

THE AVALANCHE REVIEW

CHAIR 2, ALPENTAL: Snow Safety Director Bram Thrift enjoys a moment of solitude while riding above the East Pass Flow on his way to early morning avalanche hazard reduction. East Pass Flow is a local weather phenomenon where cold air from Eastern Washington flows through the lower mountain passes resulting in a localized temperature inversion. The influx of cold air will often depress the snow level in the passes, or it may set up the conditions for a freezing rain event. In Washington State this past winter several freezing rain events have occurred in the passes resulting in damage to trees and impacts to highway travelers and ski area operations, not to mention creating some interesting ski conditions. *Photo John Stimberis*

**DECISION-
MAKING
ISSUE** PAGE 26

THE AVALANCHE REVIEW

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Jim Woodmency is the chief meteorologist at mountainweather.com and has been forecasting the weather in the Teton Range for 25 years. He is a product of Montana State University and the early tutelage of Dr. John Montagne. Back-in-the-day (mid-80s), he worked as an avalanche forecaster for the State of Alaska. Jim's goal is to try and ski every inch of powder that he forecasts.



Mike Richardson is a software developer from Seattle, WA. He is known to like cookies, and can be reached at operativem@yahoo.com.



Todd Guyn is the Mountain Safety Manager for Canadian Mountain Holidays (CMH), the oldest and largest heli-ski operation in the world. Todd is a 30-year veteran IFMGA mountain guide and he trains and examines new guides for the Association of Canadian Mountain Guides (ACMG). Todd currently sits on the following committees: Heli Cat Canada (accreditation), ACMG (technical), CAA (Infoex advisory group, Explosives).



Thomas White grew up skiing in Summit County Colorado and started exploring the backcountry as a teenager in 1977. In 2012 he traded a real estate career for the rewards of working on skis. He patrols at Eldora Mountain Resort and teaches avalanche courses for Colorado Mountain School.



Over the last year **Doug Krause** laid turns and popped slabs in Colorado, Chile, Japan, Alaska, and Norway. He is uncertain where his snowy path may lead next; that is acceptable.



Kevin Grove is a Associate Professor of Physics and Engineering at Central Oregon Community College and the Science Department Chair. He is a Central Oregon Avalanche Association board member and is the director of COAA's professional observer program. Kevin has been climbing and skiing for over 25 years and is stoked to be a new dad. He has a M.S. in Chemical Engineering from Montana State University.

FROM THE EDITOR

BY LYNNE WOLFE

As you read this spring issue of *The Avalanche Review*, please keep in mind a few editorial guidelines. TAR's purpose is to be a forum for people to share practices and develop ideas, then generate thought and conversation. We're more informal and open than a peer-reviewed journal, and that makes us able to print art and poetry and fiction and speculation. I make every attempt to have our writers create valid constructs, cite their sources, and respond to editorial concerns. It is up to YOU, the reader, to further weigh their arguments from other viewpoints, evaluate how they fit into your world view. The goal is to prompt you to THINK, to examine your own beliefs and practices against new perspectives. If you have thoughts or concerns about a TAR story, please put them into a letter to the editor, begin a dialogue, ask for further explanation of a thought process, or privately reach out to the author.

In the TAR section titled *News*, you will often see spotlights on new avalanche-related commercial ventures. I strongly believe that offering these announcements is part of our mission and a service to hard-working members of our community, whether as innovator or as potential customer—what's the latest in our field? And like any good dealer (of information), the first one is free, then please, buy an ad and support the AAA.

In this TAR you'll find the usual April theme of decision-making; this particular issue carries a more subtle focus on using uncertainty in our practice. Mike Richardson leads off by digging deeper into cognitive biases (check out the intricate graph on page 28) and how protocol and trip planning help resolve the inevitable subjectivity of perspective. Check out Cy Whitling's illustration of Mike's concept of decision-making as a flow chart on page 26. Doug Krause isn't subtle in his dislike of the term confidence, but he replaces it with uncertainty, throwing out a challenge to us to revise our language and our protocols. Thomas White, in his book review of *Wiser*, challenges us to reconsider our preconceptions and try utilizing taking a vote rather than persuasive discussion in order to achieve better decisions. Todd Guyn reprises his popular ISSW presentation in *10 Common Missteps of Avalanche Practitioners*, where acknowledging uncertainty is once again cited as a necessary activity for staying alive and avoiding hubris. Next, in a self-aware Cascade case study, Kevin Grove points out the foibles of not using a decision-making strategy.



Photo Dan Powers

The remarkable winter of 2016-17 led to a well-deserved second focus on Storm Stories. Benjamin Hatchett gives us meteorological context on page 18, while Zach Guy, Art Mears, and Brian Lazar translate atmospheric rivers into avalanche forecasts in *Going to Extreme*, page 20. Jim Woodmency compares the storm story of 2017 to that of 1986, with some dramatic photos from Renny Jackson (1986) and WYDOT's Jamie Yount and Brian Gorsage (2017). A few other storm snapshots are sprinkled through the pages. Thanks for sharing images and



TOP: Allen Steckmest and Jodi Redfield, Friends of the GNFA educators, survey the avalanches on Wolverine Mountain on the north side of Lulu and Daisy Pass outside Cooke City. There were large avalanches on most peaks in the area. We were treated to perfect visibility the day after the avalanche cycle ended.

BOTTOM: A close-up of the crown line on Henderson Mountain. A snowstorm dropped 11" of SWE with strong winds and the facets weak at the ground couldn't support it any longer. This slope last ran this big in 1997. It put 20+ feet of debris on the groomed snowmobile trail. The danger was Extreme, the first time this rating was ever used at the GNFA. Photos Doug Chabot

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stories to Karl Birkeland, Doug Chabot, Erich Peitzsch, Jim Donovan, and AAA President John Stimberis, whose cover chairlift shot invokes the feel of early morning missions on an old double chair. I eagerly anticipate including more scenes from this snowy winter in the 36th volume of TAR: please share them with TAR in the next volume. See deadlines below.

You'll also find two articles on the deep slab problem. The first, from Patrick Wright of Jackson Hole Mountain Resort, investigates an avalanche cycle in Wyoming in December 2016. The second, an unexpected deep slab event in the Birthday Chutes near Snowbird, leads Drew Hardesty of the Utah Avalanche Center from the slide itself (thanks to Mark White for stunning photos) into musings on the nature of decision-making and forecasting along the life cycle of a deep slab problem.

Ski patrollers: we bring you relevant and useful insight for your own patrol training in a suite of pieces about workshops from Leadership at Play that aim to update culture-related topics such as leadership and communication, beginning page 11.

It's been a busy winter and I'm yearning to wear sandals, but a deep mountain snowpack will keep me exploring on skis for months to come. ▲

Deadlines for next volume:

August 1 for TAR 36.1

October 1 for TAR 36.2

December 1 for TAR 36.3

February 1 for TAR 36.4

FROM THE PREZ

BY JOHN STIMBERIS

What a winter it has been! Lots of snow and the skiing has been great. Here in the PNW, and especially on Snoqualmie Pass, it's been much colder than normal. The cooler weather has translated to a general lack of rain-on-snow events in my hood (freezing rain notwithstanding). Winter can be so fast paced from season start through the many holidays. It seems like it's mid-February before it settles into place and then suddenly you take notice of how much longer the days are getting and spring is right around the corner. Fortunately we'll have snow to last deep into the spring.

Two things I really love about life are music and snow, and I find a strong connection between the two. Music, like the snowpack, is constructed from many different layers and they may work in unison or contrast. There may be a moment of rising tension that is eventually resolved, much like an avalanche cycle. The rhythm creates a pattern and establishes timing. Our work in the snow, particularly with avalanches, is also dependent on timing and patterns. We learn the patterns through practice and experience.

Direct experience, both personal and shared, is quite important to how we develop as professionals. Indirectly we learn from institutional knowledge, case studies, and other means of documenting our experiences. I'd like to mention a couple ways to share our knowledge or learn from others. The first is the development of the Avalanche Near Miss website to document near-misses in the work place and improve avalanche worker safety. The second is the release of the long awaited, next chapter of *The Snowy Torrents!* Each of these adds another layer to our experience and to the ongoing song and story of snow and avalanches.▲



The Powder and the Glory by Len Chapman and David Sly

"Dynamite Dave we need an Avacaster, not a Telecaster!"

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METAMORPHISM

The National Avalanche School instituted some key updates to offer US ProL1-NAS training for 2017/2018

Andy Lapkass assumes the job of Program Director as Janet Kellam steps down. Andy brings over 20 years of ski patrol experience to NAS, many of those years as an avalanche technician in Colorado's demanding snow climate. He has taught avalanche courses for AIARE, the AAI, and the AAA (AvPro), has guided climbing expeditions to many of the great mountain ranges of the world, is highly respected in the Colorado professional snow community and will be a great asset for the School.



Andy and AyUp. Photo courtesy Andy Lapkass

ProL1-NAS is now a designated US training category (ProL1, ProL1-NAS and ProL2) ProL1-NAS is an 8-day training program (4 days classroom, 4 days field) as compared to the 5-day ProL1 that will be offered by other course providers. It is oriented to ski area and mitigation operations and incorporates upper level operations elements not included in a basic ProL1. The four-day classroom allows students to join with over a dozen US operational leaders and top-level instructors. The end product is training that benefits early to intermediate level patrollers and route leaders of all levels of experience. It is also for avalanche forecasters, avalanche center observers, snow rangers and is excellent professional development training for instructors.

The NAS is pleased to announce its partnership with AAI to produce the four-day NAS field session. This session is for students who have attended and passed the NAS classroom. It includes basic ProL1 student evaluations and meets and exceeds ProL1 curriculum. The field sessions will continue to be hosted at regional ski areas, will include operations staff and AAI staff who for many years have led operational training programs. In addition, partnering with AAI opens the possibility for offering field sessions every year instead of every other year if ski areas could benefit from this schedule.

Anyone who has completed NAS classroom and field sessions prior to 2017 is eligible to attend a AAA-approved "bridge" course to gain equivalency of the new ProL1-NAS. ▲

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SAW REPORT:

NRSAW: Northern Rockies Snow & Avalanche Workshop

BY ERICH PEITZSCH

The 6th annual Northern Rockies Snow and Avalanche Workshop was yet again a success and a whole lot of fun to boot. Flathead Nordic Backcountry Patrol was the title supporter, and there were changes this year in the venue (now held at the O'Shaughnessy Center in Whitefish) and the format. We had a broad range of speakers this year with no pre-arranged theme. We had over 240 total registrants this year, numerous and fantastic sponsors, and a great contingent of forecasters, guides, observers, and patrollers from our great neighbor country to the north.

For this workshop summary, Lynne prompted me with the question "Several months later, what points and presentations stand out to you from that day? Have they changed your practice at all?" I'll tackle the second question first because it's easy to answer. The answer is "Maybe. I'm not sure. Perhaps." The reason for this obtuse answer is that I think it takes a while for any research result, opinion, thought, or new idea to fully modify my professional (or personal) approach to the science or craft.

So, let's start with the features that emerged from the day. Dr. Bruce Jamieson graced us with his presence and sparked a great audience discussion about using snowpack tests versus observations or both. It was quite interesting to hear the perspectives of audience members regarding when and if they choose to perform stability tests, which one they use. The ECT certainly seemed to be the go-to test for most in the audience. It was hard to gauge how many people use stability tests on a regular basis and how many simply rely on non-digging observations alone. Later on, Bruce also presented results of Scott Thumlert's work showing the stress (and fracturing of weak layers) depends strongly on the ski or snowmobile penetration and whether the column is isolated. There is also a great video of Bruce somersaulting onto the column with results showing the stress created by his head.

Equally as entertaining was Diana Saly from Montana State University as she illustrated how time-lapse photography can be used to show backcountry user habits, frequency of skiers in the field of view, and potential use for snow safety departments. This piqued interest from Snow Safety personnel from Whitefish Mountain Resort, and a time-lapse camera will be installed later this season for testing a view of an adjacent backcountry area.

This same backcountry area adjacent to the ski area was the scene of an avalanche accident that resulted in two fatalities in 2008. The Flathead Avalanche Center and Flathead Beacon Productions made a five-minute awareness video that debuted at the workshop this year. The video uses this accident as the centerpiece to educate users about proper backcountry preparation and knowledge. The "Get The..." message is highlighted as well.

Finally, and probably the crowd's favorite presentation, Dr. Terry O'Connor provided a riveting presentation entitled "Not Dead Yet." Some of Terry's thoughts and work have been presented previously in the pages of this publication, but his words resonated with nearly every attendee. Terry, an equally accomplished doctor of medicine and outdoor athlete himself, spoke with emotion about the importance of thorough and proper care for avalanche burials because they might be "not dead yet." He used case studies from Idaho and Longyearbyen, Norway, to highlight his message and took the audience on a bit of an emotional roller coaster, but ended with a very positive message that the work we do as rescuers and avalanche professionals is important and meaningful.

Overall, it was a great workshop, and certainly would not have been possible without the annual assistance from the American Avalanche Association's support of these wonderful and popular regional workshops. Thank you AAA! ▲

Erich Peitzsch is a Physical Scientist with the U.S. Geological Survey, PhD student, and former director of the Flathead Avalanche Center. He tries to spend as little time as possible getting stuck on his snowmobile.



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USFS BRIDGEPORT AVALANCHE CENTER:

Providing Avalanche Forecasting and Education for Motorized Winter Recreation Area

BY KYLE PEURSEM



A good visualization of the amount of snow received so far this year up at Sonora Pass. Photo Kyle Van Peursem

BRIDGEPORT—In 2009, Congress designated 7,254 acres of pristine forest land near Sonora Pass in the central Sierra Mountains as the Bridgeport Winter Recreation Area (BWRA), making it the first designated winter motorized (snowmobile) use area in the nation. This designation opened up incredible and challenging terrain that otherwise would not have been accessible to snowmobilers and other winter recreationists.

The BWRA primarily attracts snowmobilers, though snowmobile assisted skiers and snowboarders also frequent the area. Additionally, the Marine Corps Mountain Warfare Training Center (MCMWTC) routinely conducts winter training operations within the BWRA.

Providing access to this type of terrain through the whole winter posed a significant safety issue due to the extreme avalanche terrain and potential hazard present throughout the

BWRA. This concern led to the creation of the Bridgeport Avalanche Center (BAC) in 2012 by recreation staff on the Bridgeport Ranger District of the Humboldt-Toiyabe National Forest.

The BAC is funded through multiple sources including the California State Parks OHV Grant Program, Humboldt-Toiyabe National Forest, and U.S. Forest Service National Avalanche Center. It has one full-time seasonal Avalanche Specialist who issues weekly snowpack summaries and publishes daily snowpack and avalanche observations. Additionally, the BAC provides avalanche education to the community and offers several free snowmobile-specific avalanche awareness clinics throughout the season. This position is funding dependent on a year-to-year basis.

For the 2016/17 season, Kyle Van Peursem, recent graduate of Montana State University's Snow and Avalanche Laboratory, was hired as the BAC's Avalanche Specialist. Together with BWRA Backcountry Ranger Ryan Lewthwaite, the two provide nearly seven days a week coverage of conditions and avalanche danger in the BWRA.

The BAC staff have had a very busy winter, as the BWRA has been in the center for nearly a dozen strong atmospheric river (AR) events that

have deluged the Sierra Mountains this winter. As of mid-February, the BWRA is at 230 percent of average precipitation and 200 percent of average Snow Water Equivalent (SWE) to date.

In fact, the Leavitt Lake SNOTEL station, located in the upper part of the BWRA, has the highest measured SWE (93 inches) and snow depth (253 inches) of all currently reporting SNOTEL stations in the U.S. and Canada as of Feb. 23. It is estimated that over 600 inches of snow have fallen in parts of the BWRA so far this season.

This of course has led to some impressive avalanche cycles, including a historic wet-slab avalanche cycle during a warm AR event that dropped nearly five inches of rain between Jan. 7 and 8. During this event, a large natural wet slab avalanche released and put two different debris piles estimated to be 20-30 feet deep a few feet uphill of a common snowmobile route in the BWRA. Luckily, no one was recreating in the area during that event.

Fortunately, the warm and deep maritime snowpack has helped to prevent the development of any buried persistent weak layers through most of the season, so avalanche concerns generally revolve around storm and wind slabs and have typically subsided within a few days of a storm. This has led to incredible and relatively safe riding conditions most of the year and the riding community has been out in force taking advantage of this relatively unknown motorized winter wonderland in the Sierra Mountains.

Current avalanche conditions and general info about the BWRA can be found at www.bridgeportavalanchecenter.org or on Facebook and Instagram. ▲

Kyle Van Peursem is currently an avalanche forecaster with the Bridgeport Avalanche Center in Bridgeport, CA. He recently finished his M.S. in snow science from Montana State University in Bozeman and worked as an avalanche forecaster for the spring opening of the Going to the Sun Road in Glacier NP, MT. Prior to grad school, Kyle was a Weather Officer in the U.S. Air Force for over six years and completed a B.S. in Meteorology from the University of Utah.



A large wet-slab avalanche put 20-30' of debris within a few feet of a popular snowmobile route in the BWRA in early January 2017. Photo Ryan Lewthwaite

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In TAR 35.3 we inadvertently omitted this text box from John Brennan's update from AMS. Avalauncher users are reminded to use Teflon-cored high pressure pneumatic hose rather than Gates hydraulic hose in high pressure gas transmission situations. For more information please contact: jb@avalanchemitigationservices.com.

REPORT FROM SIA: DENVER COLORADO, FEBRUARY 2017

BY AMBER AND AARON PARMET

The SnowSports Industries America Snow Show (SIA) is a trade show that occurs annually bringing the latest industry-related developments, innovations, and products together. Being the largest dedicated winter sports show, SIA brings major players in the avalanche industry together including Mammut, Ortovox, BCA, Arva, and many more. An exciting part of the show is always avalanche safety and touring gear. This article will give an overview of new products for next year and industry trends.

The most personally exciting development at the show was Mammut's new beacons. Mammut already had a leading beacon in the industry with the release of the Barryvox Pulse in 2011, but they have made major improvements with new refinement and capability that hasn't been seen before. Though the beacon is still in the testing phase, the new technology shows great potential to improve efficiency and effectiveness from teaching people beacon skills to professional use. Mammut went through many iterations of testing and observations to guide their improvements. The Barryvox is replacing the Element and the Barryvox S is replacing the Pulse. A multitude of incremental improvements in sensors, processing, algorithm, and interface add up to an overall major improvement. Apart from the advertised 70m range and faster processing/sensors, a few professional relevant features include significantly improved signal overlap handling in multiple burials, analog mode capability at <3m, combined professional option settings. Arva has the other new beacon offering of the year with the Axio, which has a large third antenna which they say offers a more even search strip due to better worst-case antenna coupling.

Airbag design and technology continues to develop and become more widespread in product



BCA Speed cannister (blue) compared to the typical Float cannister (black). Photo Aaron Parmet



Jones splitboard with a graphic of 5 Red Flags for avalanches. Photo Aaron Parmet

lines from an ever growing list of companies. As Andy from BCA described it, "everyone wants a piece of the market." Along with an increase in the number of companies producing airbags, the companies are also producing more options when it comes to size, fit, although true women-specific packs, meaning more design considerations than merely shortening the torso, continue to be sparse. This shortage in women-specific packs is particularly true in sizes suited to avalanche workers; all are less than 30L. Dakine, which makes one of the few woman-specific airbags, said the issue is one of production volume though they hoped to release women-specific airbags in larger sizes. Other manufacturers echoed that consideration. Happily, airbags systems are getting lighter and more compact lessening one oft cited objection. The BCA Float Speed 27 introduces technology that shrinks their user-refillable air cylinders in striking range of even the tiny Arva factory fill argon cylinders. More manufacturers are switching to refillable compressed air (new offerings from Ortovox) or rechargeable battery fan systems (Pieps adds their version to the BD airbag pack family) making them more US air travel friendly. Due to regulatory restrictions, smaller light carbon cylinders available in Europe remain absent from the US market while European standards continue to require battery-fan packs to use larger, heavier batteries than many think necessary.

In general, companies are continually making incremental improvements to shovel and probe design. BCA and Ortovox have new visual markings on probes that helps make burial depth more apparent so rescuers can decide quickly how far to

dig down the hill below the burial. Ortovox continues to apply their studies done in Innsbruck to determine the most efficient shovel blade size and minimum handle length, and designed their new shovels based on the results. Overall, a bigger blade is not better because you tire out faster.

The tech binding market continues to grow as more companies adopt the current technology or develop their own. Salomon has brought their lightweight tech binding to the US market. Split board technology continues to be popular.

Companies all around are promoting avalanche safety. For example, Spark R&D is printing "Know Before You Go" information on their packaging. Jones Snowboards is printing avalanche safety tips on their boards and gaiters. Mammut has an improved avalanche safety app that has tools such as a compass and slope angle detector. In an emergency, the app will transmit your data to rescue personnel. They also have an avalanche safety blog.

These are just a few examples of the positive trend the industry is following and we certainly applaud these awareness pushes even by non-safety-oriented backcountry gear manufacturers.

One twist in a new avalanche safety product consideration is the push for better communication. The BCA Link continues to enjoy growing popularity as a recreational radio system. Some pack manufacturers (e.g. Mammut's Flip 32) are including built in line routing through the shoulder strap to a pouch in the pack designed to hold an antenna up right for maximum signal. It also moves the electronics to the back thereby reducing interference in beacon or Recco searches.

