanche beacons anyway.

Thanks to the speed of their response, the outcome was not nearly as severe as it could have been. Most notably, one Korean climber who was successfully resuscitated on scene, would not have survived if buried much longer. These four seasoned alpine guides managed to locate, assist, or fully dig out all but one of the 11 victims before additional help arrived. The one still missing, a solo skier who had left from the Paradise parking lot that same morning, has yet to be found and will likely remain entombed somewhere in the vicinity of the Ingraham Glacier.

TOOLS TO BUILD A WEATHER TIME LINE

So, without the local avalanche forecast office up and running, no available surface observations aside from Camp Muir at 10,080', and no snowpit data to look at, how do you determine the avalanche potential of an untouchable and seemingly intangible snowpack? This is exactly what can make climbing Mount Rainier and similar remote peaks so challenging. Often spurring the early morning ascent known as the "alpine start," is the potential for wet-slab avalanches that tend to occur late in the day. But when considering the likelihood of a dry-slab avalanche, this commonly practiced approach alone is not enough to avoid catastrophe.

To help combat the challenges of forecasting for an unfamiliar environment, in our current day and age of high speed internet, much can be gained from simply building and evaluating a time line of preceding weather events. Because weather-data collection and dissemination has proven to be one of the few successful worldwide cooperative efforts, an atmospheric time line can be built from archived data for nearly any location in the world with only a basic understanding of mountain weather phenomenon. The construction of such a time line can be as simple as a sketch in your notebook or as complex as writing a computer algorithm. The duration of the time line can be as short as 48 hours or as long as an entire winter season depending on how investigative you want to be. The three most important sources providing real measurable data, as

opposed to modeled data, are surface observations, atmospheric soundings, and weather maps.

Surface Observations

Surface observations include records from a host of different types of instruments. When evaluating which weather station to use, search for one that is as representative as possible to the area you are going to be traveling in. This would include a similar aspect and elevation as well as position up on a ridge top or down in a basin. Be aware of the effects of the local topography in terms of cold pooling and diurnal winds when performing your analysis. Common measurements useful for a time line include high and low temperatures, wind speed and direction, relative humidity, and accumulated precipitation. It may be necessary to draw from more than one station if these measurements are not all provided at one site. And even if they are, it's still worth comparing trends from one weather station to another. You may need to extrapolate measurements upward or downward if there's not one representative station.

Atmospheric Soundings

Atmospheric soundings display measurements pertaining to the distribution of physical properties within an atmospheric column such as pressure, temperature, wind speed, and wind direction. Essentially, atmospheric sounding data comes from the use of weather balloons, called radiosondes, that are launched on a coordinated schedule simultaneously every 12 hours of every day in varying locations around the world. When surface observations are either not available or not representative – which is often the case in remote mountainous regions – look at the most recent atmospheric-sounding data in the upstream flow of where you plan to be. To help determine the direction of the general flow, use a weather map that depicts the location of the jet stream at the different pressure heights, measured in millibars (mb). For higher elevation peaks, such as Mount Rainier, this can aid you in determining which sets of atmospheric-sounding data are worth looking at and which ones are not.

Weather Maps

In addition to helping determine which atmospheric sounding to use, weather maps can also be useful for both painting a better portrait of previous weather events and forecasting for the future. Archival weather maps can be found for different pressure heights, depending on which is most applicable, and will show former areas of high and low pressure as well as the passage of cold fronts and warm fronts. There are a wide variety of weather maps available online. Some maps have pretty colors and radar overlays, some have surface observations included, and some you more or less need to be a meteorologist to understand. Find and use the map most applicable to your area of interest that best suits your level of meteorological expertise.

ANALYSIS OF EVENTS

The diagram provided by Mount Rainier National Park shows a topographic overview of the Ingraham Direct route and locations where the climbers were thought to be when the avalanche occurred. The starting zone that threatens the Ingraham Direct from above has an upper elevation of 12,800' and an aspect that wraps around from southeast to northeast. The upper-air weather map from June 4, 2010, clearly shows the location of the jet stream, its general direction of flow, and wind speed in knots.