Overall the trends at SIA support the avalanche industry and its growth and development. It will be exciting to test these products out next season. ▲

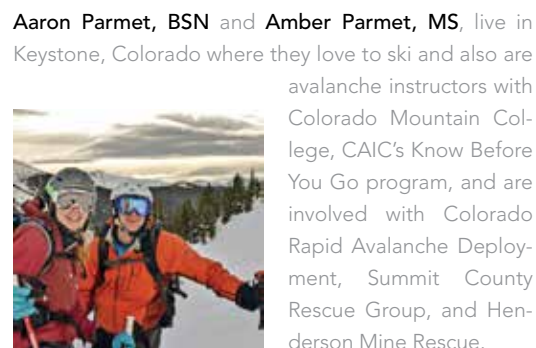


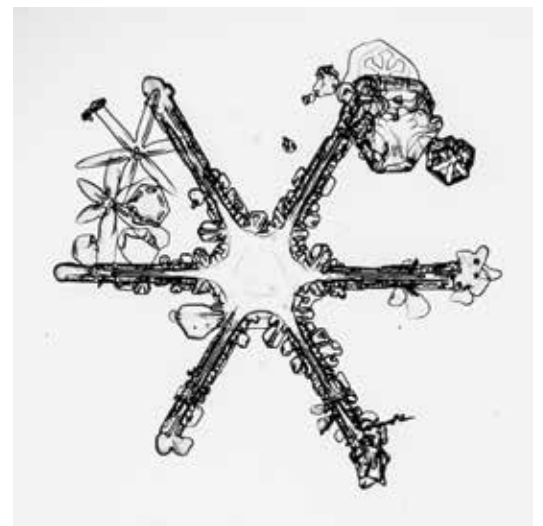
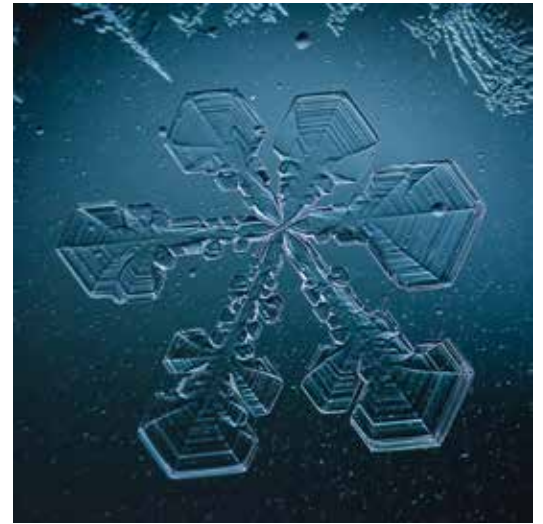
Ortovox probes with easy depth markings. Photo Aaron Parmet

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CAPTURING SNOWFLAKES

BY DOUG WEWER

Doug Wewer has worn many hats in the avalanche world. He's patrolled at Snowbasin for 17 years, been an observer and educator for the Utah Avalanche Center, been an avalanche dog handler, and volunteered on Weber County Search and Rescue. More recently, he's turned his attention to photographing snowflakes.

While teaching a Level I avalanche class at Brighton in 2009, Wewer brought some samples from the snow pit inside. He placed the crystal card in a bowl with dry ice. He used a video camera and a Snowmetrics lens to project the snow crystals onto a big screen, so the whole class could

see the crystals at the same time and could discuss it together. Wewer took a few photos of the crystals during the discussion and ended up capturing an intact snowflake, completely by accident.

Over the next eight years, Wewer captured hundreds of snowflakes with his camera, often on colorful backgrounds. About a year ago, friends started asking for prints to hang in their homes, one asked for snowflake Christmas cards, and a new gallery invited him to join. Wewer started his business "Desert Snow Photography" and began attending art festivals and showing at other art galleries. His largest exhibition to date was at Union Station in Ogden over the past winter. It included more than 40 snowflakes and frost crystals photographed in Utah's Wasatch Mountains. Each snowflake in the exhibit was infused onto a metal plate using a process called dye sublimation. Doug has found this medium to be excellent for portraying the fine details of these incredibly complex snowflakes.

"Like many other TAR readers, I've seen all kinds of snowflakes and crystals under a microscope. I thought everyone knew how complex and amazing snowflakes are. Through sharing these snowflake images with others at festivals and galleries, I've realized that most people have never seen a snowflake up close. One of the most rewarding parts of doing this is watching someone experience the fine details of a snowflake for the first time in their lives. Many folks have told

me they will never look at snowflakes the same way again."

All of the snowflakes in his collection can be purchased at desertsnowphotography.com. Metal prints, archival paper prints, greeting cards and postcards are available. Matted prints start at \$25 for a 5" x 5" size. The highest quality, largest snowflakes can be printed at 30" x 30" on metal and sell for \$995.

Follow or like @desertsnowphotography on Instagram or Facebook to see the latest snowflakes throughout the winter. Doug can be contacted at doug@desertsnowphotography.com. ▲

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PREPARING FOR THE PRO/REC SPLIT: A PERMITTING VIEWPOINT

BY KELLI ROHRIG

The idea of creating a professional/recreational avalanche education split in the US was first brought to the table over three years ago when the AAA introduced the concept at the 2014 Banff ISSW. Further information and updates were made available by Sean Zimmerman-Wall in volume 34.1 and 34.3 of *The Avalanche Review* and by AAA ED Jaime Musnicki at many of the local workshops since 2014. It wasn't until this fall at the American Institute for Avalanche Research and Education (AIARE) refresher at the Breckenridge ISSW that it dawned on me that the split was actually going to happen. The tentative rollout for the split is scheduled for November 2017.

Everyone can see the benefit of an educated backcountry user. Reported avalanche accidents are staying relatively constant even though our backcountry community is growing exponentially each year. This is a direct reflection on the increasing number of people who are seeking avalanche education. All of our local guide services and schools that offer avalanche education have been sold out, with long waitlists, all season. So far this season, we've added three additional level 1 classes to accommodate the need for education in our area.

As of next November, a fully educated recreational backcountry user will now have the opportunity to participate in four classes; Avalanche Awareness, Level 1, Avalanche/Companion Rescue, and Level 2. Although I'm stoked for the opportunity to offer a dedicated one-day rescue curriculum, my thoughts immediately turned to user days and the need for additional days next season to encompass the increase in classes offered. We are already stretched on our service days with five fully booked classes. Looking into the future, there will be more clients wanting to complete the entire recreational avalanche education track and that will tax service days further.

We were starting to sweat the need for more user days created by the new track and the potential effects on our local guide businesses. Thankfully, during our morning brain clearing ski tours, we came up with some adaptive business strategies. I thought maybe we could approach our much-appreciated special use permit administrator at the Forest Service and try to get more service days for all the educators in the area. After a formal meeting with our special use

permit guru and representatives from local businesses and organizations, I started to better understand the permitting process. I was delighted to hear that just like our avalanche community, the Forest Service is on the verge of a cultural transformation too.

SPECIAL USES MODERNIZATION

The Forest Service is an agency that has been around since the days of President Teddy Roosevelt. After 112 years, the Forest Service is officially revamping their permit process. In what was billed as the first of many planned working groups, some of the agency's top rec officials met with outdoor industry leaders last September in Denver. In a September 28th *Denver Post* article by Jason Blevins, (www.denverpost.com/2016/09/28/forest-service-cultural-shift-access-public-lands/) it was reported that the group discussed the "cultural shift" the Forest Service proposes that will "encourage more Americans to more safely explore more public lands." The article went on to say that "most importantly District Rangers and Permit Managers will be given more leeway to waive more intensive reviews and fast-track approvals for commercial or non-profit activities that don't have any greater impact than normal public use." Basically, the Forest Service recognizes the need to adjust to things like the new education track coming down the pipeline next season.

What exactly does it mean for me as an educator who works closely with local outfitters and runs a non-profit that provides avalanche education to youth? My permit administrator explained that this means a few things. Every district and forest across the nation has a different recreation demographic. Additionally, each district has a myriad of stakeholders and community issues that need to be balanced with the conservation of wildlife and natural resources. Similar to backcountry riders, each District Ranger has a different risk tolerance that he or she is willing to accept when it comes to decision-making. Each special use permit administrator has to be "fair and equitable" to current permit holders and also respond to the barrage of permit applications that range from events to research to military permits. The calm demeanor my permit administrator exuded was in great contrast to the mayhem happening around his office.

After our hour of permit banter on what we as educators can do to make permitting easier and our administrator's life easier, I felt like we had made some headway going into next season. The end result is we need to start the process now and start thinking outside the box.

SO...WHERE ELSE CAN WE RUN AVALANCHE CLASSES?

I asked my Forest Service mentor if I need Forest Service System land for all my classes. The new one-day Avalanche Rescue/Companion Rescue class will require an additional day of service days if offered on FS lands. We are also developing opportunities with a new focus on youth avalanche education in our area that may also

require more service days. Can we develop new partnerships and utilize sites like high school football fields, college campuses, town parks or similar areas? And do those sites require separate permits and permissions?

HOW DOES THE FOREST SERVICE STAY "FAIR AND EQUITABLE" TO PERMIT REQUESTS?

As a land management agency, the Forest Service needs to look out for public interest while balancing what's best for nature. We can't be granted additional service days without a fair and equitable approach with which to derive them. Historically, additional permit days could be granted after the Forest Service completed a capacity analysis. If additional capacity existed, the Forest Service would then go through a prospectus, solicit applications from potential operations and finally, award service days. Fortunately, the Forest Service has been modernizing and has opened new pathways to fast track service day approvals, especially days for educational programs. Some districts have utilized an authority which allows responsible officials to authorize educational and informational programs and activities. I know that some districts have set up "pool" days specifically designated for avalanche education days that outfitter/guides can apply for. These pool days are available through a one-year temporary permit.

START DISCUSSING OPPORTUNITIES WITH YOUR PERMIT ADMINISTRATOR NOW!

We are all well aware that trailheads, especially in areas where terrain is easily reached, are verging on overload. When we add multiple avalanche classes to these already overwhelmed trailheads, we may be overburdening the infrastructure. The advice given to me was to apply for permit days mid week. Apply for use in areas not on the top 10 visitors list. Most importantly, get your applications in as soon as possible giving your organization plenty of time to come up with creative use areas that your permit administrator can shepherd towards approval. Discussing a proposal before the application deadline may remove potential challenges. Work together with every avalanche education entity in your area to create a unified voice; we all have similar opportunities to develop a better educated backcountry community so that everyone can safely explore more public lands. ▲

Kelli Rohrig teaches avalanche classes in mountain ranges near and far. A Colorado native who has lived in the Alps, Montana and around Colorado, she now bases out of Vail. She is currently launching the Glide Project to bring avalanche education into Colorado classrooms.



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Macomber Mountain, South Aspect, 9700 feet. Mayflower Mill, January 14th storm event with two inches an hour snowfall rate. This is a very infrequent flier, it last ran in 1978. Photo Rusty Melcher KR Films, Silverton Avalanche School

AVALANCHE EDUCATION TIPS: Teaching to the Conditions and the Students' Needs

BY BRUCE ENGELHARD

Most educators will tell you that when we are teaching an avalanche course, we feel we are more effective with active avalanche problems in the operating area. Students are then better able to understand the intricacies of matching up the appropriate terrain with the contributory/associated snowpack and weather factors. Complications arise when the avalanche danger is benign, and you are trying to get your students to understand how certain terrain features will respond under more complicated and dangerous conditions.

At other times, we may be challenged to teach in unfamiliar conditions when the planned curriculum is not congruent with the real-time avalanche problems. During these moments, our pre-designed lesson plans must be adjusted to accommodate the existing conditions, and as such we may be out of our usual comfort zones of experience, and at the very least our supplemental multi-media teaching aids are not applicable.

Finally, there are those moments when it appears that some of our student's passions and desires outweigh the overall good of class as a whole. And in these moments, we are confronted with the possibility of heading off on either a "tan-ge-lanche," when we need to adhere to the fundamental curriculum that fits the needs of not only the majority of the class, but more importantly the guidelines intended for this level of education.

The challenges I mentioned above are some that I have routinely seen in teaching situations. Yes, it is much easier to explain to a classroom of students the realities of remote triggering, propagation, and collapsing when the local avalanche forecast is detailing this very problem. Those times are far outweighed by the realities of the snowpack we are dealing with on a regular basis—at least here in Utah. Unfortunately, I have all too often seen instructors limit their time in the field to only addressing the avalanche problem at hand, which may mean having an avalanche class only address terrain/route finding on a Low Danger day by turning the day into an excuse to ride steep terrain. The students then depart the class with no knowledge on how to address terrain in other conditions.

One method I have found that successfully helps address this issue incorporates something I call "Going to Narnia." Each student selects an avalanche problem during trip planning; once we are in the field, that person looks at terrain with that specific problem in mind, then explains to the rest of the group how they would travel and deal with that problem in the terrain we see. This forces the students to make observations then formulate and explain a travel plan to the group with guidance from the instructor.

During the times when we are confronted with unusual conditions, that may present the biggest challenge. I believe the key here is that a flexible instructor is a better instructor. Have a number of lesson plans available to fit the varying circumstances that may be possible, and be willing to adjust on the fly to meet those conditions as not to miss a unique teaching moment. Be creative with terrain and tools, and don't let yourself get locked into teaching the same way just because you have done it that way in the past.

Another challenge is one that comes up in almost every class. Don't allow yourself to get suckered down the rabbit hole of high-end questions that are fun to answer but sidetrack your curriculum goals for the benefit of one student. Praise their thoughtfulness and offer to discuss the topic after class over a beverage.

All educators continually step into the unknown in many ways. Each class is filled with a different set of students, and as discussed above the conditions are always changing. And the fact is, our lessons and tools we have been passing on for years continually need to be repackaged and fitted into different formats, using some of the exciting new research that has altered the way we look at things and the way we teach, e.g. propagation is not slope angle specific, allowing us to dig test pits in flat sites. Ongoing willingness to adjust our teaching styles and materials keeps us personally up to date, and allows us to present the latest and greatest information to our students. I am eagerly anticipating the consistency of curriculum that will come with the Pro/Rec Split, but I strongly believe that within this consistency we can maintain individual teaching styles and ways of presenting material.

I'd like to introduce/offer a social media-driven forum for avalanche educators to share useful teaching styles, ideas and aids that have successfully worked for them. For example, here's a successful teaching tool from Steve Achelis, creator of the website beaconreview.com as well as the Wasatch Backcountry Ski Map and Guide Book. Steve has put together a simple scavenger hunt prompting card that he shares with his students to help them identify key features and factors while traveling in the field. Go check it out at beaconreviews.com.

If you wish to participate, join the Avalanche Teaching Tips Facebook group, or email your tips to: avalancheteachingtips@gmail.com.

Bruce Engelhard is an avalanche educator based in the Wasatch. He is profiled by Sean Zimmerman-Wall in TAR 35.3.



LEADERSHIP

AT PLAY

BY ALLISON BERGH AND KAT SMITHHAMMER

Breckenridge Ski Patrol leadership contacted us in the summer of 2015 and asked whether we might be a good fit for work they were doing with their team on leadership, communication, and patrol culture. Their desire was to strengthen safety and retention, and to accomplish that they wanted to develop their team around communication, feedback and accountability. As one of the Breckenridge supervisors put it, “we’ll all be happier, more likely to speak up, and want to stick around if we strengthen those leadership skills as a team.” Breckenridge’s commitment to promoting a trusting culture and open feedback, up and down the chain, is an intentional shift from what many would describe as the historical command and control approach to ski patrol leadership and culture.

Team culture, communication, and self/team awareness have been the focus of our work with the Breckenridge patrol leadership, and eventually with four other Vail Resorts, as well as the Jackson Hole Mountain Resort patrol supervisor team. Research done by Scott Savage and Jerry Johnson, through extensive surveys of avalanche professionals in “Accidents and the Avalanche Professional: Surveying the Profession,” determined that workplace accidents and near misses occur largely due to: poor personal decision-making, loss of situational awareness, and poor communication & assumptions based on past data and experience. These factors are all key leadership skills, they clearly have an impact on worker safety, and, they are fully learnable by individuals and teams. The culture that patrol leadership creates— the norms and expectations around how patrollers interact with one another— impacts how these leadership skills are embodied and play out with their patrollers.

What we learned from interviewing over 60 patrollers is that ski patrol culture varies widely. Here are some of the questions we asked. Do you, regardless of your years on the job, feel comfortable and encouraged to speak up about a safety issue? About a non-safety issue? Does patrol leadership ask for feedback, encouraging two-way dialogue about what is working and what could be better? Does the WHY behind key decisions get passed down the chain so everyone understands what they are being asked to do, and why? Are patrollers willing to admit mistakes and/or share vulnerabilities in front of each other?

All of these leadership behaviors help build trust and encourage open dialogue within teams. Patrick Lencioni’s *Five Dysfunctions of a Team* research demonstrates that trust and space for robust dialogue are at the core of high performing teams. Whether it’s about a risk management decision, or communicating effectively to provide the best care possible on the scene of an accident, or doing a routine job on the hill, fundamental to performance is whether people trust one another enough to say what needs to be said, in a way the other person can hear.

As one ski patrol director stated, not having strong trust or the space for all voices to get heard is like having depth hoar lurking at the base of your teamwork structure. Or as Doug Krause, a frequent TAR contributor, writes in *Teamwork: Seal Team Soup*, “Groups that do not buy into team culture will forever remain just a bunch of dudes putzing about a mountain. Teams have to establish a climate of trust and cultivate a high degree of social competence.”

It was inspiring for us to see these teams invest in these conversations. We observed everything from teams acknowledging that a shift in their culture was important for team morale and retention, to one seasoned patrol supervisor commenting that he would consider being more vulnerable in front of his team to strengthen trust. Breckenridge patrol created “team agreements,” a cultural charter of sorts, which they tie to their performance reviews. This provides a clear vision of what culture they want for their team, and offers accountability for how their team works together. We appreciated the opportunity to bring our perspective on leadership and teams into these patrols.

Allison Bergh calls Wilson, WY home, spending her free time in the mountains and on rivers with friends and her three pups. She has a 20 plus year career as a NOLS instructor, a short stint as a Jackson Hole ski patroller, five plus years running a women’s mentorship program for NOLS, and has now been partner in a leadership consulting firm since 2010.



Kat Smithhammer moved to the Tetons in 2006 with Bruce, her life and adventure buddy, and their two furry friends (Luna and Hank) from Whitehorse, YT. She has been teaching and building effective teams for over 25 years in high schools, at night school, at an outdoor center, for NOLS, through guiding in the Andes and her Leadership at Play partnership. She holds a MA in Leadership and Adult Education, and is pursuing her “Integral” coaching credentials.



Social competence, mindfulness, humility, and trust: These things can be taught, practiced, and mastered.

—Doug Krause on using his article on Operational Intelligence for Ski Patrol training



Leadership at Play helps build cohesive and resilient leaders and teams. We met at NOLS in the late 90s, and founded Leadership at Play in 2010. We are passionate about adult learning and growth through play and hands-on experiences. Our clients range from local & regional non-profits, to government agencies such as the United States Forest Service and Grand Teton National Park, to organizations such as Vail Resorts, Wharton Business School and NASA. We both live in the Tetons, and our free time is spent adventuring in the mountains and on rivers, via bike, ski, canoe, kayak, pack raft, and foot!

LEADERSHIP

AT PLAY

Training Ski Patrols around the West

VAIL

Julie Rust, Mountain Operations Director
Jenn Pirog, Patrol Supervisor

BEAVER CREEK

Addy McCord, Patrol Director

KEYSTONE

Jon Roberson, Patrol Director
Mike Daly, Assistant Director

PARK CITY

Hutch Foster, Assistant Patrol Director
Bert Pacal, Assistant Patrol Director
Tessa Dawson, Patrol Supervisor

JACKSON HOLE

Drew Kneeland, Patrol Director
Jen Calder, Assistant Patrol Director

BRECKENRIDGE

Susie Nothnagel, Patrol Supervisor

Why did your patrol make the time & financial commitment for this training—training that is focused on leadership, supervision, feedback, communication, accountability, and culture?

Julie Rust: Speaking on behalf of the participating Vail Resorts mountains (Vail, Beaver Creek, Breckenridge, Keystone and Park City), we chose Leadership at Play training for a number of reasons. First, Vail Resorts puts an incredibly strong emphasis on and expectation around employee and leadership development. We have a remarkable Talent Department team and employees are encouraged to “own their own development” through a number of internal development programs, which have been extremely valuable. Our Talent Development managers, the ski patrol director best practice group, our patrols, and our employee opinion surveys led us to furthering that work through a NOLS based leadership curriculum. The Breckenridge Ski Patrol was ahead of the curve and found us Leadership at Play. From there, Allison, Shari and Kat came to work with each of us and also address our individual patrol team needs. Their efforts really resonated with all of our teams. Park City has a particularly unique story to tell here with the integration of Canyons and Park City last season and, thus, the integration of two patrols.

Bert Pascal: The Park City ski patrol is nearly 200 strong and is split roughly equally between two base area locations—Park City and Canyons. Prior to the Vail Resorts acquisition, the two patrols had distinctly different cultures. Given the size, geographic and cultural diversity and logistics of running an area this large, efficiency and integration is critical for smooth operations. Effective leadership at all levels is necessary to accomplish this. Leadership at Play was able to facilitate an effective integration concept and stimulate ideas between the two groups of patrollers.

Tessa Dawson: As our two large patrols began the task of integrating into a single entity, our management and leadership group felt that there was a great opportunity to involve our senior patrollers in creating a shared set of goals, a common language and begin the task of integrating two different patrol cultures. We felt that giving this group of leaders the opportunity to work together through this training would be a great way to set ourselves up for success this season and create an open dialogue between two groups that had had limited interaction in the past.

Hutch Foster: I'd add also the background that these distinct patrols had remarkably little interaction or communication before engaging in a workshop with Leadership at Play. The history was one of curiosity at best, or downright distrust at worst. We were starting at introductions for much of the leadership group of about 40 patrollers. In many ways, they didn't even speak a common language, though the on-hill nature of their roles was more similar than dissimilar. In two days of workshops, we were able to build a common language around the job and begin to align expectations.

Jon Roberson: We have been very fortunate over the past five years to have the support of our Vail Resorts' senior leadership as well as our in-house training and development team. During this time, we have focused on our own operational improvement and greater employee engagement. The feedback we received from our own Patrol leadership team was that they were ready for a slightly different approach. Breckenridge was the first resort to give Leadership at

Play a chance and we felt that the strides they made were the same ones we wanted to make. Without taking the time to improve our ability to give feedback, communicate and develop an environment to successfully hold each other accountable our culture would be in a fixed and locked position and any leadership development would be rudderless.

Susie Nothnagel: For Breckenridge Patrol, it was really simple: we were receiving feedback from our patrol that the patrol leadership team needed to work on our feedback and communication skills. Our patrol came right out and asked us to get better at this! Once we realized that we needed to make these improvements, we were lucky to have the support of Vail Resorts in starting our journey towards improving these skills.

Drew Kneeland: We were in the process of re-organizing our patrol structure and identifying new supervisors to increase the span of control. Our organization was pretty top-heavy, with three managers overseeing 85+ people. We were looking for more inclusivity and buy-in for our decision-making processes. In many different work environments, people are often promoted to supervisory positions because of their seniority or longevity within the organization, not because of their leadership skills. We recognized that none of us had formal leadership training, the very job we were trying to accomplish. We were also aiming for cultural change, including better communication, more accountability, and transparency. When Jen and I were cleaning out the old file cabinet in the ski patrol office, we found two folders labeled “communication.” Both of them were empty...

Describe patrol 'culture' in the recent past, currently and the desired future state. Why focus on culture? What changes do you see happening within patrol culture, and how does that impact safety, job satisfaction, training new staff, retention, etc.?

Jenn Pirog: The best word to describe the culture of the Vail Ski Patrol is the word "family." A strong family is built on trust, teamwork, and open communication. Our group has always been solid in the trust and teamwork piece of the pie, but the open communication is an area where we can continually improve. In a perfect world, no matter where a patroller sits in the hierarchy, we want them to feel comfortable asking questions, and feeling empowered to speak their mind when they have new ideas or concerns. Ultimately this makes our family stronger, happier, and safer.

Leadership at Play supported our culture goals around open communication that have been in the works for years. If nothing else, we have people talking about the work we're doing and the objectives of the session. We've heard from patrollers that openly talking about this initiative has supported an environment where people are more comfortable to ask questions and ask directly for feedback. For example, we recently held an avalanche drill with multiple burial scenarios and a full team of 10 responders. Instead of waiting for the drill leader to come to each of the participants with direct feedback, the idea is for the participant who has specific questions on their performance to feel comfortable having a conversation about it. "I missed finding the Recco buried high on the slope, but found the one located in the debris zone—could you pick up on anything with my technique on the one I missed?" or "Did I probe around the clue for too long—I was confused by when to keep moving if I wasn't getting a probe strike?" Instead of hiding an area where you know you need improvement, open the lines of communication with an experienced patroller to learn more and do better next time.

The time with Leadership at Play supported personal development as leaders. We had some key takeaways as a group that help in everyday out-post leadership such as understanding millennial differences in communication needs, asking for feedback as a leader from peers and mentees, and

the importance of giving positive and constructive feedback directly to a patroller in real time, instead of getting the feedback for the first time at a later date in formal performance review. I'd like to think that these little nuggets have improved how I personally lead an outpost.

Bert Pascal: Patrol culture has always been about the love of the sport and making a difference to the people we serve regardless of the era. Cultural shift is not unique to a ski patrol. The cultural shift is much larger than that. Checking ideology biases at the door and maintaining a distinction of basic right from wrong is necessary to move forward as a group regardless of who the group is.

Tessa Dawson: Our patrol culture encompasses the passion and drive that our group has for performing at the highest possible level and providing our guests with a safe and enjoyable experience. Our culture as a patrol is influenced by our shared wealth of knowledge, our experiences and our goals for the season. We hold great pride in making the guest experience the best it can possibly be as well as having plenty of opportunities to learn and grow ourselves.

Hutch Foster: I think that the patrol job, and with it the patrol 'culture,' is evolving toward increasing technical training, advanced medical skills, investigations, risk management, additional guest service expectations, SAR interaction with outside agencies, multi-media documentation and training, IT skills, etc. The patrol of 30 years ago, which may have consisted of the strongest and boldest skiers with some bandaids, is giving way to a new generation of highly-educated and talented individuals looking for a place to be fulfilled rather than just making money somewhere. It's surprising these days how many of them come to us with advanced degrees. As these individuals find niches in a large patrol, I think the culture piece will ultimately be

what binds them as a team. As Bert said; for love of the sport and the mountains. I hope that the "service to others" aspect remains.

Susie Nothnagel: During our first training with Leadership at Play, they did an exercise with our leadership group that got each of us to express whether we thought there was a need for our patrol culture to change. Most of us felt strongly that there was a need to change—but at that point I don't think we knew exactly what we meant by that. As we dove into that topic, we realized that the most important thing we needed to do to improve our feedback and communication skills was to have good relationships with each other. We needed to make sure we trusted each other, supported each other and respected each other. Our culture needed to support these basic things. It doesn't help to learn feedback skills if you are going to try to use these skills with people who don't trust you. Real feedback can happen when it is preceded by support and then followed up with more support.

Using this approach, we have created Team Expectations that support this culture change. We let our patrollers know that they aren't just being evaluated on their technical skills. We care just as much about their communication skills, their ability to support each other and create a culture of trust on our patrol.

Drew Kneeland and Jen Calder: The old guard patrol culture could be described as a "cow-boy up" or "suck it up" attitude. We were finding that we wanted a more compassionate and nurturing environment. We wanted to make sure we weren't putting people into situations where they weren't comfortable, or hadn't been properly trained. With a lot of turnover on the patrol, we had an opportunity to change the culture with our new staff. They hadn't been subjected to the old ways, so we could bring them in to our organization with a fresh perspective.

What parts of the training were most challenging/fun while doing it?

Jenn Pirog: One of the exercises that Leadership at Play led was teaming up with a colleague and discussing a few scenarios where potentially uncomfortable conversations needed to happen about a colleague's—and in many cases also a friend's—work performance. Then the exercise transitioned into giving real life feedback to a team member about where they excel in the workplace, and areas for improvement. It's a rare person who enjoys giving or receiving constructive criticism, and this was great practice in raising our comfort level in communicating—both on the giving and receiving end of things.

Bert Pascal: Two distinct ideologies sat down in a room, integrated and were expected to come up with a list of common goals and solve on-going patrol issues. Both patrols showed respect to each other as solutions and creative ideas were discussed.

Tessa Dawson: The time that we were able to spend focusing on coming up with common goals and strategies opened up many peoples perspectives

on the other group of patrollers. It was the first opportunity that our two leadership groups had to sit down and have an open and honest conversation and allowed many to see how similar we all were. The most challenging aspect of the training was letting people process their thoughts and feelings without applying my own opinion or judgments.

Hutch Foster: I found the most challenging parts to acknowledging where each individual is in their personal process, and working on an aligned plan that accommodated all of those differences. While the culture will undoubtedly evolve, we don't all move along that path together, and yet need to have a functional team of many people at each step along the way.

Addy McCord: The most challenging thing about the training was how it was introduced to the group in their meeting. It was a bit confusing. We also discovered that having to give open and honest feedback to a member of the team to be the most challenging but also most rewarding

activity during the training. The teams appreciated the honest and open feedback and that has changed several relationships for the better.

Susie Nothnagel: The most challenging has been to make sure that everyone on our leadership team is living up to the Team Expectations. It is discouraging for a patroller to see a leader that isn't living the culture we are promoting. The most fun has been hearing some patrollers who I wouldn't have expected to embrace this culture change turn out to be really excited about it.

Drew Kneeland: Reflecting on our own personal management and communication styles. Seeing longtime, extremely talented patrollers learning new skills and perspectives. We came to realize that our human skills were as important, if not more important than the technical skills we had acquired over many years. It was also fun to realize that the goals, values, and mission of the new supervisory group were well aligned, although we had never talked about that before.



Reuben Krabbe



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What impacts have you seen within your team from spending time on these topics?

Jenn Pirog: It's valuable to have the outside perspective on our group dynamics, and to also bring in ideas from their learnings with other organizations.

Addy McCord: Several of our team members have taken to the Situation-Behavior-Impact model when giving feedback and several of the quieter voices are working on speaking up. We feel that any time spent talking about our leadership styles, communication, and our effectiveness as a team is time well spent, but our team is very dynamic and constantly changing. As we approach mid-season it will be a good test to see how we are doing as a leadership team when it comes to giving feedback. We must continue to hold each other accountable as the season progresses. Tapping into an outside group helps remove any personal feelings of "us vs. them" out of the training and gives a unique external perspective to our team.

Jon Roberson: The biggest impact has been to let our supervisors and specialists know that much of our work world is what we make of it. Our ability to speak effectively to each other, not question other people's motivations, give each other feedback, be part of the decision making process for our operation and develop our own long term plans are all pieces of what could be considered new. Our job as managers is to then focus these efforts and communicate them in the best way to the resort's senior management. By bringing more people into the process, the waters may occasionally get a little rough, but we are working through that and the majority of the time we end up with more information to make better decisions.

Bert Pascal: Some great ideas were generated and implemented. Greater unity between the two groups was established.

Tessa Dawson: A greater unity and level of respect was developed because of the time we spent with Leadership at Play. Allison and Kat were able to mediate some really great conversations that were honest and open and without judgment.

Hutch Foster: Communication at all levels has been noticeably improved. Patrollers are able to engage in projects together, problem solve, and have ownership of the results.

Susie Nothnagel: There is a new openness to discussing our own leadership skills that we didn't used to have. In our most recent round of promotions, we made decisions based on a patroller's communication skills rather than just their technical skills. It is refreshing to be using these parameters to measure the merit of our patrollers.

How are you evaluating whether this is time well spent?

Bert Pascal: Time will tell, but there was definitely an immediate benefit evidenced by the greater open lines of communication and sharing of creative ideas. Specialized programs have benefited from a shared background of experience; best-practice policies and procedures have been forthcoming.

Hutch Foster: We know that we have an ultimate desire for a blended patrol culture that is developing

a shared background of experience; a unified team. All time spent in a combined workspace with common goals moves us in that direction. The Leadership at Play opportunities have helped us build those initial interactions in a carefully coached environment without bringing any expectations from management, leadership or line staff to the table. It is important for those of us in leadership to remain aware that we bring a lot of pre-conceived ideas to this alignment process, and that doesn't always con-

tribute in a productive way when we want to push the ownership of the program down into the ranks.

Susie Nothnagel: It will be tough to know exactly how much we are moving the needle of culture change. Our hope is that we see it through retention: we want to create a patrol culture that is so comfortable, so much like a family that people will want to stay around and keep patrolling with us for a long time.

How do you recommend other teams/patrols going about training on these topics? (Why the choice to use an external consultant—pros/cons?)

Bert Pascal: Come with an open heart regardless of set ways or ideologies.

Tessa Dawson: Having someone proctor the conversation and mediate difficult topics gave us much needed direction and structure.

Susie Nothnagel: If other patrols are anything like our group, they may need to broaden their focus.

We had been trying to improve feedback skills, but that wasn't addressing the bigger picture. We needed to consider whether our culture supported feedback and open communication. It helped us to use an external consultant who was impartial and could listen to our concerns, some of which dealt with challenges that happen within our corporation.

Drew Kneeland and Jen Calder: Practice

the skills, and adapt them to your own situation. Practice accountability with one another, and revisit the process constantly. Don't get too attached to making things perfect on the first go-round. Remember you need to be flexible and open-minded. Don't force the change on people. Let them see the success on their own, and the benefits of making a change. Our people are our best resource.

If you could magically endow a rookie with proficiency in three skills or knowledge domains, what would they be? Why?

Jenn Pirog: I'd endow a rookie with general character traits as opposed to specific skills or knowledge domains. We have a quote in our patrol meeting room about what it means to wear the cross—it says, "Hard work, teamwork, attention to detail, and leading by example." If we have good communication around the proficiencies above, any rookie patroller will succeed in any specific patrolling skill.

Adddy McCord:

1. Self-awareness of strengths and weaknesses, understanding how they show up. We find the most refreshing patrollers are those who are willing to accept that they do not know it all and are willing to learn and take feedback. Understanding that some things need to be black and white while other things may be gray areas and require different ways to get things done.

2. Problem solver. Patrollers who think on their feet and are able to solve problems when they arise tend to be very successful. Along with the willingness to solve problems there needs to be a willingness to collaborate with coworkers and sometimes even fail.

3. Self-motivator. There is always something to learn in our job. There are always guests in need of assistance, snow to be shoveled, hazards to be marked, and things we can all do to improve our work environment for us and for our guests. From the moment you punch in there is information thrown at you, weather, trail closures, events, and more. A self-motivated patroller seeks out this information and intimately knows our mountain.

Bert Pascal:

1. Information exchange—speaking and listening.
2. Critical thinking, regardless of ideological bias.

3. Know the difference between right and wrong. The majority of issues could be traced back to one of these three skills..

Hutch Foster:

1. A passion for learning. Curiosity.
2. Great communicator—spoken, written, and ability to give and get feedback.
3. A high level of self-awareness—physically, mentally, emotionally.

Susie Nothnagel: I would want them to embody some of the things that are part of our Team Expectations: a strong work ethic, a respect for others and a positive attitude.

Drew Kneeland and Jen Calder: Humility, Strong Work Ethic, Communication skills. These skills lend to the building of a strong team.

How do you know if the training is working?

Adddy McCord: If the training is working then we will have an engaged and happy workforce. We try to gauge this through personal relationships, staff meetings, retention, employee scores, and feedback.

Jon Roberson: I see glimmers of staff rising up to take on new projects and own the operation. I also see bits of conflict where someone tries a new approach, it does not quite work out and things go a little sideways. This can be frustrating for some staff who felt that everything was fine as it was and we do not need to change anything. I believe that these mini-misses are the basis for the most growth we will see in these patrollers. Patrollers need to manage risk, but not be risk averse. A climate that squashes creativity and ownership, while offloading accountability to managers or the resort only, locks us in to a perpetually negative cycle. I want to break this cycle.

Bert Pascal: The training is working as evidenced by the best practices that came from it being implemented and being successful. Leadership at Play gave us some effective tools to build off of. Two distinct cultures are integrating successfully.

Tessa Dawson: For us it will be evidenced by the desire of our patrollers to want to learn and work with their counterparts based out of the other base area. There was a level of animosity and misunderstanding that began to be broken

down during this training and I think its successes will continue to be evident as we have opportunities to continue to learn from each other's experience and knowledge and work together as we move forward.

Hutch Foster: I think the initial indicator will be watching the behavior of individual patrollers when opportunities or needs arise that cross the physical/cultural boundaries between the two groups. My observations this season to date are that quite a few patrollers have taken advantage of openings to explore the others' terrain without the hesitation of last season. Additionally, when projects come up that will require significant resources to handle, it is becoming easier and there is more comfort in pulling those patrollers from both teams to work together.

Susie Nothnagel: Ideally, it should be through discussion with our patrollers on a daily basis. As I said earlier, it won't necessarily be easy to gauge, but I would hope we will see improvements in retention, safety and job satisfaction.

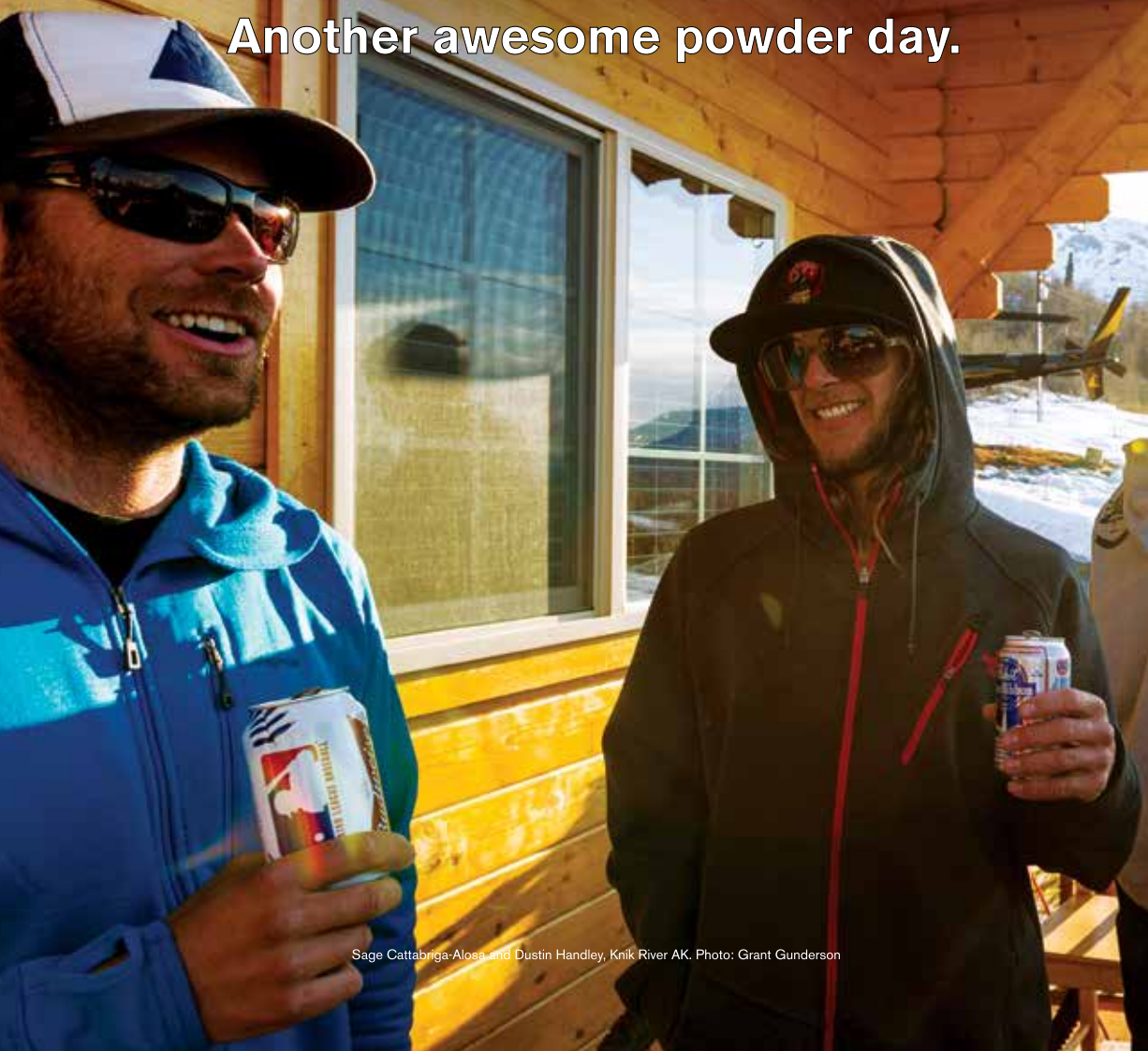
Drew Kneeland and Jen Calder: We believe that our new structure is allowing people to be more forthcoming with suggestions for improving our organization. We have also created an organizational structure that allows for more advancement and growth. To be honest, we don't really know if it's working. We are eternally optimistic.

A ski patroller looks over Breckenridge Ski Resort, known for its five huge peaks, 2,908 acres, four terrain parks, a 22-foot Superpipe, 11 bowls and the highest chairlift in North America. Photo Nate Zeman, Vail Resorts.



Cheers.

Another awesome powder day.



Sage Cattabriga-Alosa and Dustin Handley, Knik River AK. Photo: Grant Gunderson

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How will you sustain the learning and change effort?

Julie Rust: As a leader within Vail Resorts and of the Vail Ski Patrol, it's my job to check in and see how we are following up on the prescribed "next steps" given to all of us by Leadership at Play and understand and discuss what development opportunities have been created for our teams as a result. I'm personally committed to using and regularly revisiting the work we did with Leadership at Play across the enterprise—with patrol directors at the other resorts as well as every member of the team—and encouraging everyone to continue our development journey collectively and individually. We're all in this together. There are so many opportunities to build off of what Leadership at Play provided and of course each individual at Vail Resorts can also supplement that learning and "next steps" with a number of ongoing offerings provided internally at Vail Resorts to keep development top of mind.

Jenn Pirog: Keep the conversation around patrol culture, communication, and feedback going! As long as we are still talking about ways to build a stronger team with open lines of communication, we'll be continuing to make improvements.

Addy McCord: The only way to sustain learning and change is to keep talking about it and to remain

committed as a manager to having the best team possible. Addressing leadership challenges in a timely manner as they arise is also important.

Bert Pascal: Leadership at Play gave us some great exercises and drills to facilitate effective communication and leadership skills. Our increased volume of guests and growth as a patrol will necessitate we embrace change and continue to grow with it.

Hutch Foster: We continue to try to build on the foundation set in the fall with different level leadership meetings and projects. We have worked to involve patrollers at all levels in process an decision making. .

Jon Roberson: Sustaining this effort is one of the hardest parts of this change. With big snow years and busier times, we feel the tension between pure operations and staying focused on developing the team's leadership skills. The development of our team commitments has been the most sustaining part of this. The commitments are the topics we keep coming back to. When I fall down and do not live up to the commitments, the team lets me know and that creates a two-way street for letting them know

the same. Whether it is in the daily work, supervisor or specialist meetings, opening new terrain or revamping a program we give plenty of opportunities to let staff take on leadership roles. The question when they take on these roles is did they live up to our commitments and make a positive impact on the operation of the Patrol. These are the conversations I want to have.

Susie Nothnagel: The last two years we made this culture change a central part of our patrol welcome back/orientation. Then mid-season, we are conducting another training to refresh the discussion with a small group of patrollers. We have incorporated our Team Expectations into our staging competencies and our evaluations so that they will be brought up with every patroller several times a season. We are currently working on a design that will hang in each of our patrol huts with key words from the Team Expectations, serving as a reminder of these values.