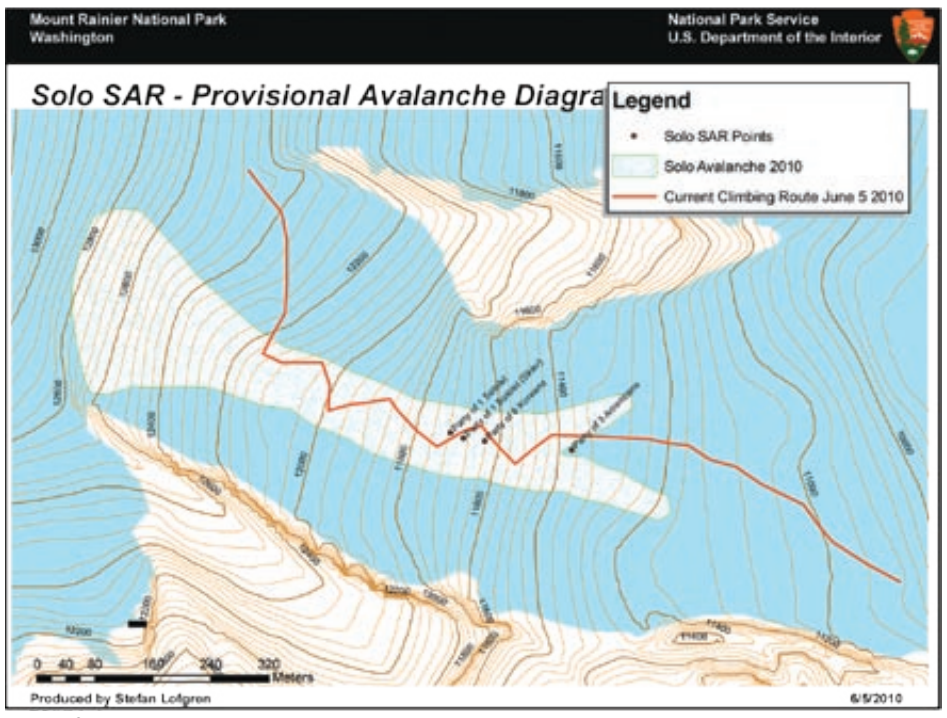
This map was referenced from archival data and is representative of the 300 mb pressure level – about the same elevation as Mount Everest's summit. Although Mount Rainier stands at only half this elevation, around 600 mb, due to the mountain's location near the coast and the lack of any other obstructing terrain, the general flow at the 600 mb level can be considered similar to that at 300 mb. Atmospheric sounding data can confirm or reject this theory. Notice that the general flow of the jet stream as it approaches the Pacific coast is moving over Washington and Oregon from the southwest. Upper-air maps from the previous four days also led to a similar interpretation. From this analysis alone, we can begin to form a hypothesis concerning the potential for wind loading of leeward slopes on the mountain.

Now turning to the best available surface observations – a weather station located at Camp Muir and a SNOTEL site located at Paradise, both of which are on the southeast flank of Mount Rainier – make the most logical choices for representative measurements. The daily maximum and minimum temperatures, relative humidity, wind speed, and wind direction for each of the four days prior to and including the day of the June 5 avalanche were extracted from archived Camp Muir telemetry data. Snowfall totals were then extrapolated from the Paradise SNOTEL data using the formula for Snow Water Equivalent (SWE) and assuming a typical Pacific Northwest 10% density.