Drew Kneeland and Jen Calder: Because this is all so new to us, it can be challenging to keep these new skills current, particularly when we get into our busy operational season. It's easy to default into old habits. ▲

STORM STORIES

Editor's Note: Atmospheric rivers during January and February created remarkable storms and notable avalanche cycles. Here are some of the most striking photos and anecdotes, along with a deeper look at the phenomenon of atmospheric rivers as seen in other historic storm cycles.



COOKE CITY, MONTANA

TOP: From Karl Birkeland: I had the opportunity to go up in a plane and take some aerial photos of some of the slides in Cooke City. The biggest one was off of Henderson Mountain. It had a runout angle of 20 degrees and it put 10 to 20 ft of debris on the groomed snowmobile trail.

It was John Priscu's plane. He's a scientist from MSU that studies extreme life, such as life under ice sheets. He does some of that work with Ed Adams and uses the cold lab facilities at MSU for a lot of his work. He likes to fly...and he likes looking at avalanches, so it was really a great day in the air!

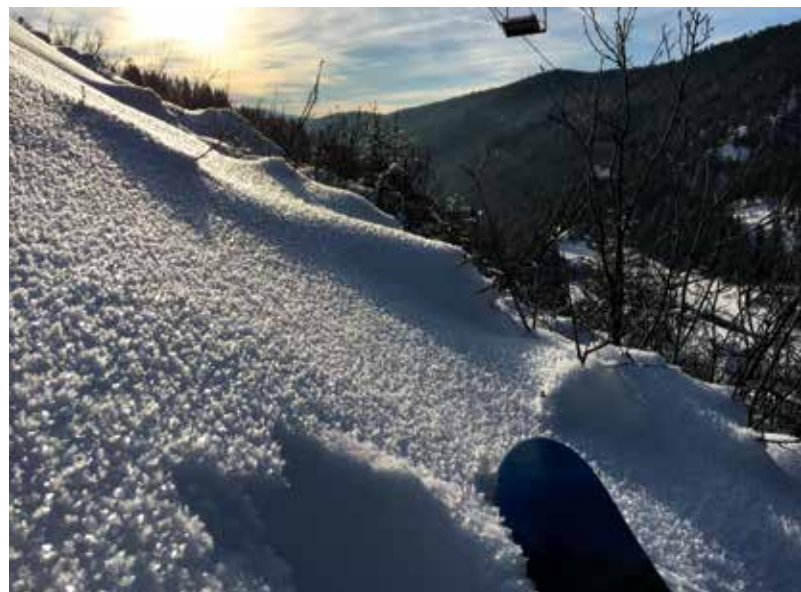
See more photos from the Cooke City avalanche cycle on page 3.

FLATHEAD, MONTANA

BOTTOM: From Erich Peitzsch: December into early January were colder than average for the month in northwest Montana. Three arctic air mass intrusions left this region cold and relatively dry with a basal snowpack more reminiscent of Colorado than northwest Montana. Snow water equivalent (SWE) values were below average (65-80%) leading into February. A rain event January 19 created a melt-freeze crust to nearly 6500 feet in most locations throughout the advisory area. Meager amounts of snow totaling about 12-14 inches fell on top of this crust from January 20 to February 2. During this time near surface facets and sporadically distributed surface hoar formed, but remained unreactive due to the lack of a slab. Then, someone turned on the fire hose....to 11....and we got our slab. From February 3-6, up to 5 inches of SWE and over 50 inches of snow in some places with strong winds blanketed the advisory area. A widespread and large natural avalanche cycle ensued. A lull in the storm for about 30 hours allowed a warmer air mass to infiltrate the advisory area. Rain levels rose to nearly 7000 feet and natural avalanches continued. On February 11, when the storm ceased, we cautiously stepped back into the backcountry. Crowns were visible on more slopes than we could count. Every elevation, from creek banks to the alpine, contained remnants of the widespread avalanche cycle. Some crowns reached an estimated 0.30 miles in length. Many of these slides released on top of the January crust, but several observed avalanches also stepped down to the basal facets and depth hoar.

Left photo Erich Peitzsch

Right photo Sarah Geurts Miller




Update from an AAA Graduate Research Grant

BY BENJAMIN HATCHETT

During the last three years, the emerging concept of atmospheric rivers, which are elongated, narrow corridors of strong mid-latitude water vapor transport associated with the warm sector of extratropical cyclones, has exploded into the vernacular of the general public. While not all cyclones are associated with an atmospheric river, those that are frequently produce extreme multi-day precipitation totals on par with hurricanes (Ralph and Dettinger 2012). When these features become oriented towards topographic low points along the western Cordillera, strong inland moisture transport can take place leading to extreme precipitation within the intermountain west (Rutz et al. 2015; Alexander et al. 2015; Swales et al. 2016). During the extended winter season (October–April) in particular, extreme precipitation is an excellent way to promote avalanche activity, and one component of the AAA-supported research sought to address this linkage.

In an examination of avalanche fatalities that occurred during or shortly following atmospheric river conditions from 1998–2014 using archived fatalities on the Colorado Avalanche Information Center website and via this archive (www.avalanche.org/accidents.php), we found that atmospheric rivers are commonly associated with avalanche fatalities in coastal snow avalanche climates with a decreasing association as one moves inland to intermountain and continental snow avalanche climates (Hatchett et al. 2017). We followed Rutz et al. (2014) and defined atmospheric rivers as regions where the vertical integral of water vapor flux exceeded a threshold value ($>250 \text{ kg m}^{-1} \text{ s}^{-1}$) over a specified length ($>2000 \text{ km}$). Two important findings follow: 1) that although the frequency of atmospheric rivers decreases with distance inland, the number of fatalities per atmospheric river increases and 2) inland moisture penetration through the known preferred moisture transport corridors often observed during the fatal avalanche incidents. Examination of SNOTEL stations near the incidents demonstrated heavy to extreme precipitation (85th–99th percentile) and increases in snow water equivalent typically exceeded the 30 mm threshold established for increased avalanche activity (Atwater 1954; Perla 1970; Bair 2013). Overall, we found broad consistency between regional snow avalanche climates (Mock and Birkeland 2000), climatological precipitation contributions from atmospheric rivers (Rutz et al. 2014), and percentages of avalanche fatalities during atmospheric rivers. Our results suggest that the characteristically weaker snowpacks of the intermountain and continental snow avalanche climates are more susceptible to heavy loading during atmospheric river events. Global climate models robust-



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The background image shows three people in winter gear standing on a snowy mountain slope, looking out over a vast, snow-covered landscape under a clear blue sky.

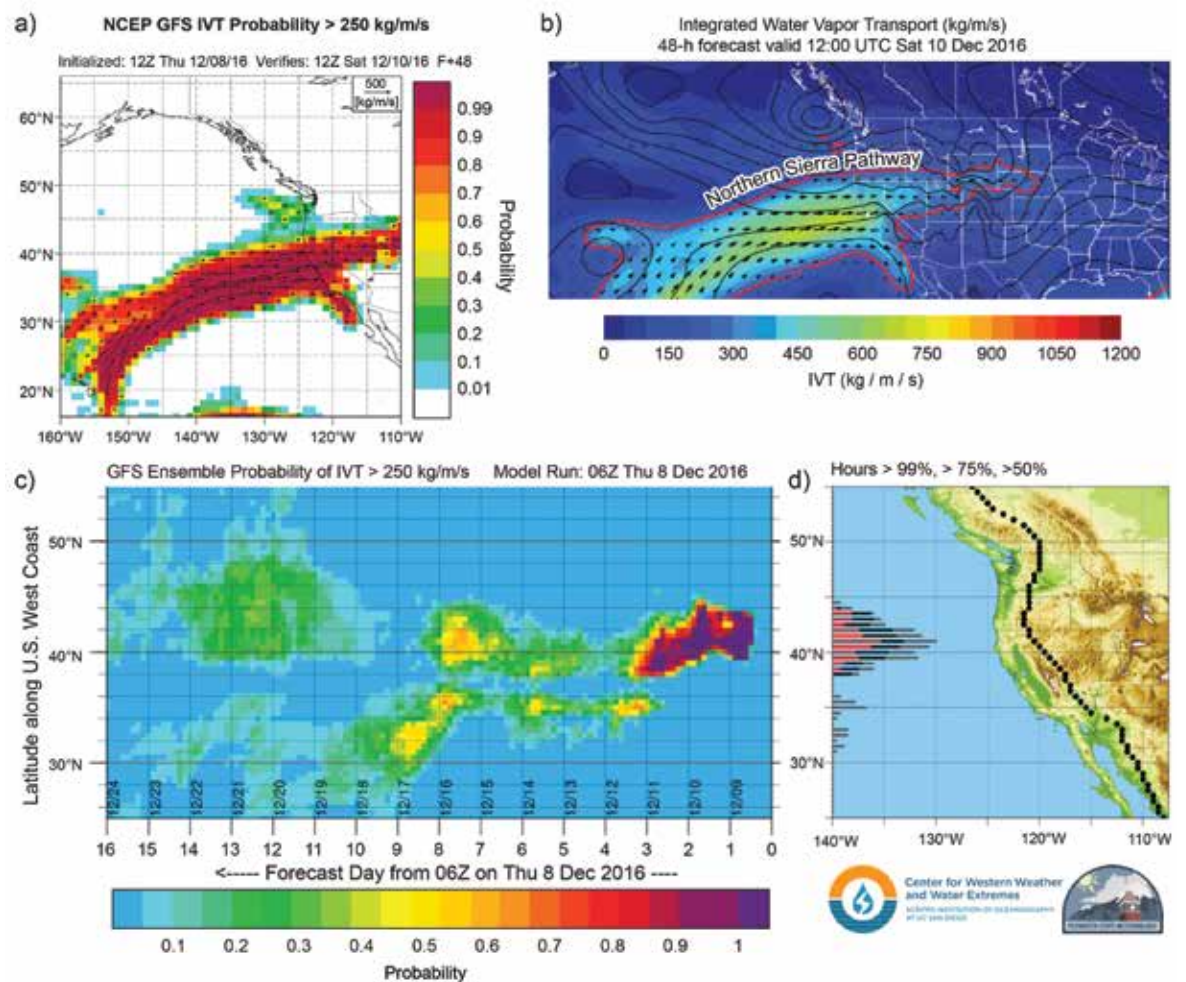
ly project future increases in water vapor transport in a warmer world (Lavers et al. 2015) via the Clausius-Clapeyron relationship, which states that a rise in temperature leads to an increase in the saturation vapor pressure of water. This relationship thus implies that greater moisture will be available for transport as the climate warms, leading to potentially enhanced precipitation rates and thus more loading during intense storms. We interpret these results as indicating that atmospheric rivers will only become more important in mountain environments. We also highlighted several forecast tools recently made available for public usage (Figure; Cordeira et al. in press; available at the Center For Western Weather and Water Extremes, http://cw3e.ucsd.edu/?page_id=491) that provide an ensemble-based perspective of atmospheric river magnitude, timing of landfall, and likelihood of inland penetration. It is our hope that these tools will be utilized by the avalanche community to improve their capabilities to work safely and to enhance the benefits they provide to the public.

The second component of the AAA-supported research focuses on examining the characteristics of upside-down storms, or storms that start cold(er) and become or end warm(er) with a reversed snow density gradient (more dense atop less dense). In this project, which is currently limited to the northern Sierra Nevada, we are using novel observations of snow levels during storms from the California Department of Water Resources/NOAA Hydrometeorological Testbed network, atmospheric reanalysis products, and surface-based observations to better characterize the processes that take place during upside-down storms and how both snowpacks and watersheds respond on hourly timescales. Some of our preliminary findings were presented at ISSW 2016 (Hatchett et al. 2016), two papers are nearing the submission stage, and three proposals to continue this work are pending as of time of writing. ▲

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As a life-long maritime mountain rider based in the Sierra Nevada, Benjamin Hatchett has always been fascinated by the storms that produced incredible quantities of snow as well as high elevation rain. His current research at the Desert Research Institute spans dryland and alpine hydro-meteorology and hydroclimate dynamics, paleoclimatology, fire weather, and urban sustainability.



Forecast tools that can be used in evaluating atmospheric river (AR) and moisture transport characteristics with regards to avalanche hazard in the western United States. The event shown penetrated inland via the Northern Sierra pathway (Rutz et al. 2015; Alexander et al. 2015). (a) Filled contours show the probability of integrated vapor transport (IVT) magnitudes exceeding AR criteria ($> 250 \text{ kg m}^{-1} \text{ s}^{-1}$) based upon 20 members of the NCEP GFS Ensemble for the 48 hour forecast valid at 12Z 10 December 2016. Vectors show IVT from the control forecast. (b) NOAA Western Regional Headquarters GFS Ensemble 48 hour IVT forecast valid at 12Z 10 December 2016. Magnitudes of IVT are shaded (units in $\text{kg m}^{-1} \text{ s}^{-1}$) and vectors show IVT in exceedance of $250 \text{ kg m}^{-1} \text{ s}^{-1}$. The red outline bounds the area satisfying the AR threshold of IVT. (c) Time-latitude plot of the fraction of GFS Ensemble members with IVT exceeding $250 \text{ kg m}^{-1} \text{ s}^{-1}$ making landfall along the west coast of the United States over a 10-day period beginning at 0Z 8 December 2016. (d) GFS Ensemble-based forecast probabilities of IVT exceeding $250 \text{ kg m}^{-1} \text{ s}^{-1}$ by latitude for inland points (black dots correspond with bars along y-axis) during the 84-hour period beginning at 6Z 8 December 2016. Gray, blue, and red bars denote $>50\%$, $>75\%$, and $>99\%$ chances of exceeding IVT thresholds, respectively. Note the correspondence of the peak of the bar chart with respect to the moisture plume depicted in (d) during the 8-11 December 2016 period.

4 5 Going to **EXTREME**

BY ZACH GUY (CBAC), BRIAN LAZAR (CAIC), AND ART MEARS (CONSULTANT)

In December of 2015, the Crested Butte area had an unusually prolonged and high-intensity storm and widespread avalanche cycle. Most of our avalanche paths had three to four-foot-thick slabs tear out, propagate the full width of their starting zones on basal facet layers, and produce extensive D3 avalanches. Due to a lack of volume in the start zones, the slides only ran about half of their historic tracks, generally R3 in size. The danger was rated High (Level 4) through the cycle, but it spurred conversations with CBAC and CAIC forecasters about whether the danger reached Extreme (Level 5) during this event. It became clear that more explicit operational guidance for when to issue Level 5 avalanche danger needed to be established. This would help forecasters decide between Level 4 and Level 5 ratings in future events, and improve consistency in hazard ratings, at least at the statewide level. Brian Lazar and the CAIC team set about establishing some criteria for use with the CAIC and CBAC, and arrived at the following forecasting guidelines for painting it black.

- An EXTREME danger rating means you expect a very unusual event.
- You expect widespread natural avalanche activity D3 in size, with the potential for some natural avalanches D4 or greater in size.
- Expected avalanches will break trees, and may include areas of mature timber. Historic avalanche paths may expand laterally and/or in vertical extent.
- Exposed structures, even along valley floors, will likely be damaged or destroyed.
- Extreme danger means avalanches will likely run full path. Thus, EXTREME danger should be issued for all elevation bands.

For the Crested Butte area, we are fortunate to have Art Mears's records of historic storms and avalanche cycles dating back to 1986, which we have referred to several times in the past few years during big storms. Art has records and "on-the-snow" experience of four major storms in the Crested Butte area dating back to 1985. The 1986, 1995, and 2005 storm periods probably produced the most widespread D4s and at least one D4.5 or D5 in 1995, but 2010 didn't despite a huge precipitation intensity (PI) spike near the end of the storm. Here is Art's recap of those four cycles.

- 1. 1986 (February)**—This was a persistent warm SW flow (sometimes referred to as an atmospheric river). Mean air temperature at Schofield Pass during the storm was -4.8°C . Winds were moderate and slabs were distributed on many exposures. The antecedent snowpack was 1.0-1.5m deep in the valley. This was the largest and longest of the storms (343mm SWE at Schofield Pass Snotel) but did not have the highest one-day PI. Because of the storm duration, warm temperatures and lack of very high daily PI, released slabs were quite thick because they didn't release until the near the storm end. Avalanches fell from various exposures and were long-running.
- 2. 1995 (February)**—This was also a warm storm (average temperature was -6.0°C) with total precipitation of 246mm. Again, winds were moderate and slabs were distributed on many exposures. The antecedent snowpack was about 1.1m deep at Gothic. A high precipitation rate (89mm/day) occurred near the end of the storm. Avalanches were widespread from various exposures and many ran long distances over small gradients.
- 3. 2005 (January)**—This was a warm storm (-5.0°C average temperature) with 203mm precipitation. HS increased from 1.8m to 2.9m at Schofield Pass during this storm. Winds were moderate and avalanches were widespread. Many ran long distances into the runout zone.
- 4. 2010 (December)**—This storm was another "atmospheric river." The mean temperature during the storm was a very warm -3.0°C . A total of 239mm of precipitation accumulated with a record 24-hour amount of 96mm on the next to last day of the storm. Winds were generally quite light. The antecedent snowpack was thin (about 1.0m at Schofield and only 0.7m at Gothic), weak and typical of an early-season continental snowpack. Avalanches were widespread on various exposures but generally were not as large as during the previous 3 storms considered here because avalanches released earlier on the weak snowpack. Very warm temps and rapid settlement may have contributed to stabilization during the storm.

A February 2014 storm was a two-phase, slow churner that lasted for 12 days, with the highest PI during the first phase of the storm. This storm was colder, with temperatures averaging -8.3°C . It fell on a 1.5 m snowpack at Schofield Pass, with a weak surface and known basal weak layer that had become less reactive following several large early winter storms. In the first 48 hours of the storm, 105mm of precipitation fell, followed by a relative 5-day lull and then gradually increasing precipitation for the next 5 days. During the mid-storm



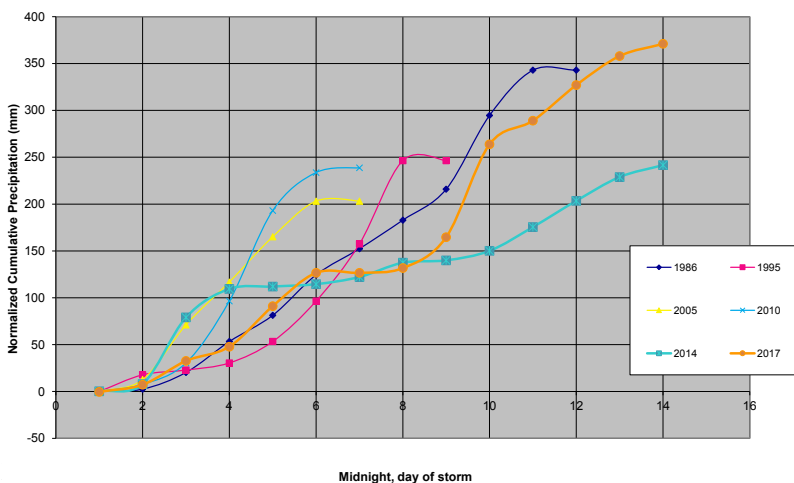
A very large avalanche that crossed Taylor Canyon Road (just below the reservoir) on January 11, 2017. This slide closed the road for several days. Photo Unknown



A D4 avalanche that ran during the January 2017 cycle, extending the historic trimline below Scarp Ridge. Photo Zach Guy



Normalized Cumulative Precipitation (mm) 6 major storms at Schofield Snotel
(Extensive avalanches & "Level 5 danger")



ABOVE: Crested Butte was in the bullseye for the January 2017 storm. Almost 15" of SWE fell at nearby Schofield Pass in the first two weeks of January. Photo Xavier Fane www.xavierfane.com

LEFT: Cumulative snow water equivalent at Schofield Pass, north of Crested Butte, during six major storms.

widespread as what we observed in December 2015 or February 2014. However, we did see numerous D3.5 to D4 avalanches that knocked over mature timber. A lot of evidence was obscured by subsequent snow before we got good visibility, but as we venture further and deeper into our forecast area, we continue to spot snapped tree trunks suggesting long running avalanches. It appears that the peak of instability probably occurred on January 9th, during the maximum precipitation intensity, although our data on the timing of observed avalanches is still limited.

Following the 2017 cycle, Art, Brian, and some of our forecasters discussed why this cycle may have come up short in extent compared to previous cycles. Despite a record-breaking load, it appears that the combination of several factors may have contributed to fewer very large avalanches than expected. First, the lack of pronounced basal weak layers appears to be a significant player. This winter, we also had a distinct break in precipitation mid-storm. This is in contrast to most of the previous historic cycles, especially 1986, that roared along and peaked in intensity near the end. The warm temperatures near the tail of the storm, with almost instantaneous settlement, may have also contributed to a stabilizing trend.

A reflection on these events supports common notion that extreme events are challenging to forecast. Historic storm events don't always produce historic avalanche cycles. These historic types of avalanche events happen rarely and are tough to recognize when they are occurring. During major storms, we don't have views of our alpine start zones and runouts, so we get very little feedback on what is happening in the mountains. If we have fragile weak layers, the walls come crashing down before the volume builds to historic sizes. These events happen during unusually intense precipitation periods, which weather models only sometimes capture, or their human interpreters sometimes doubt when they are accurate.

Cumulative snow water equivalent is an important factor to consider, but equally important is the precipitation intensity and the slope of the precipitation curve. A steepening curve, especially without a mid-storm lull, is a strong indicator. Having a poor basal structure also appears to be a contributing factor, although especially fragile structures, especially at the storm interface, may contradict extreme cycles because they prevent the buildup of historic slab sizes. Another impressive takeaway is that we have seen six impressive storms in just 31 years, suggesting that they are not all that uncommon for this area. Four of these events occurred in the just the last 17 seasons. Maybe they are becoming more frequent? ▲

the avalanches were confined to storm instabilities, with nothing breaking deeper. This, along with the relatively slow and steady precipitation rates continuing later into the storm gave us false confidence that the basal layers wouldn't come down as dramatically as they did.

This cycle met the Extreme criteria listed above. Extensive D3 and D4 avalanches ran to valley bottoms, taking out structures in both the Aspen and Crested Butte areas. Despite lengthy debates and careful consideration, we missed this one, and kept the danger at High through the peak of the cycle.

The January 2017 "Snowpocalypse" storm surpassed all of these previous storms in spectacular fashion. Over the course of 14 days, another two-phase atmospheric river delivered 374mm of precipitation, with temperatures averaging -6.6 °C. The second phase of the storm, which followed a two-day lull, came in warmer, windier, and with a higher PI. The storm fell on a 1.4 meter snowpack. Unlike most typical Colorado winter's, the snowpack began building in late November and relatively consistent snowfall reduced the development and spatial extent of basal weak layers.

The peak precipitation intensity of this storm occurred on January 9th, when 96mm of precipitation fell over 24 hours, matching the record 24-hour snowfall from 2010. This was roughly twice that predicted by high resolution models that day. On January 11th, the 11th day of the storm, we raised the danger to Extreme (Level 5) for the Gunnison/Crested Butte areas when another strong pulse impacted the Elk Mountains. Precipitation continued but decreased in intensity for the next two days, and we subsequently lowered the danger.

The jury is still out on how widespread and destructive the 2017 avalanche cycle was. Despite the massive load, avalanche activity was not as

The Storm of **THIS** Century

BY JIM WOODMENCY

It was Tuesday afternoon, February 7th, 2017 and I had already been at my desk way too long that day, watching it dump snow out the window. Since my office is at the base of Snow King Mountain (Jackson, WY), I decided a quick boot-up the mountain would provide a needed break.

About eight inches of fresh, relatively low-density snow had accumulated in my driveway, and I figured it could wait. You know: ski first and shovel later.

By the time I returned to begin the shoveling duties, the snow in town was beginning to mix with rain and sleet, and some sort of snainy, schlit-like precipitation. I tossed in some non-technical meteorological terms in there, by the way.

That easy-shoveling, low-density snow I had left behind in the driveway was now become a sopping mess to remove as well as a more intense upper-body workout.

It wasn't long before the wind was driving the schlit sideways and stinging my face. Winds were swaying big pine trees, scoring a solid "7" on the Beaufort Scale. Gusts were exploding the day's accumulation of powder from those trees, reducing the visibility to shovel-length, at times. The weather in my driveway got a little gnarly. Elsewhere, it was nothing short of horrendous.

At the time, it hadn't quite hit me that this weather would become the "Storm of this Century" here in Jackson Hole. These were weather conditions like we haven't experienced in more than 30 years, going back to February of 1986, when we had the Storm of that Century.

That February had a similar-length storm cycle, which also produced massive quantities of snow and rain, high winds, and an historic avalanche cycle.

That will be the gist of this article: a recap of the wild weather of this past February's storm cycle versus the February storm cycle of 1986.

February 2017 Storm Summary

The month began just like January had left off, with copious amounts of snow that had skiers, boarders, and 'bilers giddy with delight. This storm cycle actually began on Groundhog's Day. I'm not sure exactly what the local groundhog saw on February 2nd, 2017, but he should have sounded an alarm that we were in for a stretch of wild weather.

By that Tuesday night of February 7, the odd mix of precipitation types had changed to all rain. By Wednesday, February 8, it was raining all the way up to almost the 9,000-foot elevation in the mountains. That continued for the next three days, through Friday afternoon, February 10.

The wind had reached its crescendo on that Tuesday evening February 7, when powerful wind gusts knocked over a string of 17 power transmission lines along Highway 390 near Teton Village, near the base of the mountain.

Maximum wind gusts in the valley reached 61 mph at the Jackson Hole Airport.

On top of the tram, before the power went out, gusts reached 75 mph. At the top of Fred's Mountain at Grand Targhee, wind gusts topped out at 81 mph that same evening.

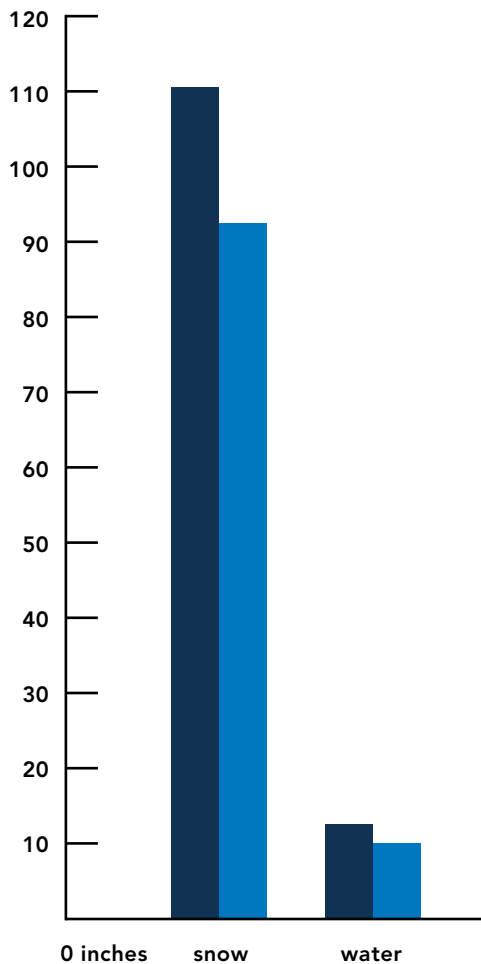
An anemometer at a residence along the Village road, which I trust to be relatively accurate, reached a peak gust of 83 mph, about the time the transmission towers folded.

Snow and water amounts during the first 11 days of February 2017 were huge, by Jackson Hole standards. I know there will be folks in the Sierra this year that will scoff. Nevertheless, total snowfall at Rendezvous Bowl during the roughly 11-day storm, between February 1-11, 2017 was 92 inches, just over seven and a half feet of snow. That 92 inches of snowfall contained 10 inches of water.

Needless to say, there were avalanches everywhere during this storm cycle, and avalanches in places that no one had ever seen before. There were avalanches that ran across the highway north of town, burying the "Welcome to Jackson Hole" sign. There were avalanches that closed the Snake River and Hoback Canyons to traffic multiple times during the ensuing week.

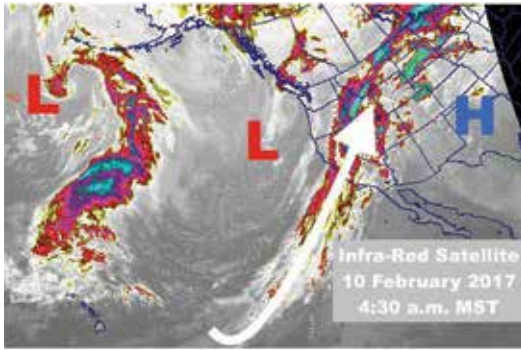
Teton Pass had many large slides that were R3-D3; both natural and explosive induced, crossing the highway in multiple places on both sides of the Pass. One avalanche in Glory Bowl left behind 20 to 30 feet of debris across 150 to 200 feet of highway. Miraculously, Teton Pass was only closed for four days.

The avalanche activity seemed to reach its crescendo on Thursday and Friday, February 9 & 10. Sadly, that Thursday, snowmobiler Josh Roth was killed in an avalanche near Black Mountain, south of Alpine, WY. The finale of this cycle was an in-bounds, skier-triggered, avalanche on a mogul run at Snow King Mountain.



STORM COMPARISON FEBRUARY 2017 & 1986

■ 1986
■ 2017



Southwesterly flow of sub-tropical moisture brings tons of water and warm temperatures towards the end of the storm cycle.

February 1986 Storm Summary

The February 1986 storm also started out cold, with lots of low-density snow to delight the ski crowd, for the first day or so. Then it got warm, and it poured rain in the valley. “Rain turned city streets into rivers,” as was quoted in the *Jackson Hole News*.

It also rained up to around the 9,000-foot elevation in the mountains, and snowed mightily above that elevation. Wind gusts during the height of that storm period reached 100 mph at the top of the tram.

Looking at data from the Rendezvous Bowl weather instruments, for the 12-day period from February 12 to the 23, 1986, there was 110 inches of snow accumulation with 12.5 inches of water.

For a period of time in February of 1986, both Snow King and Jackson Hole ski areas closed down, and Teton Pass was closed for a full two weeks.

All in all, February of 1986 had 18 more inches of snow in the mountains and 2.50 more inches of water than February 2017, over roughly the same number of days.

In the middle of that winter’s storm cycle, on February 17, 1986, Tom Raymer was killed in an avalanche on Moran Face during hazard reduction work.

On February 24, 1986, as the storm clouds were clearing and the ski area was “bombing the hell” out of the mountain, a lone round from the 105mm howitzer was fired at the Headwall (above where the top of the gondola is today). One of the largest avalanches in modern times resulted from that shot.

The avalanche ran down past the base of the Thunder chairlift, oozing down the lower mountain in the rain-soaked snow as a wet slide, to within 200 feet of houses near the base of the mountain. It dropped almost 3,000 vertical feet and ran over a mile-and-a-half in linear distance.

The likelihood of an avalanche of that magnitude ever happening there again is almost nil with modern avalanche reduction methods employed on the mountain today.

These two February storm cycles, 30-some years apart, were quite similar. Both were the result of a constant flow of Pacific moisture, coming out of the West and Southwest that was nearly relentless for 10 to 12 days. That moist flow, in both cases, also brought warming temperatures, which caused heavy rainfall at lower elevations. Both storm cycles resulted in massive avalanche activity. While February 1986 may have had more snow and more water, February 2017 ran a very close second. ▲

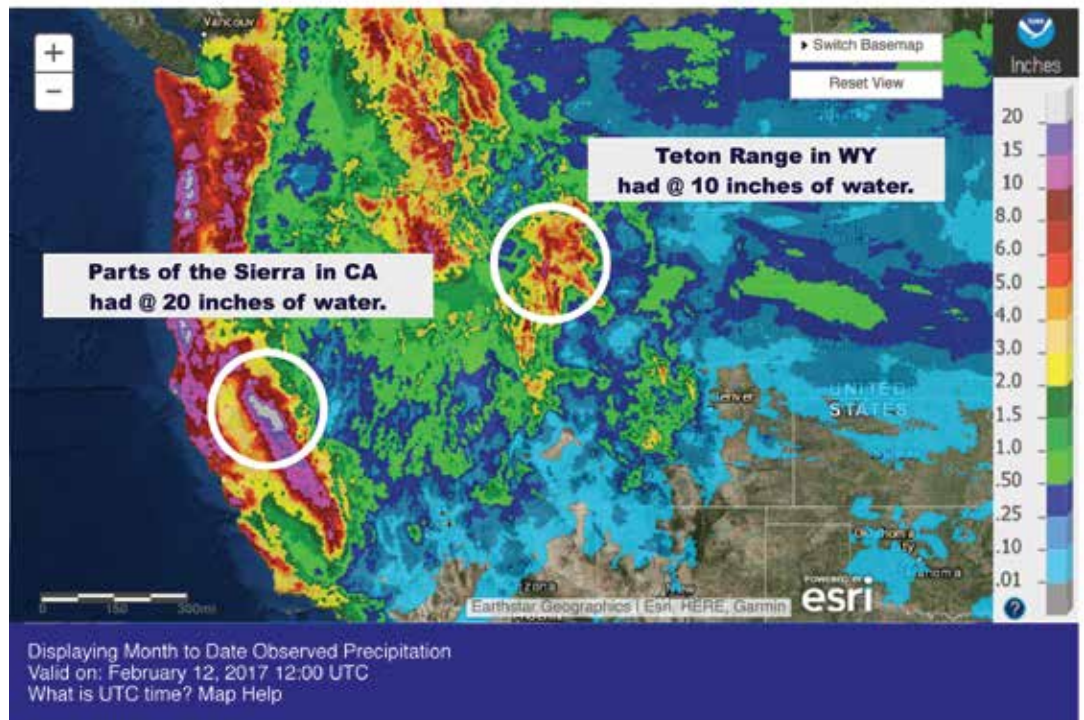
Special thanks to Renny Jackson, Rod Newcomb and Jamie Yount for helping me put this storm of 2017 in perspective with the great storm of 1986.



SS-AX-R4-D3.5. A Gazex triggered avalanche at Glory Bowl on Teton Pass, February 2017. The avalanche started as a dry snow avalanche at 10k ft. and then entrained a significant amount of wet snow when debris crossed the rain line at 9k ft. The debris pile was 25 ft. deep across 150-200 ft. of the highway. Photo Jamie Yount



Total Estimated Precipitation from February 1 thru 12, 2017



Both weather maps with text on top of them are courtesy of Jim Woodmency. See the following page for photos of both the 1986 and 2017 seasons.



Photos by Renny Jackson of the Headwall avalanche, February 1986. A ride on the JH aerial tram led to birds-eye shots of the crown and of the debris flow that oozed to a stop not far from houses in Teton Village.

2017

TOP: Debris pile from a wet slab Friday afternoon February 10th from the Granite Creek Slide area. Photo Brian Gorsage



CENTER: On February 7, 2017, this line of 17 power poles on Teton Village Road failed in sequence, cutting electricity for Teton Village and closing Jackson Hole Mountain Resort for five days. Photo Jim Woodmency

RIGHT: Jackson Hole was closed to the outside world off and on for four days as the bottom dropped out in Snake River Canyon and Hoback Canyon, during the Feb 7-10 storm cycle. Teton Pass was closed as well as rain up to 9000' brought snow onto the road from newly discovered avalanche paths. Photo Brian Gorsage



BOTTOM: Wet slab on highway 191 just north of Camp Creek. Wet slab ran late afternoon on Thursday February 9th. (At the time the slide path was not listed in the WYDOT avalanche atlas.) Photo Brian Gorsage



SKIPPING STEPS IN TRIP PLANNING LEADS TO ACCIDENT FORMATION: COGNITIVE **BIASES** AND PROTOCOLS

BY MIKE RICHARDSON

Last fall I came across a beautiful poster that featured a stylized human brain encircled by a very significant number of cognitive biases. In addition to its beauty, the poster is rather intimidating. In avalanche education, we often speak about the human factor, and when doing so we usually refer to a convenient, easy-to-remember acronym such as FACETS. The poster provides an undeniably stark reminder that our short and highly-convenient acronyms are just like our short term memory: short and highly-convenient.

A few years ago I wrote an article entitled *The Psychology of Backcountry Safety*¹, and in that article I used the term ‘accident formation’ to refer to the complex series of events that lead to avalanche involvement. It has long been my belief that skipping steps such as trip planning, and failing to follow protocols such as travel technique, are significant contributors to accident formation. However, I have been unable to connect my beliefs with hard evidence. The poster provoked a sustained period of reflection and discussion with industry professionals. During this process I was finally able to connect my beliefs and intuition with hard evidence.

It is unlikely that most people, except perhaps domain experts, will memorize an enormous list of cognitive biases. So if we’re not going to memorize anything, what is an appropriate course of action? The answer is surprisingly simple, and we can find the hard evidence we need in the commercial aviation industry.²

Like avalanches, many accidents in commercial aviation are either linked to or caused by human error. Pilots are subject to the same cognitive biases as the rest of us, and because of the potential for disaster, commercial aviation is strongly regulated by governments, airlines, and professional bodies. Stated simply, at every stage of a journey, the domain of commercial aviation is imbued with protocols designed to keep pilots, passengers, and people on the ground safe. Safety protocols found in commercial aviation include rules about alcohol consumption, rules about flying time, rules about flight plans, rules about equipment checks, and, well, there are rules for just about everything. These protocols are re-

quired to ensure the safety of the approximately 1.5 million people who board commercial flights every day.³

Web sites such as YouTube offer us the possibility of seeing things outside our common frame of reference and experience. This includes thousands of videos that show commercial airline pilots preparing for flights. If you watch even a few videos, you’ll notice pilots filing flight plans, checking the weather, and performing pre-flight checks. The complexity of these procedures is sufficient to require checklists. Again, most people, no matter their domain, expertise, or experience, simply cannot recall from memory all the steps required to execute any reasonably complex endeavor to an extremely high standard of repeatability. It’s just easier to require to file flight plans and follow checklists for every single flight without exception.

Checklists are important because they ensure that pilots don’t skip important steps. For recreational skiers, trip planning should always be the first step. Are you choosing terrain appropriate for the people on the outing and for current conditions? Or are you flying blind into a thunderstorm? Backcountry skiing is rife with opportunities to cut corners and ‘wing it,’ if you’ll pardon the pun, but doing this is a disservice to yourself and your ski partners. Uncertainty is the common attribute of all avalanche problems, and trip planning is the first step in managing this uncertainty, especially when terrain choices are viewed through the lens of the public avalanche bulletin.⁴

For industry professionals, the act of planning a backcountry outing is bedrock, and though it gets tedious to do the same thing over and over again, recreational backcountry skiers must be reminded that the terrain remains the same, but the people, snowpack, and weather can change on an hourly basis. Others will note that another significant difference between recreational skiers and professionals is that most professionals spend a lot more time on the snow, and participate in programs and conferences, such as ISSW, to ensure continuing education. Yes, this is an important difference, but the fact that recreational skiers have fewer opportunities to gain experience is actually another reason why it’s so important to internalize good planning and travel habits from the beginning.

As professionals, you already know all this, or you know most of it. In the past I’ve promoted the importance of teaching uncertainty, and I’ve been able to provide hard evidence as to why this is so important. I’ve also promoted the idea of strictly following protocol, but up until now I haven’t been able to describe why this is so important beyond gut feeling. The cognitive biases

poster made it simple: most people can’t manage that much data. There are simply too many things that can go wrong.

Consider a generic ski outing to a small mountain the day after a 30-centimeter snowfall. The objective is to ski three 300-meter runs through gladed trees. How many routes are there up? How many routes are there down? Where did the wind blow? Where did that snow go? What’s inside the snowpack? What was the existing snow surface like? What was the storm like? Warm? Cold? Fat flaked? Is an ordinarily fast ski partner dealing with fatigue because they were up late the night before? There are an extraordinary number of possibilities when taking into account the terrain, weather, snowpack, and people, and the number of, and character of, these possibilities broadly outlines the uncertainty.

In the context of backcountry skiing, a protocol defines a set of rules, and standards if you will, for managing this uncertainty. From this point-of-view, protocols are designed to ensure that safety is integrated into every step of a backcountry ski outing, and it would be very easy to say that protocols are more important for beginners than for experts. But the hard evidence we find in commercial aviation shows us that protocol is important for everyone. For example, during trip planning the question of alternate objectives arises quite frequently. **The existence of alternatives shows us that a trip plan is not linear, but is in fact a tree of choices we can modify in response to how our ideas about avalanche problems line up with reality.** The protocol for backcountry skiing says that we should understand all the main branches in the planning tree before we leave home, but the protocol also acknowledges the existence of smaller branches that can be filled in only after we have gathered information in the field. Accident formation can occur when the main branches of the tree are poorly chosen, or when the smaller branches of the tree are poorly chosen, but both mistakes arise from violations of protocol.⁵

So far we’ve identified the two main components of the planning tree: the main branches and the small branches. It’s important to note that while planning can help us identify the main branches, the dynamic nature of terrain, snowpack, weather, and humans can make it very difficult to characterize the small branches ahead of time. Clearly, proper trip planning can help us avoid catastrophic errors, such as choosing terrain wholly inappropriate for conditions, but the small branches are more numerous, and provide many opportunities for the accumulation of

Editor’s note: As Mike Richardson and I worked through drafts of his article, we came to a shared vision of a graphic that would illustrate the non-linear tree design of real decision-making. My Teton artist friend Cy Whitling seemed like the obvious choice to create this illustration on the facing page. You can find more of Cy’s work at www.cywhitling.com.

small mistakes. **Numerous professionals, across many domains, believe that accidents are caused both by poor choices in the main branches of a plan and by errors that accumulate in the small branches as well.** It is in these small branches that we also encounter the most difficult uncertainties, because it can be very difficult to anticipate the number and nature of these branches beforehand. These numerous small branches are exactly where human forecasting skills are at their worst, especially for people who are less skilled.

I feel like this is where managing uncertainty becomes critically important.

Reprinted by permission of the author, John Manoogian III.

I've said, for the better part of a decade now, that skiers should always make conservative decisions when their uncertainty is high, regardless of the reasons, and I feel like this advice is never better than in situations where the number of branches begins to exceed the scope of experience and skill we have in reserve. In these cases, skiers must be taught that being faced with an overwhelming number of uncertain choices is perhaps the most important sign that they should regroup and prune the tree back to its main branches. The main branches are far simpler and provide a much simpler structure for decision-making.