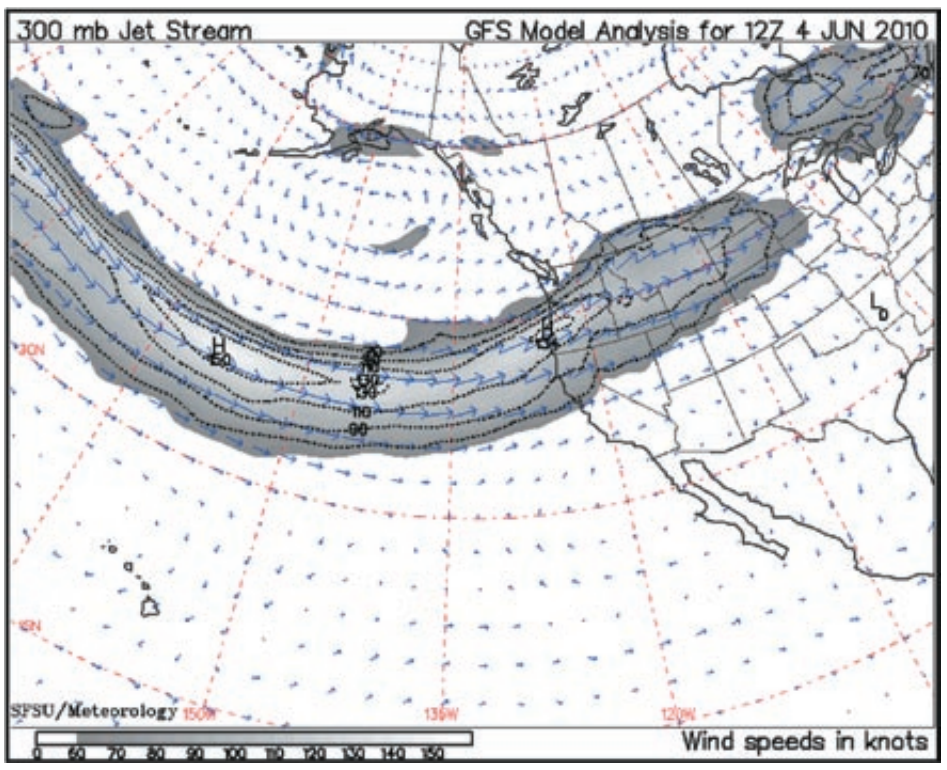
SWE = Snow Depth x Snow Density

In the time period from June 1-5, the Paradise SNOTEL received 2.76" of precipitation. Because it is not unusual for it to be raining at Paradise while sunny and clear at Camp Muir, it is important when making such assumptions about the snowfall amounts on the upper mountain that the relative humidity for Camp Muir, additional atmospheric sounding data, and a 500 mb weather map be taken into account. Congruent with all available data, as well as personal accounts from those actually on the mountain in the days prior to June 5, Camp Muir and above received approximately 2-3' of snowfall. Camp Muir winds were also recorded as strong and persistent from the southwest at an averaged maximum of 40 mph.

Because the summit of Mount Rainier is at 14,410' while the highest available weather station in the Northwestern region is Camp Muir at only 10,080', atmospheric sounding data can be used to glean further information about winds aloft. With the atmospheric flow already determined to be coming out of the southwest, the Salem, Oregon, atmospheric sounding was used to ascertain average wind speeds and direction for the 600 mb to 700 mb



Map of the avalanche on the Ingraham Glacier, with the climbing route and the location of the buried climbers marked. *Diagram by Stefan Lofgren*



This map of the jet stream from June 4, 2010, shows high wind speeds pointed right at Mt Rainier.

Once the data are all in one place, an untouchable snowpack doesn't have to be an unknown.

pressure height. The sounding data showed a very similar outcome to that of Camp Muir with very consistent southwest winds but a stronger averaged maximum wind speed of 55 mph.

CONCLUSION

The time line created to illustrate all the data discussed above, combined with some knowledge of the local topography such as the aspect and slope angle, would indicate a very high probability for significant wind slab development in the starting zone above the Ingraham Direct during this period of time. June 5 was the first real break of a several-day storm, and forecasted high temperatures alone for that day should have been enough to cause most climbers some concern. The exact trigger for the avalanche that buried these 11 climbers remains unknown, but is thought to have been triggered by at least one climber or perhaps the combination of them together. Other possibilities could easily be a cornice drop, the collapse of a serac, or perhaps just natural activity associated with the

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Mt Trelease Avalanche and History

Mt Trelease is located just west of Loveland Pass, Colorado, and adjacent to the Loveland Pass ski area.

From Dale Atkins:
Info on the slide *(all dimensions measured with GPS, 50 m tape, and altimeter)*:

Date: 2010-12-22
Time: 2405 (or maybe the evening before)
Path/Area (specific to general): Trelease, Mount Trelease, Loveland Ski Area's backcountry, Front Range, Colorado
Class: HS-N-R4/D2.5-O/G
Aspect: NE to E (mostly E)
SZ Elevation: 12,310'
RO Elevation: 11,900'
Vertical: 410'
Slab width: 1800'
Slab thickness: 8'-26'
Much of crown was 8-10' – where I am standing in the photo measured 26 feet! *(see photo, below right)*

This was an impressive avalanche cycle but it did not come close to comparing with Feb 1986 and Feb 1995 cycles. Interestingly, there is no record of this path running in '86 (probably the biggest cycle since the late 1880s, at least until the 1995 cycle). Locally in this immediate area, the Feb 1995 cycle produced many more – and also bigger and thicker – avalanches than Dec 2010. At least one in the 1995 cycle was much thicker. Trelease ran in Feb 1995 but was unremarkable. There were some big avalanche cycles in the 1950s, but back in those days, no one recorded slides on Trelease.

From Halsted Morris:
Back on February 22, 1998, Cathy Fraser, Lee Metzger, and I skied in and looked at an avalanche in this bowl. My pit book says that back then the avalanche was a HS-4-N-O&G; it was estimated at 800' wide, 400' vertical run with a 7' to 10' fracture line. Doing a "ruff" measurement on the topo map, I'd estimate this avalanche at 2,000' wide. Fracture depth is harder to estimate, but I'd say its in the 12+ feet deep.

Sidenote: In the wide angle shot *(top photo)*, the viewer's right lower corner is the location of the second avalanche accident fatality in Colorado this season. Kyle Shellberg was the victim; he was a student of mine and friend. He was also a former pro ski patroller at Loveland Ski Area. ❄

Top photo by Doug Evans.
Bottom two photos by Dale Atkins.