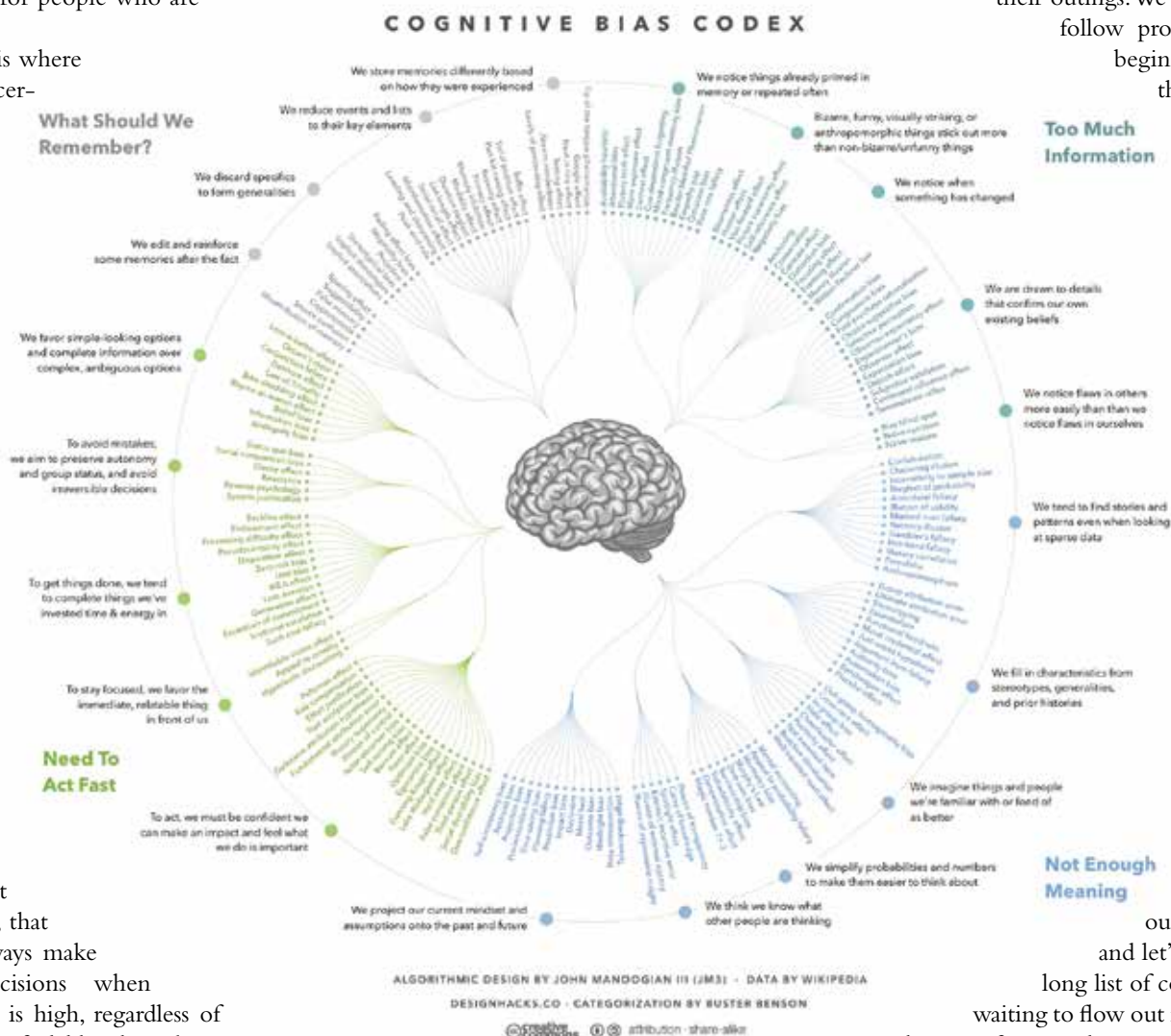
Think of it this way: you're at 2500 meters, on a northwest facing slope, and the danger rating is considerable. The results of snowpack tests are inconclusive and you feel very uncertain. What do you do? You can reevaluate the stratigraphy. You can reexamine the environment for signs of wind-deposition. You can check the temperature. Is it warmer? Cooler? These are all correct actions for someone capable of sifting through the information and prioritizing it accurately, but these actions are not correct for someone without those skills. For those less skilled, the appropriate response is to recognize the uncertainty inherent in the proliferation of small branches and the associated unknowns, and to go back to the main

branches. In other words, choose simpler terrain or simpler circumstances.

This is critically important because it was at the main branches that the error started to form: the choice to enter the slope and evaluate it. It wasn't a mistake at the time, but it is quickly becoming a mistake, and the ability to leverage the topology of the planning tree to recognize that a mistake is at hand is an absolutely critical skill that is so difficult to develop. This is the very root of accident

recreational backcountry skiers often experience so much difficulty: they focus on the secondary branches even though the secondary branches have simply pointed out that there are problems in the main branches that could not be foreseen without information gathered in the field. Properly trained individuals are far less apt to fall into traps in the primary and secondary branches, and this is a matter of training, professionalism, and experience.

As educators, we can do nothing better for our students than teach them to follow protocol so that safety is integrated into every aspect of their outings. We mustn't teach them to follow protocol because they're beginners, we must teach them to follow protocol because the complexity of a backcoun-



tion in the secondary branches: a small mistake sets of a chain of events that we don't think we can anticipate. But in fact we be trained to both recognize the mistake and to anticipate the chain of events. That's another reason why protocol is so important, because without it, we are, in effect, operating as if we were untrained.

The correct action in this situation is to turn around and choose simpler terrain. In turning around, you return to the main branches of the tree where two options for descent remain. This is a much better strategy because it removes a very significant amount of uncertainty from decision-making. Emergency medicine professionals do this all the time: the first considerations for any ER doctor, the main branches of the tree are ABC: airway, breathing, circulation. If these main branches are not addressed, then any focus on secondary branches, such as level-of-consciousness or blood counts, is both beside the point and a serious error. Once there is time to focus on secondary branches, high uncertainty information is considered, but not weighted strongly until hard evidence is available. I think this is where

try ski outing is sufficient to overrun our short term memory, and let's not forget about that long list of cognitive biases that are waiting to flow out into a ski outing in the absence of protocol.

The differences between avalanche professionals and recreational backcountry skiers has been discussed many times, and I believe that a signature feature of professionals, and of professionalism, is the ability to strictly follow protocol. In light of the swarm of cognitive biases, and in light of the pervasive uncertainty of avalanches, following protocol, especially the development of good habits with respect to planning and travel, is perhaps the most important thing you can teach your students.

Perhaps it's time for a longer conversation on what backcountry skiing protocol really means. ▲

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- 2 *The Avalanche Review*, April 2013, 'Risk: Sometimes We're Focusing on the Wrong Action', Page 22, Dale Atkins.
- 3 Bureau of Transportation Statistics (www.transtats.bts.gov)
- 4 ATES, ParksCanada. ATES Technical Model v.1-04, www.pc.gc.ca/pn-np/bc/glacier/visit/a7.aspx
- 5 Evan Byrne, NTSB, 'The Human Factor' 2012 Conference (www.youtube.com/watch?v=9SWkDQIFLgg), @ 6:00 Minutes

KILLING CONFIDENCE

BY DOUG KRAUSE

Words matter. Why choose a word that empowers some of our most fundamental biases? A word that, irrespective of expertise, grows in power as experience accrues. A word bound in ego. A word that sets us up for failure. *Confidence* paints our beliefs a pleasing shade of how smart we think we are. It is time for that to stop.

Humans are biased to see the world as less complex than it is. We jump to the easy answers. If we find an explanation that might be true, and we like it, let's roll with that. *It looks like it goes.*

Confidence describes how good we feel about something, whereas uncertainty highlights what we don't know—the actual problem. Uncertainty precisely targets the holes in our knowledge.

Every day we spin yarns that downplay uncertainty and eschew evidence.

I haven't seen any avalanches today, so the stability must be better than I thought.

Feeling good, feeling confident. What could go wrong?

Suppressing uncertainty, through denial or rationalization, is one of the primary ways humans cope with a dearth of information.

We are masters of building narratives that support our beliefs. I write and lecture and podcast on this stuff, yet I find myself falling victim to it all the time. Daniel Kahneman sums it up with brevity so poignant it borders on wit: **"An individual who expresses high confidence probably has a good story, which may or may not be true."**

We are prone to seeking evidence that supports our beliefs rather than contradicts them—confirmation bias—because being right feels good, and it's easier than starting over. For similar reasons, self-justification rampages through evaluation of our own decision-making, even among those that know better, because being wrong feels bad. Confidence speaks to how right we feel. It is a sop to our ego.

When failure is ambiguous, like on a nothing-went-wrong day, it's easier to justify decisions. That self-justification virtually destroys the possibility of learning from our weaknesses. Confidence enables the hindsight bias, aka the I-knew-it-all-along effect. Increasing confidence threatens increasing knowledge.

Decision-making research tells us that folk are more confident in their judgments than is warranted by the facts. It says we can feel real fine about any particular decision, even if we know we have a poor overall record of being right.

What kind of self-indulgent alpine witchcraft is that?

Even if we stink, inevitably we're still the hero of our own story. Kahneman and Tversky coined the term Illusion of Validity to describe the human penchant for maintaining high confidence despite high uncertainty. The Sword of Damocles may hang by a hair over our cozy bed of confidence.

One fine day in Syracuse (Sicily, not New York) the Greek Damocles was brown-nosing King Dionysius. He praised the power and authority wielded by Dionysius as a profound blessing. "Oh, you think so?" rejoined Dionysius and offered to switch roles with Damocles, so that he might experience first hand the blessings of power.

Clearly, the brown-nosing impeded Damocles' ability to smell the obvious trap disguised as a parable. He eagerly accepted and took his place upon the throne where he reveled in power and luxury.

However, the fool is quickly parted from his reverie. Over the throne Dionysius suspended a massive sword by a single hair. The sword represents the incessant peril faced by those in positions of power. A hair's breadth separates responsibility from doom.

Damocles begged for a return to his former position of ignorant sycophancy.

I had a near-miss a while ago that I've reviewed in my head a hundred times—trying to figure out what we did wrong and what we could have done better. I clung to the easy answer for two whole friggin' years. It was only recently, when I actually—physically—made a list of all of our lapses and errors that the light finally shone through, that I was able to pierce the veil of self-confidence and self-justification that shrouded our process. When I spoke of the incident in the past, I even mentioned these mistakes, but I pooh-poohed them. Only the cold hard words on the page jerked me out of delusion.

Questioning belief is a fundamental component of reassessment, yet too often we frame that with an affirmative that supports belief: confidence. We allow confidence to bridge the gaps between evidence and uncertainty. It's a bridge that needs burning. The pillars of evidence and uncertainty can support or refute belief quite well on their own.

In *The Black Swan*, Nicolas Nassim Taleb describes the pervasive human tendency to underestimate (or fail to appreciate) uncertainty. He uses the phrase—exiting doubt—to describe this tendency and points out that we usually exit doubt without realizing it.

Confidence paves that subtle path to the exit: a passive low grade certainty that compromises situational awareness and undermines skepticism. Confidence can be the lazy way of settling a matter. I think it's probably fine. Focusing on uncertainty invites more work. Is the uncertainty acceptable? If not, how can we reduce the uncertainty or build a margin that decreases our vulnerability?

It is time we stopped using confidence and instead train ourselves to frame belief in terms of evidence and uncertainty. This applies to confidence ratings in hazard forecasts, confidence as a way of qualifying our beliefs, and, what the hell, anything else you can think of.

The Canadian Technical Aspects of Snow Avalanche Risk Management devotes an entire section to uncertainty and requires that it be "clearly communicated." Yet Avalanche Canada still opts to qualify their forecasts with a confidence rating. I know that many professional American operations still use confidence ratings in their forecasts. I suspect the term also permeates current avalanche education and informal backcountry discourse. We need to 86 that shit.

I've purged Confidence from my daily hazard forecasts and replaced it with Uncertainty. It's a semantic change, but an important one that contributes to framing the daily mindset in a more appropriate manner. Uncertainty encourages us to pause and reassess. It encourages us to target the unknown, and, as Steve Conger asserts in TAR

34.4, it begs the question of whether that uncertainty is acceptable. We can use that answer to seek more evidence, give 'er, frame a margin, or get the hell out of there. If you haven't read *Acceptable Uncertainty* from TAR 34.4, do it now.

I've kept my uncertainty ratings simple—with no attempt to define what High, Medium, and Low actually stand for. This is not a standard; it's a nudge. It's a way of presenting information that encourages skepticism of belief.

That being said, I actually think levels of uncertainty should be defined. Surely there is a committee somewhere that can handle that challenge.

I'm trying to purge confidence from my normal discourse, and it is challenging. Not only do I slip and use the word, when I catch myself, and try to reframe in terms of evidence and uncertainty, often **the void of support for my belief comes into sharp focus.** I can see clearly through the gaps in that bridge into the chasm of uncertainty that lies below—and that is alarming.

I respect the role of confidence when rapid action is required. Overwhelming uncertainty can paralyze. I clearly remember finishing my Level One course and being overwhelmed by uncertainty. That was not the last time. I respect balance, but I find valid confidence is less common than getting hoodwinked by assumptions that it will probably be fine.

Using language to guide judgment may alter patterns of behavior. Language can be the vessel of clarity that sets us up for success or failure. **Words matter.** ▲

Thanks to Keith Gale, Jerry Isaak, Drew Hardesty, Steve Conger, and Mike Richardson for their assistance with this diatribe.

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10 COMMON MISSTEPS OF AVALANCHE PRACTITIONERS

Presented at The International Snow Science Workshop 2016 in Breckenridge, Colorado

BY TODD GUYN

Uncertainty is a sign of humility and humility is just the ability or willingness to learn.

—Charlie Sheen

Canadian Mountain Holidays, Banff, Alberta, Canada: Avalanche practitioners work in a hazardous environment, characterized by a large degree of uncertainty. While extensive operational efforts are undertaken to minimize uncertainty, it cannot be eliminated. As a consequence, accidents and incidents will continue to befall this challenging workplace. There are often many different contributing factors to any avalanche incident, but the one constant is the presence of man.

The purpose of this presentation is to outline and discuss 10 common missteps or errors that avalanche practitioners and winter mountain travelers make in the course of their career or life.

To identify the most common missteps, a short questionnaire was distributed among 70 IFMGA mountain guides or ACMG ski guides with 10 or more years working in a production helicopter skiing company in a team environment. The company averages 6000–7000 guests in a guided wilderness skiing setting per season spread over 11 different operations. It has been operating for 52 years with an annual guiding staff of 125 certified guides. None of the factors discussed fall exclusively within the snow science area, but are rather the results of the interaction between the avalanche hazard and the people working and traveling in the mountain environment. Although the discussion of bias is not new in the social science realm of the avalanche world, it is insightful to review and reflect on observations of the seasoned practitioners themselves.


INTRODUCTION

Working with a large group of mountain guides for the past 21 years has provided valuable insight into the day-to-day operations of an occupation in an uncertain and high risk environment. For the last five years, I have been the mountain safety manager for 12 operations, with the main focus being on snow science, hazard, and risk.

This has given me the opportunity to discuss the hazards and risk with some of the most experienced guides in the world. The paper began with an interview request from Wagner skis to highlight "Mistakes Even Experienced Backcountry Skiers Make." It was written by Krista Crabtree and can be found in Wagner skis journal, or at this link www.wagnerskis.com/journal/backcountry-mistakes/.

It was a worthwhile piece and I felt it could be expanded to be directed at operating professionals in the avalanche industry.

The intent of the paper is for practitioners to stop and give thought to some common human factors we all face and all have within us, regardless of experience.



COLORADO MOUNTAIN COLLEGE
Avalanche Science

“ The Avalanche Science program addresses a gap in U.S. avalanche education between recreational courses and professional certification courses. It combines education and mentorship in a structure previously not available to aspiring avalanche workers. ”

— Brian Lazar, Deputy Director
Colorado Avalanche Information Center

▶ ColoradoMtn.edu/AvalancheScience
Leadville, Colorado
Elevation 10,200 ft.

SETTING AND METHODOLOGY

Canadian Mountain Holidays (CMH) is one of the oldest adventure travel companies in North America and the most experienced and biggest Heli-Skiing operator in the world.

CMH operates in the Purcell, Selkirk, Monashee, and Cariboo mountains of eastern British Columbia from eight backcountry lodges and three town-based hotels including the Adamants, Bobbie Burns, Bugaboos, Cariboos, Galena, Valemount, McBride, Revelstoke, K2 Naskup, Gothics, and Monashees. We have recently added a Nomads package which operates from Halcyon Lodge. Our operating area encompasses approximately 15,000 square kilometers of terrain, granted under Licenses of Occupation from the British Columbia government.

CMH hosts between 4500 and 6500 heli-ski guests on mainly week-long trips every year, which also makes it the largest heli-ski operator world-wide in terms of guest skier days.

CMH has a winter guiding staff of 125 guides all certified and qualified with the following:

- ACMG or other IFMGA member associations, including CAA level two certification
- Annual CMH pre-season guides training (3 days)
- Annual CPR and AED recertification (4 hrs)
- Annual CMH area training / set up (5 days)
- Professional CPD requirements for ACMG / IFMGA and CAA members
- Advanced first aid recertification (40 hrs every 3 years)
- WSBC Avalanche Blasting Recertification, if applicable

The Mountain Safety Manager (MSM) role was first incorporated into CMH in 1991. The role was established to focus solely on all aspects of snow stability evaluation, hazard assessment, and risk management procedures for CMH skiing operations.

During the winters of 2012/13, 2015/16, questionnaires were sent out to all the guiding staff with 10 years or more of heliskiing experience. The total number of guides replying has about 70 -80 with results from both of those seasons combined. The results were compiled and sent to all the winter guiding staff. The positive feedback indicated it was an interesting and successful project for the guides.

10 COMMON MISSTEPS OF AVALANCHE PRACTITIONERS

1 Misapplication of terrain

There are constants in the formulation of avalanche hazard on any given day and one of the main elements is the terrain itself. It changes little over time and before decisions are made it can be studied and interpreted. As competent professionals we all know the physical factors involved in identifying avalanche terrain but we continue to falter in our mitigation of the risk by not adjusting location to meet the hazard at the time. The snowpack lies over the terrain but it is not a constant and can be unpredictable and therefore uncertain; leading to the importance of interpretation of physical terrain. You can solve most avalanche hazard issues by choosing the right terrain for specific conditions. Competent practitioners often underestimate the complex uncontrolled nature of the environment. The cultural trend of our society and industry often views our terrain as an amusement park. This can have an influence on our respect and caution towards mountain travel and terrain interpretation. We cannot change the snowpack, the terrain, or the weather but we can change where we are and how we travel in the mountain environment. To quote one of the guides:

“Even more fundamental than hazard assessment, decision-making, and safety equipment, our most effective tool to manage the inherent hazards we encounter is how we manage our movement through the terrain.”

Bigger margins of safety in terms of terrain have made a difference to many experienced guides. Remember the basics: size, angle, and shape. Respect the terrain.

2 Being Impatient with Conditions

Humans are not particularly patient. How many people have switched lanes in traffic or flipped through the TV channels only to get back to exactly where you started or worse? When we have goals we are trying to reach, be it guest satisfaction or opening unskied terrain we often view time as a hurdle to achieving those goals. This naturally leads to impatience. What has cost you more in your life- being patient or impatience? A common comment from the guides was the trap of doing too much too fast with a given avalanche problem.

“One of the continued things I see is too much trust in a surface hoar layer gaining strength. Time and time again, I see and hear that “blank layer is now not a problem or that it is no longer a concern. I will make decisions on a SH layer after some weeks or longer until I justify to myself the layer is no longer a concern with direct observations of tests to back up my actions. If I think about it the more time I give a layer, the better I feel and that can be months later.”

It has also been noted that sometimes not acting on short term feedback, (ie ski cutting), but instead deliberately slowing down and letting time pass allows opportunities to eventually present themselves. Practicing patience and waiting out conditions was viewed as a positive trait amongst the guides which, in the end, leads to a less stressful work environment and a higher level of certainty about prediction of avalanches.

The key to everything is patience.

“You get the chicken by hatching the egg, not by smashing it open.”

—Arnold Glasow, American humorist

Competent practitioners often underestimate the complex uncontrolled nature of the environment.

Getting more information is not always the correct answer. The challenge lies in getting the data that is most relevant to your issue. We need to ask—is more really better?

3 Trying too hard to outwit the avalanche hazard

As a general rule, thinking is a good thing. Having a logical and methodical approach in your decision-making is something highly valued. Although quite often avalanche professionals try to seek a way around a problem using analytical skills when the problem is just too widespread or uncertain in nature. We do our damndest to get to the solution using our conscious analytical brain, unfortunately due to our cognitive bias(es) we fail to see the blind spots we missed along the way. Quite often we just try too hard, when waiting out the problem is the best solution.

“For every complex problem, there is a solution that is simple, neat, and wrong.”

—H.L. Mencken

4 Acting too much on emotion

Understanding how your brain works in decision-making is an important element for a safe and successful career in a high risk workplace. Your brain works in two ways: the rational part that gathers information to help you make an informed decision and the emotional part (the feeling) that’s trying to have a good time. But you really have to keep yourself in check and balance between the feeling and the rational process. You need the emotion to have a fulfilling life but must not be controlled by it. Just because you want to have a good time and ski the slope, conditions might not be right. The rational part needs to say, “All the info says it’s bad, I’m not going to ski it.”

5 Information overload

These days the excuse of not being informed is usually not valid. Living in the technical age, access to current conditions is easier than ever. One of the issues facing the avalanche professional is the sheer volume of information available and the time and resources required to process that information in a meaningful way. It is important to understand what is essential to your decision-making towards a said problem and to remove what is not. Getting more information is not always the correct answer. The challenge lies in getting the data that is most relevant to your issue. We need to ask—is more really better?

“Most of what exists in the universe—our actions and all other forces, resources and ideas- has little result; on the other hand, a few things work fantastically well and have tremendous impact.”

—Richard Kock

6 Not being vigilant to changes in the environment

The weather and the snowpack are closely related. It is highly valued to be aware of changes in both these elements. These changes can be quite subtle in nature, but amongst the guides it was noted that a failure to recognize these environmental changes led to inconsistency predicting avalanche behavior. Make a conscious effort to add the question, “What I am missing here?” to your internal dialogue.



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7 Letting familiarity influence your mindset

The familiarity heuristic is one of the most cognitive embedded biases we carry in our decision-making process and for a lot of the time it serves us well. We generally equate the familiar with safety and knowns. In contrast, the “gut feel” we have about a familiar piece of terrain can be quite misleading and may lead to an underestimation of risk. When we return to the same areas often, we usually get in a positive reinforcement loop, get complacent, and can lose the perspective of potential risk. The duality of working in familiar terrain and snowpacks remains a challenge. The guides valued and strived to acquire the trait of keeping an open mindset with fresh eyes.