Human Factor Case Study #7

Near the top of the slide one can see two tracks in the bed surface. Those are PY's and Maxim's tracks after the fact, dropping in approximately where the slide was triggered. The cliff below the tracks was the intended feature for Maxim and I. The looker's left side of that feature was where the snow was barreling like a wave. I ended up looker's left two thirds of the way down the slope out of frame.

Coast Mountains Avalanche Report

Story & Photos by Athan Merrick

On February 8, 2011, I headed to the Pemberton Ice Cap, just north of Whistler, British Columbia, to film with skiers PY Leblanc, Mathieu Gagnon Theirault, Maxim Arsenault, and Dave Gheriani, for my production company Dendrite Studios. We accessed the terrain via snowmobile and choose that specific zone on the Ice Cap because it was sheltered within a tight valley from the recent strong winds. It is a zone we had filmed previously in the season; we wanted to go back to film more unique angles on the slope. Filming on slope and beside the athletes is a feature I feel separates Dendrite Studios from some other ski film production companies. It also carries higher risk for all involved, because there are two skiers on slope – something that we are all very conscious of, and a lot of ski photographers and cinematographers are aware of.

We skied some northeast aspects earlier in the day that resulted in one small release due to the impact of a landing off a large cliff. The release did not propagate very far and was around 10 meters across. It was briefly commented upon within the group, but did not raise any flags.

We moved on to an east face around noon. The sun had been on the face all day, but being far north and still relatively early in the winter, with well below 0º C temperature, we decided to pursue on-slope filming. We picked out the features from the bottom and doubled up on the sleds. By this point it was 1pm. The first feature went smoothly on the steeper upper section of the face. The face then flattens out before a final steep section. We were on top of a ridge-type feature above some cliff bands in the final section, and it was pure ice due to a recent rain event before the 15 cm of new snow fell with strong winds. We talked about doing a shot on the cliffs below and PY backed off.

PY Leblanc has been sled skiing in the Coast Mountains for over 10 years. He is considered a pioneer of many of the zones commonly seen in ski and snowboard films in the Whistler area. He is a former champion of freeskiing competitions and has put out numerous film segments. He is currently unsponsored and supporting a family. He is out in the mountains for the pure love of it. He is 37-years old and his segment from our film from last year, *Out of the Shadows*, may be his best segment ever. I have a lot of respect for PY and his clarity in the mountains, but at times his confidence scares me. This was the first time I have ever seen him back off of something. PY later said, "Given all of the circumstances, it just didn't feel right." PY's intuition from many years of experience clearly played a role in his decision-making and feelings on the slope. *(See "Intuition in Expert Decision-Making" on page 16.)*

Maxim and I decided to go to his Maxim's feature, which was lower down. I jumped off a small 3' air into a chute/bowl area with the intention of going to a slight spine that made its way down to a cliff band to shoot. The jump was fine, but as I was skiing across the slope, everything broke a foot deep.

Everything happened in split seconds, and I had 10,000 thoughts and scenarios overlapping each other. The dominant thought was always analyzing the situation and trying to get out. I was traveling to my left, and my first reaction was to straight-line. That thought evaporated by looking down and seeing that the entire slope was breaking all the way down to the glacier. To the left of me everything was breaking for hundreds of feet. To the right everything was breaking, but only 100' further due to cliff bands. I looked above to see it breaking 75' above me, but I also noted that PY and Maxim were not caught in the slide. I shifted to my right and dug my edges in as hard as I could to not get taken. I was quickly rushed into a chute to my right.

It was quite apparent I was going for the ride. The snow was funneling against the left wall of the chute, banking off it like a wave and curling over about 10' high. At this point I threw my poles, put my AvaLung in my mouth, and bit down hard because I was 100% convinced I was going to be buried. I could hear Maxim yelling, "Avalanche, avalanche – watch him, watch him," to make sure Mathieu at the bottom was following my last-seen point.

The wave of snow off the left wall curled on top of me, and I was completely under the snow. I continued to fight it, trying to go right. I was swimming with my arms to try to keep my head up and using my skis to try to keep moving right. Right was my only chance to get out of the slide. Two thirds of the way down the slope, I popped out of the side of the slide and watched the whole slope crash down into the glacier below while the snow continued to rush by me. I had a quick glance uphill to make sure nothing else was coming down then took my AvaLung out. I bent down and took a huge breath and screamed, "F**k!" a couple times. I yelled up to Maxim and PY that I was skiing down and to wait. I found my poles quickly and skied down to the sleds, fell over, and relaxed. I hope to never experience that again or anything close to it.

Post-Slide Observations

- Trust your gut. PY backed off on something because he didn't like the feeling of what the snow was doing. Listen to the more experienced users. They will not always be there though, and they should never trump your own personal bad feelings. While I did not have any bad feelings, I should have heeded his.
- Pay attention. The ice on the ridge was the most apparent layer of ice I had seen since the rain. The snow had clearly been blown completely off it. The bowl where the slide occurred was fresh. The wind had clearly not stripped the snow. I should have seen this sign and am disappointed in the fact that I didn't.
- Terrain management and travel. In general I always maintain safe passage priorities in the mountains. I stay to ridges and spines. I do not cross big bowls and always have safety zones in mind. Because we had picked out features from below, I simply ignored those rules as I traveled to the next feature. We should have ruled out that feature at the bottom when choosing them, because there was no safe way to get to it.

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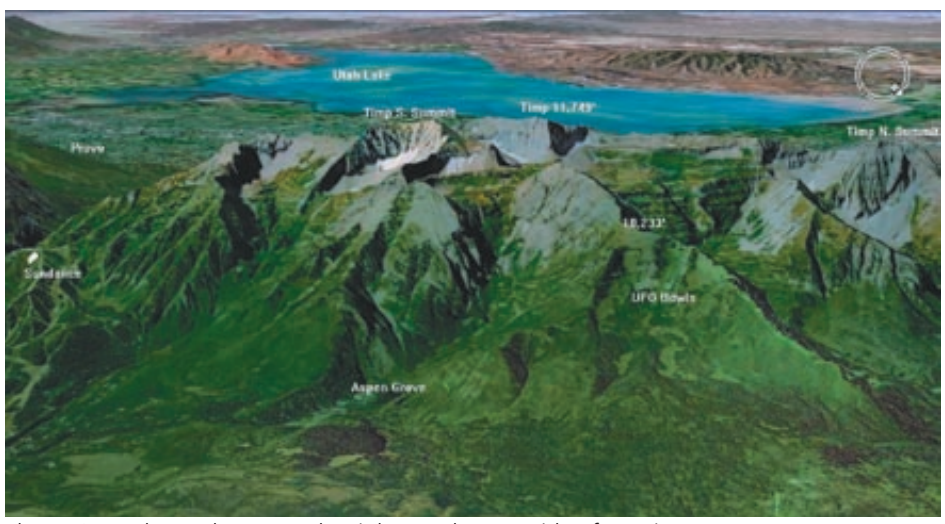
Human Factor Case Study #8

UFO Bowl: A Study in Human Factor

Story by Craig Patterson

Ah, the human factor…that little guy at the center of Fesler and Fredston's Avalanche Hazard Triangle from *Snow Sense*, surrounded by snowflakes, a hill, and a layer cake of snow? Isn't that just a nebulous concept at the heart of the many lectures that we throw at our students attending avalanche courses, hoping that it will stick and help them recognize the "how and why" of decision-making in avalanche terrain? The human factor doesn't affect professionals working in the snow, because we are the ones teaching others about it, right?



The UFO Bowls are shown on the right, on the east side of Mt Timpanogas.

THE LEAD UP

On February 23, 2010, Bill Nalli and I, both employed by the Utah Department of Transportation, ventured behind the Timpanogos Massif in the Southern Wasatch to track a recently buried layer of surface hoar. We frequent this area to monitor the snowpack and apply what we find here to our larger avalanche paths that affect US Highway 189 through Provo Canyon. This terrain is relatively more forgiving and can be accessed without the same level of exposure as entering Bridal Veil, Lost Creek, or Slide Canyon – 5600' slide paths to the south.

It was the first bluebird day after a mild five-day storm period that deposited 30.75 cm of snow and 2.8 cm H20 with light NE winds on top of a layer of 3-5 mm surface hoar that formed on February 16. This was the third such layer of SH to be deposited in the southern Wasatch during the month of February, each layer subsequently buried by small storms that came in with light winds, preserving the feathers intact and upright.

Upon arriving at our intended destination via snowmachine, we noticed many unusual surface disturbances in a zone that sees relatively little traffic (compared to our neighbors to the north). Sled traffic in the meadows and lower slopes was extensive, which is normal for the area. The four snowshoe tracks that climbed the slope en echelon and walked across two starting zones were not normal. Neither was the single file line down the gut of UFO Bowl #3 that the snowshoers had used to descend from 10,000' to 8400'. We pondered that track for an hour or more on our ascent, not sure at first if it was an animal track, cornice fall, or a boot pack. There were also four sets of ski tracks on the skier's right side of the bowl and a few partially covered crowns from avalanches that had likely run during the storm on February 20.

The area appeared "hammered," which led to numerous discussions about what had happened back here in our quiet neck of the woods. We were familiar with the area and had never seen it like this. The word was out about the UFO Bowls. The tracks across the slope were a distraction, and we took some comfort in the fact that most of the area had been thoroughly "tested."