8 Underestimating Consequence

We are constantly surprised by the magnitude of avalanches. We underestimate the destructive size that the terrain and snowpack can produce. The failure to make necessary adjustments in terrain choice can be based on the lack of understanding of the magnitude and intensity of an event, making this a human error. Because events may not be everyday occurrences people diminish the relevance of past experiences.

9 Lack of Communications

The main misstep noted by the guides had to do with a lack of communication, which was the single biggest factor involving events of consequence. Miscommunication can be found on a larger scale amongst teams, or small scale, person to person, in situations such as giving directions. It also came in many forms including not being transparent, choosing the wrong communication style, not knowing your audience, incorrect tone, and not speaking up when doubt lingered. There are many reasons why communication is an issue, but the bottom line is a lack of information in one form or another. If we have a workplace where we work with other people we must continue to seek ways to facilitate open and meaningful dialog toward the essential tasks at hand.

10 Underplaying of Uncertainty

The current definition of uncertainty in the Canadian avalanche industry is:

The state (even partial) of the deficiency of information related to the understanding or knowledge of an event, its consequence or likelihood (ISO, 2009).

Due to the spatial variability and the physical environment of the mountains we often work in a highly uncertain state. It is important to recognize this element in the entirety of our decision-making. We often overestimate what we know or what we think we know due to past success in our field which can lead to overconfidence. Overconfidence and a failure to recognize the level of uncertainty in the physical environment we work in leads to faulty decisions based on incorrect premises.

More targeted information gathering, understanding the uncertainty, and differentiating between what we actually know and what we think we know can help reduce the uncertainty and in the end our overall risk in our field.

It ain't what you don't know that gets you into trouble. It's what you know for sure that just ain't so.

—Mark Twain

CONCLUSION

As science slowly grinds away explaining the uncertainties in nature, we are left to live and work within an environment which carries risk. Although all the points fit into some heuristic bias or other, the interesting point is not the box or name of the bias but how they are actually manifested and communicated by real practitioners. There is nothing new in our failings, they seem very common and familiar to all of us but perhaps being cognitive of others' mistakes we can see them in ourselves.

Remember these common mistakes the next time you head into the backcountry, and remember to stay safe out there! ▲

ACKNOWLEDGEMENTS

I would like to acknowledge and thank CMH, all the winter guides and managers past and present for their time, thoughts, discussions and mentorship with special mention to Roger Atkins and Dr. Pascal Haegeli. Without their dedication to providing a safe and enjoyable mountain experience for CMH staff and guests we would not have the opportunity to partake in a wonderful pursuit.

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Education: the path from cocky
ignorance to miserable uncertainty.

—Mark Twain

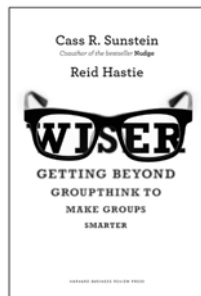
An avalanche in CMH's Bobbie Burns tenure gives primary information that helps to resolve uncertainty. Photo courtesy Todd Guyn



SYSTEMATIC **BIAS** IN GROUP DECISION-MAKING

BY THOMAS WHITE

The leader who is always anticipating what may go wrong and seeking to uncover solutions to imagined problems is likely to inspire the most creative group thinking.



PART 1: THEORY

Two heads will often be worse than one. That's the unsettling message of Cass R. Sunstein and Reid Hastie in their book, *Wiser: Getting Beyond Groupthink to Make Groups Smarter*.

Sunstein and Hastie's explanation of the ways in which groups deliberating on difficult decisions often make worse decisions than individuals should worry all of us working in hazardous environments. *Wiser* challenges us to examine whether common methods of conducting AM and PM meetings and a culture of consensus decision-making may be putting us at extra risk. We may be unintentionally introducing a systematic bias into our group decisions.

In 2005—a year after Ian McCammon's paper on Heuristic Traps—author James Surowiecki published *The Wisdom of Crowds*. The book recounted the story of a crowd at an English county fair. A prize was offered for guessing the weight of a prize ox. The median of the 800 guesses proved to be within a fraction of a percent of the ox's actual weight. Taken as a group the fairgoers' assessment was far more accurate than the closest guess of any individual. How was that possible?

The notion that groups working together will find best answers to difficult questions is seductive. Concluding that by carefully reciting and considering known facts and reaching a group consensus we will eradicate individual biases and protect ourselves from McCammon's Heuristic Traps is easy. It's easy, but it's wrong. Surowiecki cautioned in his book that not all group decisions will be wise. Statistical groups—like the group at the county fair—can make astonishingly accurate decisions. However, a statistical group must have a diversity of opinions, a method for capturing and reconciling that diversity and it is critical that statistical group members not confer with each other before making their decision. Members of statistical groups are not unbiased. Each member of the group will certainly have their own individual bias. However, since these biases are all different they will tend towards canceling each other out. It is the existence of a diversity of biases that makes statistical groups so powerful.

Most decision-making groups do not meet the requirements of a statistical group. Decades of research by behavioral psychologists and the collapse of a global financial bubble have shown that in many situations groups may be foolish and crowds can become irrational. *Wiser* provides a clear explanation of the ways in which group decision-making can go astray. These negative group factors are broken down into four principal processes: amplification of individual errors, cascade effects when the ideas of early speakers carry disproportionate weight, group polarization which causes group decisions to reflect extreme rather than moderate views, and a systematic group bias towards emphasizing shared information and discounting facts known only to a few. All four of these processes are activated by one irresistible human factor: the reputational bias. The reputational bias gets its power from our desire to fit in with others, to conform with a group. According to *Wiser*, co-workers or groups whose members share similar training are especially vulnerable.

Two psychological experiments (one from the academic world, the other from popular entertainment) demonstrate the power of the reputational bias and by extension the four negative group factors.

In the 1950s, the psychologist Solomon Asch did a series of experiments on the effects of peer pressure and conformity. The Asch Conformity Experiments were presented as an examination of visual perception where the assigned task was to compare the length of two lines. Unknown to the test subject, only he was the subject of the experiment. The rest of the people in the room were secretly working as part of the experiment. After hearing four previous people announce an incorrect but unanimous opinion on the length of two lines the test subject would proceed to agree with the group's unanimous—wrong—judgment. When interviewed afterwards many of the experimental subjects admitted that they had known that the group's answer to be incorrect but had decided to go along with the majority. However, a certain portion of the test's subjects actually believed that the group's answer had been correct. The effect of peer pressure was enough to alter the test subject's perceptions.

A less rigorous but amusing experiment in group conformity was conducted by the reality television program *Candid Camera* in 1962. An unsuspecting man walks into an elevator filled with actors working for the show and becomes an unwitting guinea pig. When the actors slowly turn to face the back of the elevator the victim of the prank hesitates for a moment before slowly conforming with the group facing the rear of the elevator. Video of both the Asch Conformity Experiment and the Candid Camera Elevator prank (which has become part of an advertisement for an insurance company) can be found online.

Should I stay or should I go? That binary choice was posed by The Clash, an English punk band. In the avalanche realm the choice might be: *close the road or keep it open?* Binary questions are problems with only two possible answers.

When faced with a binary choice, *Wiser* suggests a simple procedure to avoid the effect of negative group factors on decisions. Take a vote. In order for the voting process to capture the full diversity of knowledge and group opinion, it's important that before voting that the group



A lesson in human factors with AMGA instructor Jeff Ward during a 5:45 am January meeting with AMGA Ski Guide Course students on the study plot at Sol Mountain Lodge, BC. Photo Thomas White

not discuss facts or deliberate on the alternatives. The vote must be secret. Just state a binary question, tally the responses, and accept the wisdom of the group. A secret vote conducted by a group without prior deliberation could be a quick way to reach a decision, but will choices made this way be any good?

Wiser presents the work of an 18th century French social theorist and mathematician, the Marquis de Condorcet, to show that voting can lead to optimal solutions to binary questions. Consider the example of a group of four highway workers making a binary choice whether or not to close a road. Let's assume that each of the four workers can be expected to make the right choice four out of five times (an 80% likelihood of making the correct choice). The Condorcet Jury Theorem shows that the decision reached by a vote of the four workers is nearly 100% likely to be correct. This is important when keeping in mind that if the workers started with a 80% chance of making a correct individual decisions and they have a discussion about the problem and reach a consensus decision, the likelihood of evaluating the hazard correctly is likely to be less than 80%.

A day touring through avalanche terrain will pose many problems without binary solutions. Determining the proper strategic mindset to adopt for the day's trip is a problem with several possible answers. *Wiser* introduces the Delphi method as a tool for problems like this: an iterative process that helps a group to progressively narrow down a range of choices to discover the optimal choice. A group of experts provides anonymous answers and their corresponding reasoning for their answers. The facilitator then summarizes the responses, discards the least supported response, and the process repeats until the group converges on a single choice.

Translating decision-making theory into practices we can use in avalanche terrain is an endeavor that needs a few guiding principles.

PART 2: PRACTICE

Consider an analogy between human wellness and group decision-making. In this comparison systematic group bias is not the germ; it is the vector of transmission. The germ infecting a group decision might be any of the heuristic traps and associated biases identified by Ian McCammon. (*Editor's note: See Cognitive Biases article by Mike Richardson in this issue of TAR, page 27.*) Systematic group bias occurs when an individual bias spreads to the whole group. Systematic bias replaces the diversity of bias found in statistical groups with a unified shared bias. Instead of an epidemic the result is a contaminated decision. Not every uncovered cough will lead to a flu epidemic. Likewise, not every contaminated decision process will result in an avalanche accident. However, if groups allow systematic biases to distort their decisions, eventually a bad outcome—a preventable incident—will occur.

As we have learned, covering our cough with the crook of our elbows can keep us from spreading the flu. Washing our hands after using the toilet can prevent cholera infections. Likewise, there are techniques of group decision hygiene that can reduce the chance of reaching a contaminated decision that leads to an avalanche tragedy. The second half of *Wiser* is devoted to examining the ways in which groups can collaborate without succumbing to systematic bias.

A secret vote conducted by a group without prior deliberation could be a quick way to reach a decision, but will choices made this way be any good?



Avalanche class students, led by instructor Joey Thompson, use a quick vote to preserve and record the diversity of students' opinions. Photo Thomas White



Taking a vote without deliberating beforehand can lend an accurate decision on an important matter. Is the stability Fair or Poor? Revisit the question at day's end. Photo Thomas White

Below is a list of eight ideas adapted from *Wiser* to reflect the needs of avalanche professionals.

1 Find and support anxious and restrained leadership.

Wiser praises the value of anxious group leadership. The leader who is always anticipating what may go wrong and seeking to uncover solutions to imagined problems is likely to inspire the most creative group thinking. A group's leader has an important role in preserving the diversity of group opinions. *Wiser* advises that group leaders should be self-silencing. If a leader can defer sharing her own information until she has heard all the thoughts of other group members it helps reduce the negative effect of privately held knowledge—facts known to only some of the group. If the leader can create an atmosphere in the group where all points of view are treated with respect she is most likely to lead the group to a good result.

2 Create diverse groups.

Guides know that if you are locating your position with a map & compass, bearings from widely spaced landmarks will establish a position more accurately than bearings taken from closely aligned features. Likewise the more widely separated the viewpoints of a group, the more creative and innovative their conclusions are likely to be. A group composed of a mountain guide, a forecaster, and a patroller is more likely to discover a creative solution to a problem than a group of three guides with similar training and experience.

3 Preserve the diversity of opinions.

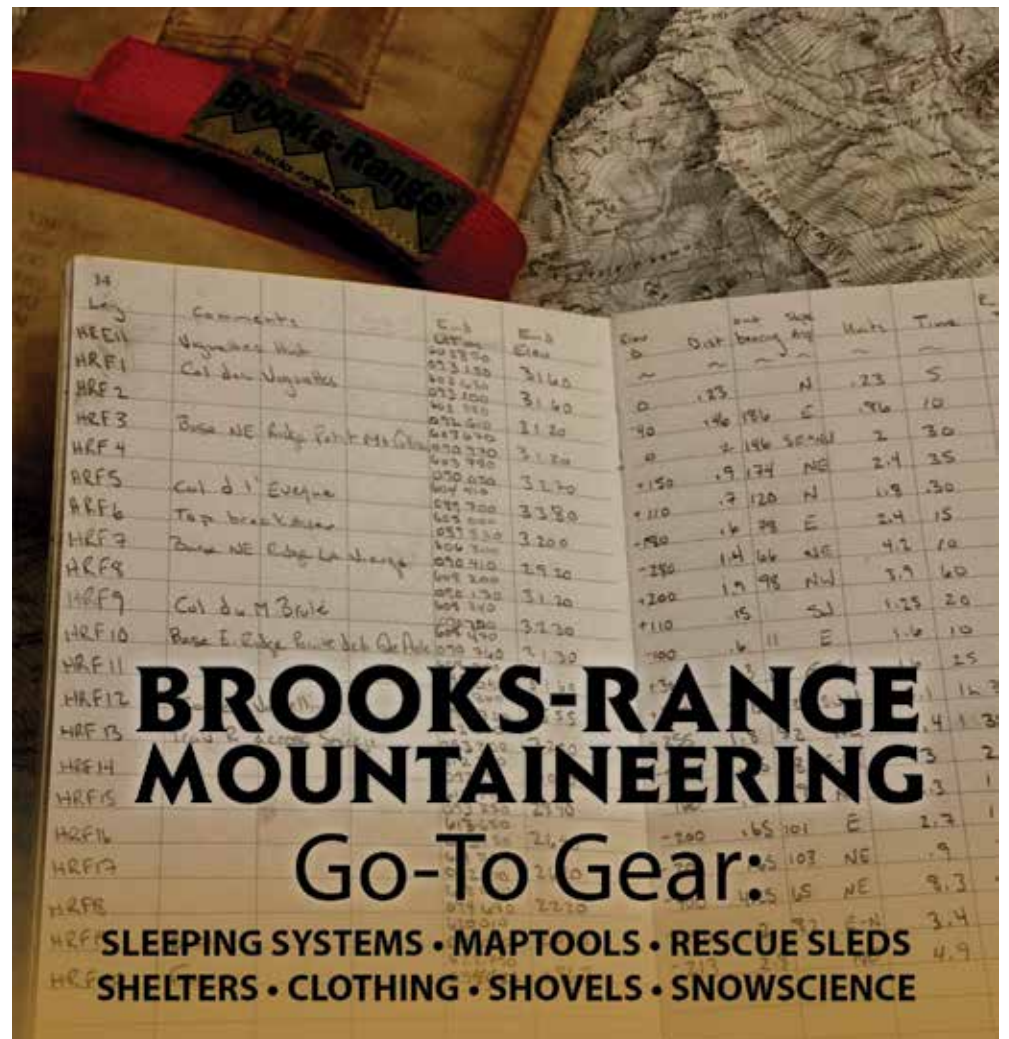
Water cooler chat may taint the diversity of group opinions, especially if it takes place right before more formal deliberations. If a fellow guide, your coworker Ann, informs you of the morning forecast just prior to an AM meeting you may go into the meeting with a single bias you picked up from the forecaster. The diversity of opinion—yours, Ann's and the forecaster's—about the day's conditions is lost.

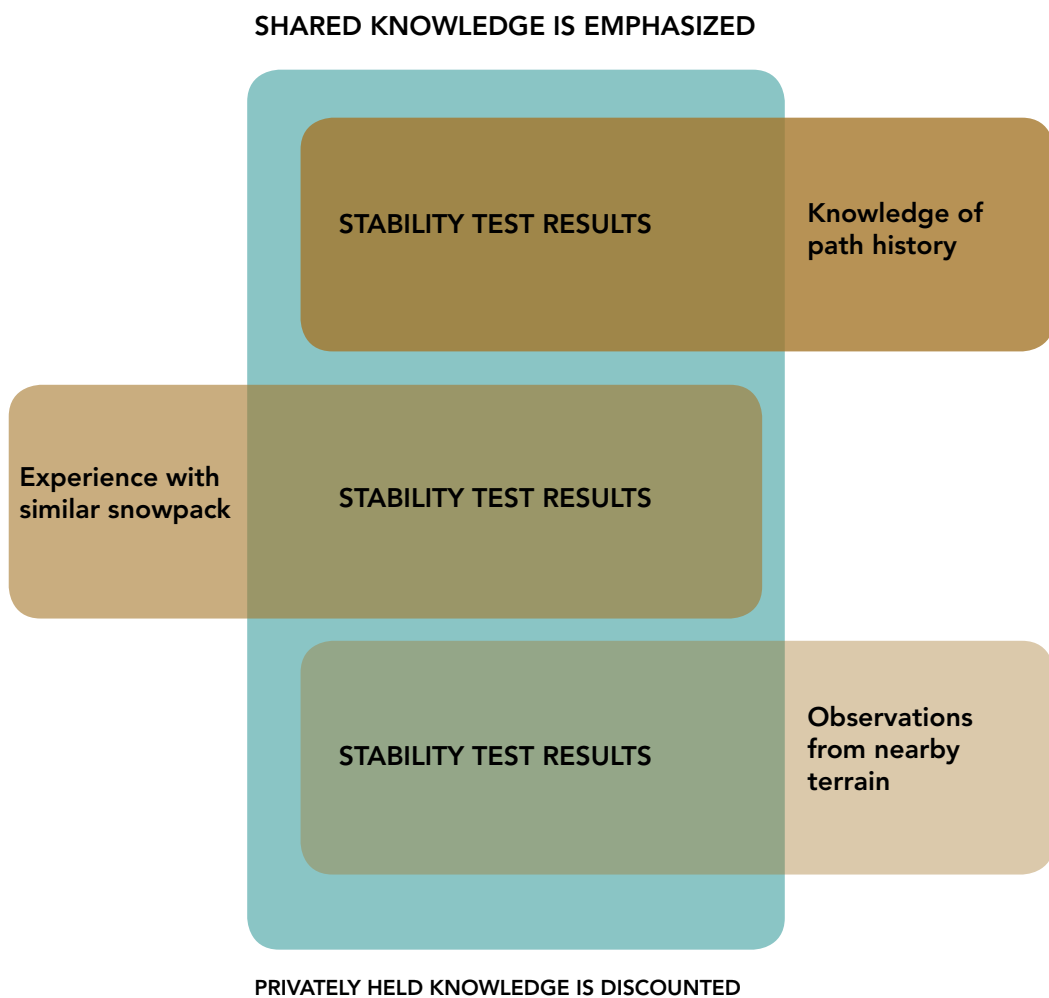
4 Priming critical thinking

Properly priming the group's deliberations can affect the outcome of deliberations. If a meeting begins with the words consensus or agreement, group members are more likely to withhold information to achieve consensus. The words "critical thinking" or "creative" introduced at the beginning of a meeting are more likely to draw out unique views or facts that may be known to only a few.

5 Capture the diversity of opinions

It is essential that the deliberative process reflects the unique viewpoints of everyone in the group. Once an opinion is stated, the desire to preserve one's reputation in the group causes





The process of group deliberation tends to overemphasize shared information and discount knowledge held by only some of the group.

a psychological pressure to conform—as in the Asch experiments. Consider the situation of asking your colleague Mike to look over your tour plan as a safety check. If you show him the plan and ask, does it look OK to you? He may hold back from pointing out problems in your plan out of fear of damaging your working relationship. Alternatively if you were to approach fellow guide Ann and say to her, I’m planning a tour for tomorrow, could you write down some possible hazards you think I might encounter? Then have her check your plan against the list of hazards, you are more likely to be told about a problem with your route.

6 Reconcile the diversity

Now that you have discovered that you, your companion guides Mike and Ann, as well as the local forecaster all have a different take on the day’s conditions, is the time to start discussing and resolving your differences. If you and your coworkers have a positive working relationship and respect for each other’s opinions an informal chat may be all that’s needed. In some cases a more formal process like voting or the Delphi method may be helpful. The tips 7 & 8 may help with reconciliation.

7 Assign roles to group members

Role-playing exercises such as appointing a “Devil’s Advocate” or conducting a pre-mortem are other good ways of trying out a new perspective on a problem.

8 Adopt a new perspective on the problem.

Wiser recounts the story of two top executives at Intel struggling to make good of the company’s lackluster memory chip division. When one executive suddenly posed the question, “what would a new executive team do in our place?” the change in perspective gave them the insight to realize that the memory chip operation was dragging down the entire company. The solution was to get out of the memory chip business. Guides and patrollers are two cultures with different perspectives on managing avalanche hazard. The exercise of seeing your problems from a new viewpoint may yield unexpected insights.

These ideas are not intended to replace guides AM/PM meetings; the AIARE Decision-Making Framework and Communications Checklist; or any of the other excellent tools developed by educators, forecast centers, and patrollers to facilitate better decisions. The eight points above can be applied with only slight adaptation of the decision-making processes already in use in our industry. They should be part of an ongoing cycle of constant improvement and revision in the way we protect ourselves, each other, and the public. ▲

The words “critical thinking” or “creative” introduced at the beginning of a meeting are more likely to draw out unique views or facts that may be known to only a few.

DECISION-MAKING AND **DISTRACTIONS** IN THE CASCADES

BY KEVIN GROVE

Sharing our collective mistakes will help us all learn, grow, and ultimately save lives. I have been studying snow for many years but just recently starting diving into the field of psychology to learn more about intricacies of the decision-making process.