THE SNOWPACK

While ascending our normal route up a sub ridge leading to the main north-south ridge that connects all of the bowls, we marveled at the mayhem that had occurred back here and the poor route decisions of others. At 9880' I stepped onto an ENE aspect and dug a hole in the snow. The structure was comprised of a buried layer of 3 mm surface hoar, 20-25 cm down, with a fist-hard layer of precipitation particles above and a 4-finger hard layer of decomposing fragments below. A second layer of buried surface hoar from February 10 was also present but not reactive.

Two compression tests were performed with scores of CT11 Q2 and CT12 Q2. A tilt test also revealed the 2/16 layer of buried SH. A discussion ensued that the weak layer we had come to monitor was present, but that there was not enough of a slab on top of it for it to be reactive in this area today. It was 1300, the sun was beating down, and Bill joked about escaping the heat by trying to hide behind a lonely pine tree on the slope. Leaving the pit location, we climbed back to the ridge and continued to our highpoint of 10,050', the top of Bowl #3. Winds were calm, the sky was clear, and the late winter solar radiation was strong. Looking southwest, we noted the only recent sign of instability that we observed that day, a SS-N-R2-D2 on steep, rocky, northeasterly-facing terrain below the 11,749' summit of Timpanogos.

Preparing for the descent, we felt confident that it would take more of a load to activate the 2/16 buried surface hoar layer. Little did we know that the ambient air temperature currently was +1.5ºC. We knew it was warm, but missed the rapid rise in temperature from -14ºC that morning. It's likely that creep rates were accelerated in the area, adding stress to an already weak structure. The trap was set; all that was needed was a trigger.

THE DESCENT

We had committed on this day to coming to the UFO Bowls, taking a look at our buried weak layers, and likely skiing some good snow on the way out. No discussion was ever had about our exit run. We came, we saw, we conquered…something like that. Bill dropped in to the line first without either of us making a plan. We had skied in this area so many times before that it went unsaid how we would manage the descent. From the top of the bowl, the obvious line descends next to a stand of mature conifers and doglegs to the right. The individual remaining up top cannot see his partner down the run, so we historically have managed it by time; watch the clock until 2+ minutes have elapsed, which allows for the first skier to descend and pull up below on an island of safety.

At the 9400' elevation there is a steep convexity through a slight choke in the terrain. It is at this point that Bill began to trigger manageable soft slabs on our 2/16 layer. It's likely that the warm air was moving upslope, and this was the first trap. Bill pulled up, as we do when we trigger avalanches, and stopped to take a look at the slab and weak layer and take photos.

I was above; two minutes had elapsed and due to all of the tracks on the slope, I sniffed out my own fresh line. The finite resource laden across the slope felt scarce – now or never to get fresh

above: Looking back up the path of UFO Bowl #3 after the avalanche occurred. Bill's final position is circled. Note the debris running through the trees, the small crowns to the left that Bill triggered and was photographing, and Bill's tracks coming down from the top.

left: A look at UFO Bowl #3 the morning of the incident with tracks on the slope: some human, some from an unidentified mammal.. *Both photos by Bill Nalli*

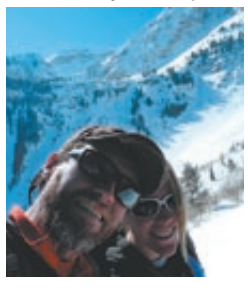
tracks. I chose to descend through the NE-facing trees close to the sub-ridge line, believing there to be better snow and less traffic, unaware that there was slightly more snow here due to wind transport. At 9800', I unintentionally triggered a SS-AS-R2-D2-I, 25-40 cm deep, which propagated above me 100'. The debris caught and carried me into a stand of trees and partially buried me up to my thighs. After yelling, "Avalanche!" in surprise, I watched the debris accelerate downslope rapidly, confident that my partner was safe below me to the right.

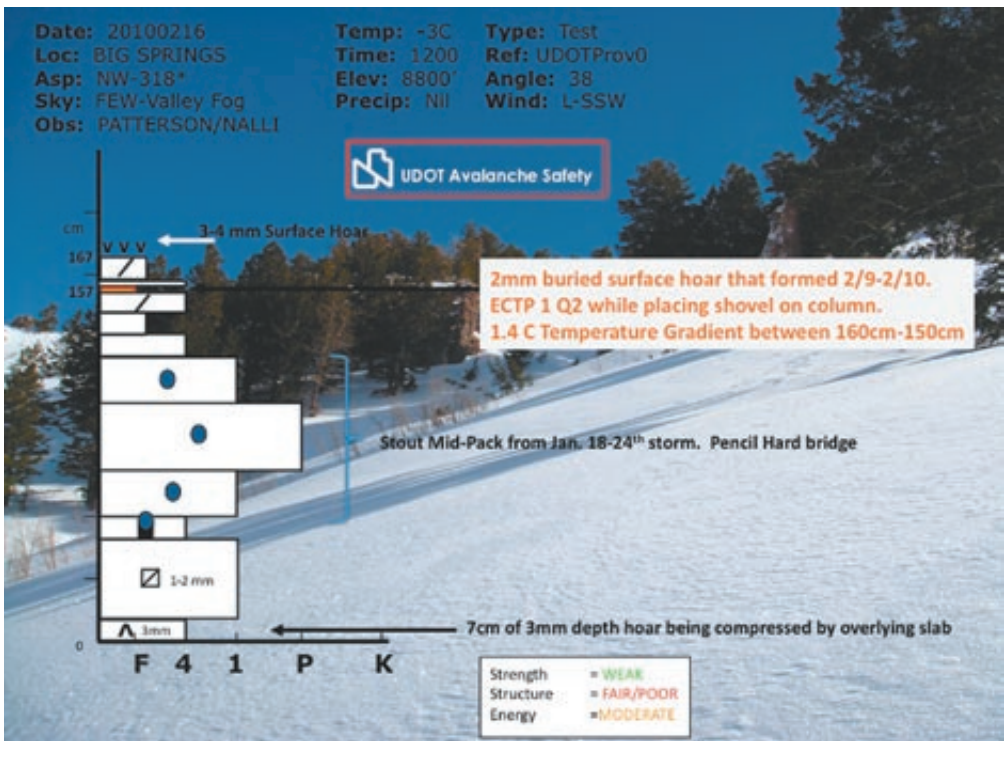
I freed myself and traversed into the track, realizing suddenly that this was a much larger avalanche due to it entraining snow as it raced downslope. I was unable to make contact with Bill and quickly understood that he wasn't safe below me. I initiated a signal search with my transceiver and once I reached the convexity in the line, I was able to see his red coat at the tongue of the debris.

Bill was partially buried on his side and attempting to dig himself out. It turned out that he was in the track and was finishing taking pictures of the two avalanches that he had triggered on his descent. He was putting his camera away when he was broadsided by snow and sent through the spin cycle, bashing small alders on the way down. He ended up leaving some gear underneath the debris and, more significantly, injuring his knee. Bill had torn his ACL the season prior and was fairly certain that he had just repeated the calamity. It turned out that he suffered a deeply bruised knee capsule and only missed a few weeks of being on his skis. His surgeon proclaimed that this was indeed proof that the original ACL surgery had been successful.

We made a lot of mistakes and got away with them on this day, walking away humbled with tails tucked between our legs. Many obvious clues were present; arguably six of seven from McCammon's ALPTRUTh acronym. Adding insult to injury, we succumbed to the common expert traps of familiarity, commitment, and scarcity. Mostly, we were distracted and approached the day slightly cavalier. We didn't maintain a running dialogue, and when we needed it most, we didn't have a way to communicate with one another that conditions on the ground had changed. A small avalanche was triggered in relatively unforgiving terrain. All things being said, the outcome, although significant, turned out better than expected.

Craig Patterson is an avalanche forecaster with the Utah Department of Transportation and an educator with Utah Mountain Adventures. He started working in the snow as a skiing and climbing guide in Alaska and now calls the Wasatch home, where his best days are spent chasing his daughter around the ski hill. He hopes to someday be able to better recognize the human factor in the field and practice what he preaches to students. ❄





In the benign snowpack of the Coast Mountains, steep rocky terrain usually lets you get away with making a few mistakes, but not this time.

COAST MOUNTAINS AVALANCHE

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- Heed warnings. The earlier small release should have raised warning flags in everyone, potentially even sending us all home for the day. At the very least it should have prevented us from shooting on slope.
- The sun. While I am not convinced it played a major role – due to cold temperatures, sun still low in the sky, and a slight haze – it still should have been discussed as it quite possibly contributed to the release of the slope.
- AvaLung. The ability to keep an AvaLung in one's mouth during a slide has been questioned before. My thought process regarding the AvaLung went something like this: "Throw poles. Get it in mouth [which I did with my hands]. Oh God, what if I waited too long? I always hear how if you wait too long you're screwed. YES. It's in." I did not even remotely think about it after that. I guess I just bit down hard instinctively. The next time I thought about it was after I was out to the side and spitting it out. Perhaps it helped that earlier in the day I had it in my mouth and took a few breaths. That couple hours ago familiarity could have made a difference.
- False sense of security. We are blessed and cursed here in the Coast Mountains that 99% of the time we can get away with skiing things you couldn't anywhere else. I am rarely ever concerned with any layer beyond the recent storm cycle here. That false sense of security perhaps contributed to this incident.
- Check the report. The Canadian Avalanche Centre staff are very good at their jobs, and I should have paid more attention to their report – and I will from now on. Their forecast nailed this slide on the head. The danger rating for the alpine was "Considerable." They focused avalanche problems as "wind slab on NW, N, NE, E, and SE slopes below ridge crests." Their snowpack analysis included, "10-30 cm of new snow is upside-down and bonding poorly to a variety of old snow surfaces, including hard crusts and ice layers." This slide was a wind slab, on an east face, below a ridge crest, 30 cms deep on an ice layer. *See full report at www.avalanche.ca/cac/bulletins/archive/south-coast/27616*

Final Thoughts

I was convinced I was going to be buried, but never stopped fighting to get out of the slide. PY, who had a clear vantage point of the whole thing, later said, "It's a good thing you are an athlete, because I don't think you would have gotten out of that otherwise." I was also somewhat comforted by the fact that my two partners were above me, safe, and could come down quickly to find me. One more partner at the bottom for spotting further reassured me of a safe recovery. But the biggest thing was that even when I was completely submerged, I was still actively trying to get out with all my might.

An additional thought on avalanche gear. I have thought for a while that I should invest in an avalanche airbag system. I've just been too broke is the real reason I haven't pulled the trigger. I still think I want one. We talked about an airbag afterwards. There is no denying that in major catastrophic slides, like Xavier de la Rue's from a couple years ago, the airbag 100% saved his life *(see vimeo.com/2492092 – slide description begins at the 30-minute mark)*. In this slide I would have 100% pulled the cord no question, but I think there is no way I would have made it out the side of the slide with an airbag deployed. I would have been dragged all the way to the bottom with potential injuries. PY said he has refused to wear one in the past with a different film crew for that reason, but agreed for certain big terrain he wouldn't mind having it. Interesting topic for debate nonetheless.

Athan Merrick is a former competitive big-mountain freeskier with four top-five finishes at international events. He grew up in Santa Fe, New Mexico, skiing the desert cold smoke. Currently he spends his winters in Whistler, BC, skiing a coastal snowpack and running Dendrite Studios. Dendrite's first film, "Out of the Shadows," won the Best Big Mountain Film of 2010 at IF3, and was a Sierra Nevada award winner at Mountain Film Festival.The film is now available for a "pay what you want" rate only at dendritestudios.com. Athan spends his summers working in the Vancouver film industry as a cinematographer and lighting technician. ❄

UNTOUCHABLE SNOWPACK

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solar radiation from first light. This piece of the puzzle, along with where the solo climber may have been laid to rest, remains a mystery.

To no avail, climbing rangers the evening before had warned climbers at Camp Muir of the hazardous conditions on the upper mountain. But the question is not whether these climbers should have listened to climbing rangers or should have been able to foresee such avalanche conditions on their own. Mountaineering is an inherently dangerous activity, and certain associated risks must be accepted in order to take the next step towards the summit. The real question at hand is whether or not these climbers (or other such climbers under similar circumstances) have at least been exposed to all the resources available to help make the most educated decisions possible. Although there is admittedly much more to factor into the equation than just some data from the internet once you do actually find yourself staring up at a mountain, it has been my experience that such tools can be exceedingly useful in determining the overall disposition of a place before you even arrive. And as it turns out, you do not have to be an avalanche forecaster, meteorologist, or veteran mountain guide to hone this skill – you just have to take the time.

METEOROLOGICAL INFORMATION ONLINE

Surface observations:
mesowest.utah.edu

Atmospheric soundings:
weather.uwyo.edu/upperair/sounding.html

Weather maps:
www.intellicast.com

Mountain weather forecasting seminars:
www.mountainweather.com

Weather and climbing route conditions for Mount Rainier:
mountrainierclimbing.blogspot.com

Kevin Hammonds has been a climbing ranger at Mount Rainier for the past three seasons and has just joined the Sylvan Pass avalanche forecasting staff at Yellowstone National Park. He formerly was a member of the Park City ski patrol and the Baker River Hotshots. He will be starting graduate school in the Department of Atmospheric Science at the University of Utah this fall and claims that although he will miss his seasonal lifestyle, he looks forward to facing new challenges and spending more time with his new wife, Kate Meyerhans.

An image from an avalanche on Mt Rainer this past June, where a big cycle this spring caused an incident that involved 11 independent climbers, four of whom were buried, three out of four recovered. One was never located. SS-N-I-R4-D4 *Photo by Jason Thompson, jthompsonphotography.com*