I made a poor decision on January 23, 2010, to ski a line on Middle Sister in the Central Oregon Cascades. I was skiing with a new partner a week after the last storm cycle rolled through our area. Like many alpine adventures, we started in the dark, heading into the Sisters from the Pole Creek trailhead. The day began with a good discussion about the whumping I observed a week prior in a different region of the Cascades. Knowing most instabilities in our maritime environment settle out after a couple of days, we discussed a cautious approach to the day, agreeing to assess the conditions as we progressed with our plan. The yellow light conditions assessment in the early morning should have turned bright red as the day continued. As I was digging hand shears along the way, I noted a firm bed surface with high propagation in the upper slab. We continued moving through small isolated pockets of wind slab surrounded by areas that the wind had completely scoured clear of any new snow.

Several hours later, after changing our **original objective** because we were physically unable to ascend North Sister due to post-holing conditions, we approached a 35–40 degree slope from the back. Whimsical clouds moved in and out of the glorious Cascades. I continually futzed with

a brand new video camera as the battery was dying in the cold temperatures. I shot one photo after another as we approached the slope. The light and setting were sublime. My partner was slightly ahead of me. He reached the top of the slope first, pulled out his video camera and said, “You go first.” That was the entirety of our discussion about skiing the slope. I quickly pulled off my skins, made a large, arcing turn to my left and as I began the next turn to the right, I could see the slope cracking and propagating above me. I quickly jerked back to the left and saw the entire slope moving. I was lucky to be able to ski off the moving slab and walk away. This experience left me dazed, confused, and disappointed in the decision I had just made.

I reflected on this experience and made a video found here: www.youtube.com/watch?v=q7c7ShujrF8. It wasn't until over six years later, when my daughter Liv was born this past April, that I really started thinking more deeply about decision-making, risk tolerance, and critically assessing several close calls from my past.

Daniel Kahneman won a Nobel Prize in economics as a behavior psychologist. He is a decision-making expert and we can apply his work to the snow-science world. In his book *Thinking, Fast and Slow*, he discusses two types of decision-making processes. System one is fast, automatic, totally hidden and can best be described as intuition. System two is slow, calculating, effortful and deliberate. Intuition is gained over many years of experience in environments that provide immediate and reliable feedback. Expert intuition can be difficult to gain in “wicked environments” with

mixed feedback. Kahneman talks about the difference between anesthesiologists and radiologists. Anesthesiologists get immediate feedback that is very accurate. Radiologists, on the other hand, get mixed-message feedback long after decisions have been made or actions taken. It is very easy for the anesthesiologist to gain expert intuition and quite difficult for the radiologist.

We are somewhere in between in the avalanche world in the quality of the feedback systems. Some avalanche characters, like wind and storm slabs, are easier to gain expert intuition, as the feedback is often immediate and clear. Persistent slabs and deep persistent slabs, on the other hand, can be difficult to build solid intuition. Skiing a slope with a deep slab problem may or may not avalanche depending on many variables. **Intuitive decision-making and expertise alone in high risk, low frequency environments can lead to unfavorable results.** It is best to also check in with system two along with giving a healthy margin of error and respect to these avalanche characters. Blase Reardon discusses wicked environments, Kahneman, and similar decision-making topics in his well-written TAR article about Mr. Magoo in TAR 32.4.

Kahneman takes a bit of a ‘humans-as-hazard’ approach looking at how we make mistakes when relying solely on intuition. I also started reading Gary Klein, who takes more of a ‘human-as-hero’ approach looking at the power of intuition and recognition-primed decision-making. Both psychologist’s models have merit. I gained much insight from reading their work. Slowing down and making sure to check in with slow and fast decision-making processes is critical to making good decisions in the mountains. Applied to my near-miss experience, I am convinced that if I slowed down to check in with system one and two, dug a 30-second hand-shear at the top, and assessed the stability of the slope, I would have proceeded differently.

Kahneman’s approach looks at how humans use heuristics to make fast decisions. Heuristics are rules of thumb to shortcut a long, slow decision-making process. They can be incredibly powerful, but can also lead to cognitive biases, or errors. The availability heuristic refers to things that come to mind easier are considered more likely or probable. This possibly caused me to look at a powder slope on a sunny day, one week after the last storm in the Cascades, seeing only powder instead of a possible hazardous slope. How many times have I skied fun powder a week after a storm vs. how many times have I experienced a persistent weak layer in the Cascades?

Many distractions throughout my day, including the cool light, dying camera battery, new camera, new partner, being filmed, and being rushed also could have contributed to my poor decision. Kahneman writes, “Anything that occupies your working memory reduces your ability to think.” Lynn Hill took a 75-foot fall in France after failing to complete her knot after getting distracted. Fortunately, she landed in a tree and walked away. Robin Feuerbacher, a colleague of mine in the OSU-Cascades engineering department, studied



The day's first objective was the Thayer Headwall, which is a steep gully just left of center in the photo. We were VERY lucky to be turned around because of post-holing conditions. I think there is a very good chance that had we gained access to the upper mountain, we very possibly could have found the persistent slab problem that I found on Middle Sister. The consequences, however, could possibly have been much more severe because that is a much bigger piece of real-estate. Photo Kevin Grove



Andrew Orlich carving turns on Broken Top on a more normal sunny day in the Cascades. Photo Kevin Grove

surgical residents performing simulated laparoscopic surgery to remove the gallbladder. Distractions were purposefully inserted during key times of the procedure. Eight out of 18 surgeons made critical errors while distracted and only one out of 18 made critical errors without being distracted. Ron Simenhois and Scott Savage looked at 33 near-misses from avalanche professionals and found that 80% of the time they were distracted before or during work the day of the near miss. In addition, poor communication contributed to 40% of the near misses reported in their findings.

I have taken away many lessons from this near miss, and I continue to learn and reflect on past mistakes. The main take home points for me from this particular situation include: be aware of distractions, slow down to make sure I am checking in with both system one and system two thinking, use checklists at key decision-making times throughout the day, and maintain good communication with my partners before, during, and af-

ter a tour. I have spent a lot more time in the past 25 years thinking about the snowpack, weather, and terrain than I have about decision-making and I'm excited to keep learning more about this topic. ▲

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Kevin's partner approaching the slope in question on Middle Sister. Photo Kevin Grove



Be aware of distractions, slow down and check in with both system one and system two thinking, use checklists at key decision-making times throughout the day, and maintain good communication with partners before, during, and after a tour.

DEEP SLABS

AVALANCHE CYCLE IN NORTHWEST WYOMING:

Analysis using historical loading thresholds

BY PATRICK WRIGHT

During mid-December 2016, the mountains of northwest Wyoming experienced a major deep-slab cycle with large avalanche events running on an October rain crust (Figure 1). The following analysis provides a timeline of conditions leading up these events. In addition, peak loading and settlement rates are compared to historical thresholds. With near-record loads and well-defined sliding and weak layers at the base of the snowpack, December 2016 proved to be both an intriguing and intimidating period for deep slab activity in the region.

Early season snowpack

Four storm systems in October resulted in precipitation at 200-300% of the 30-year average and set precipitation records at multiple recording stations in western Wyoming. These storms were progressively warmer, ending with rain to an elevation of 11,000' during the last week of October. A cold front on October 30 brought lower temperatures and 7" of new snowfall to the Teton region. The first half of November was mostly dry and warm under a high pressure ridge, resulting in melt of the snowpack to bare ground on southern aspects below 10,500'. On east, north, and west aspects above 9,000' (and to 8,000' on well-shaded north aspects) the October rain crust persisted, with overlying snow becoming faceted. The rain crust was found to be up to 16" thick on north aspects.

Snow began to fall in the Teton region beginning on November 16. By November 24 three storms had resulted in total snow depths at the high elevations ranging 10-30". Initial avalanche activity on the October rain crust did not occur until November 27-30. Rapid loading on November 28 and sustained winds resulted in both natural and artificial triggers of 15-30" soft slab events running on the rain crust.

Isolated deep slab events during early December

A storm system during December 3-5 resulted in 10-20" of new snow with an upside-down density structure. This system produced multiple natural soft slab events (24"-42" depth) throughout the Tetons, with three reported high-elevation deep hard slab events (60" depth). Deep events were also triggered with explosives on December 6 at Jackson Hole Mountain Resort (JHMR). Although these are in-bounds slide paths, an early-season backcountry snowpack existed at JHMR during this time. These events coincided with a rapid increase in multi-day cumulative snow water equivalent (SWE) at the Mid-Mountain study plot at JHMR. In particular, the 10-day cumulative SWE increased from an already heightened baseline load

Editor's Note: I had already grabbed a stack of Mark White's characteristically high drama and high resolution photos of the Birthday Chute when Patrick Wright's piece about further research on the Deep Slab problem came in. As a literary matchmaker, the fit seemed perfect, and Drew's musings on decision-making dovetail nicely into the rest of this issue's closer look at uncertainty.

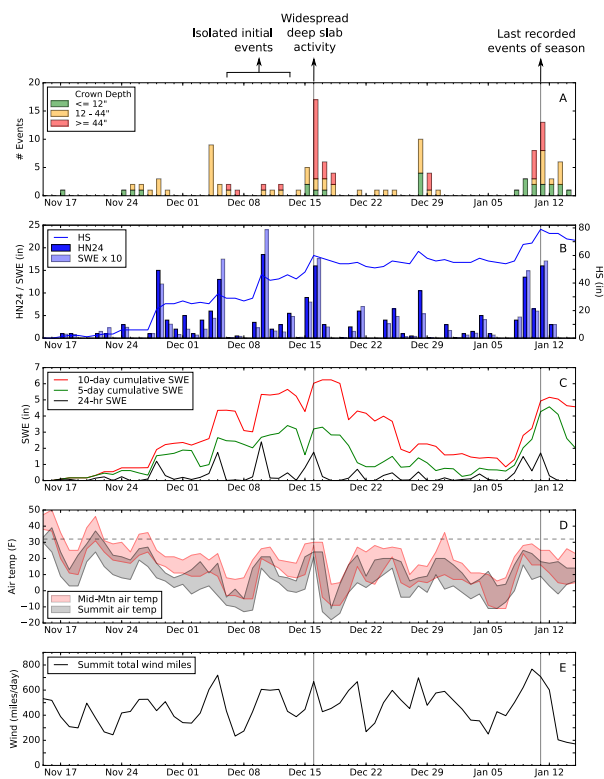


FIGURE 2: Weather and snow conditions leading up to mid-December deep slab cycle. Recorded avalanche events for the backcountry are shown in Panel A, with colors corresponding to crown depth. Received 24-hr precipitation at the Mid-Mountain study plot at JHMR (8,180') is shown as SWE x 10, alongside 24-hr new snow totals (HN24) and total snow depth (HS) (Panel B). This display allows quick estimation of new snow density, where new snow and SWE bars of equal height indicate 10% density. Multi-day cumulative SWE totals at the Mid-Mountain plot (Panel C) demonstrate major loading peaks during December. Air temperature is shown as previous 24-hr maximum and minimum at the Mid-Mountain plot and the Summit of Rendezvous Peak (10,450') (Panel D).

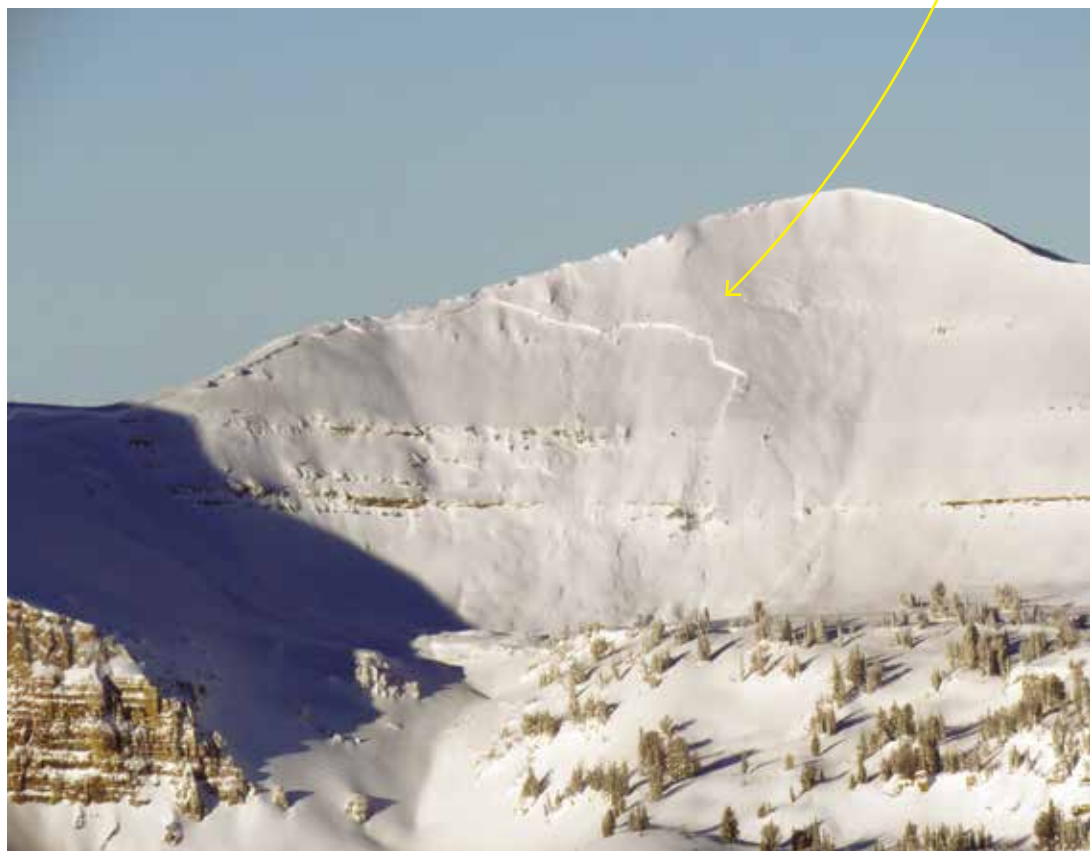


FIGURE 1: A deep slab avalanche on the east face of Peak 10,406' in the southern Teton Range, Wyoming. This event likely occurred on December 16, 2016, with an estimated crown depth of 62" (HS-N-R3-D3.5). Photo Bridger-Teton Avalanche Center

reached with the late November storm. The peak 10-day SWE was 4.35", significantly above the historical 10-day median for days with deep slab events (2.99") (Wright et al., 2016). This system was also accompanied by very strong winds (719 miles of wind at Rendezvous Peak summit).

A second storm system during December 9-10 resulted in additional isolated deep slab events. An impressive 24" of new snow with 3.4" of SWE was recorded at Rendezvous Bowl on December 10 accompanied by 606 miles of wind at Rendezvous Peak summit. 5-day cumulative SWE at Mid-Mountain increased to maximums only slightly higher than those reached on December 5, while 10-day totals again added to previously received loads, rapidly increasing to a new season maximum of 5.34". Light to moderate snowfall and strong winds continued through December 13. Although deep slab events were somewhat isolated during this period (Figure 2), significant events occurred on Cody Peak, Mt. Taylor, and Breccia Peak.

Widespread deep slab activity during December 14-16 storm

A major storm from the mid-Pacific arrived with a warming trend during the night of December 14-15. By December 16 the Teton region received up to 30" of new snow with over 3" of SWE accompanied by strong winds. 5-day cumulative SWE totals at Mid-Mountain rebounded back to the levels achieved during December 11-13. The 10-day SWE increased to a new season maximum of 6.24". Snowpack settlement was at 4-6"/day during the storm and remained elevated at 2-5"/day during December 17-18.

The December 14-16 storm event exceeded loading thresholds for many high-elevation slide paths, with widespread activity reported when skies cleared on December 17. Natural activity occurred in major slide paths throughout Grand Teton National Park and the southern Tetons with crown depths ranging 48"-72". These events occurred during active loading with no known events after December 16, despite high settlement rates in the day following the storm. The received water content during this storm (2.81" during 12/15-12/17) amounted to 33% of the existing water content in the snowpack overlying the rain crust (8.62" received since November 16).

The continuous snowfall since late November created significant loading on the snowpack that is among historic highs. 10-day SWE totals greater than those achieved on December 17, 2016 (6.24") have only occurred in 8 other seasons since 1974.

Last reported deep slab events of 2016-17 season

On December 23 a human-triggered cornice collapse outside the Grand Targhee boundaries resulted in the fatality of a snowboarder who was carried over a 500 ft cliff. On Dec. 29 four 22-lb heli-bombs were deployed to provide rescuer safety, resulting in a deep slab event (72" depth). Snowfall events had continued throughout late December, yet there was an overall decreasing trend in multi-day cumulative SWE totals during this period, and a lack of any continued activity on the October rain crust.

The last deep slab events of the season occurred with significant storm loading during January 8-12. Two events were recorded on January 11 in Prater Canyon in the Salt River Range (N aspect, 9,700'), and Treasure Bowl on Table Mountain (NE aspect, 10,800'). It should be noted that large events (up to 60" depth) reported on January 12, 2017 are considered deep slab events, but did not run full-depth to the persistent October surface and are not considered as part of the persistent deep slab cycle. After six days of clear and cold weather with no deep slab activity, the "Persistent Deep Slab" problem was dropped from the Bridger-Teton Avalanche Center bulletin on January 17.

Conclusions: December 2016 in a historical context

The early season snow structure in northwest Wyoming was primed for deep slab avalanches at high elevations with a distinct sliding and weak layer. In addition, we experienced near-record levels of load on the snowpack during December. This was a good season to stay away from upper elevation steep terrain and also a great case study to try and learn something more about deep slab failure.

The period with deep slab activity during mid-December showed 3-day cumulative SWE levels at the Mid-Mountain study plot at JHMR nearly peaking with the first major December storm, then reaching similar peak values with each consecutive storm. The 5-day totals showed a slightly more increasing trend as the December storms progressed. The 10-day totals, however, best reflected the peak in cumulative loading resulting from the December 14-16 storm, and best coincided with widespread deep slab activity (Figure 2). For a persistent deep slab problem, 3-day and 5-day cumulative SWE totals may not reflect long-enough loading periods, whereas the 10-day totals

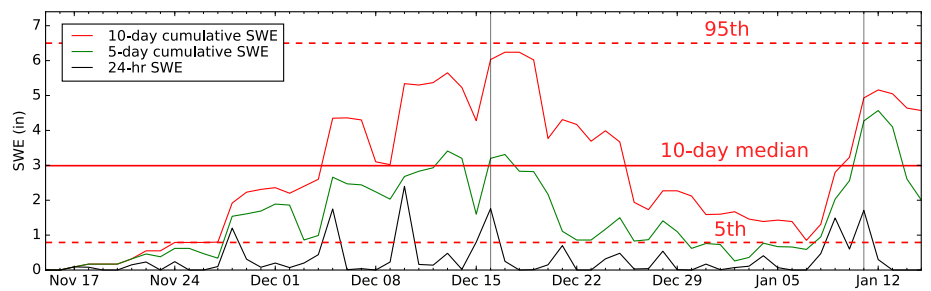


FIGURE 3: Panel C from Fig. 2, shown with the distribution of historical 10-day cumulative SWE totals for days with deep slab events (N=501, 1974 - 2016) (Wright et al., 2016). The historic median (solid line) is shown along with the 5th and 95th percentiles (dashed lines) of the distribution. Note that the three major peaks in the cumulative 10-day SWE totals for December 2016 all fall within the upper half of the historic distribution, with the loading peak reached December 17-18 almost reaching the 95th percentile.

may be a better way to visualize and track the increased load. Depending on the storm system, an even longer multi-day window could be useful.

Utilizing data collected at JHMR since 1974, historic trends in multi-day SWE for days with deep slab events provide context for the SWE totals received in 2016. The 3 major peaks in the 10-day cumulative SWE totals for December 2016 all fall within the upper half of the historic distribution for the Mid-Mountain plot, with the 10-day loading peak reached during December 17-18 almost reaching the historic 95th percentile (Figure 3). If there is potential for deep slab avalanches, multi-day SWE totals that exceed the historic median are likely an indicator of loads that may be close to threshold levels.

Settlement rates were also a good indicator, with many days of elevated settlement (3-6"/day) leading up to the major deep slab activity. These rates were mostly greater than the historic median settlement values for days with deep slab events (3"/day).

It is significant that there were only three deep slab events recorded after December 16, despite continued gradual loading during late December and early January followed by rapid loading on January 12 with 10-day SWE totals almost equivalent to the mid-December peak. With increasing snow depths in late December and early January, loading events had a diminishing impact on weak layers at the snowpack base and the deep slab gained strength. In addition, the problem layers (ice crust and facets) likely had time to "heal" (increased bonding with the crust and rounding of facets). At the time of this writing, a historic storm system impacted northwest Wyoming resulting in 10-day SWE totals of 11.9" on February 11, 2017. These water totals are almost equivalent to the highest storm totals ever received at the JHMR study plots, only slightly less than a 12-day SWE total of 12.75" received during February 1986. Despite this massive loading event, there were no additional deep slab avalanches.

Although in retrospect the end of the December 2016 deep slab cycle can be reconciled, it is often challenging to forecast the close of a deep slab cycle. Dropping the deep slab problem was largely guided by a lack of activity on the problem layer after it had been heavily loaded during January 9-11. Reduced settlement rates were an additional indicator of stability with many days of 1-2"/day occurring during January 12-17. Although forecasting the timing of deep slab cycles will remain a challenging task, analysis of cumulative multi-day precipitation totals in a historical context can provide a baseline range for expected loading thresholds. January and February of 2017 also demonstrate a historical trend for the northwest Wyoming snow climate: large loading events that occur later in the season with increased snowpack depth do not necessarily result in continued deep slab avalanches. This reinforces the importance of monitoring the condition and depth of problem layers and the character of the overlying slab, which will be unique season to season. ▲

References

Wright, P. J., B. Comey, C. McCollister, and M. Rheam (2016), *Deep slab instability: loading, temperature, and settlement rate thresholds related to failure - Part II, Proceedings of the 2016 International Snow Science Workshop, Breckenridge, CO, USA.*

Patrick Wright has spent summers since 2011 doing field work on the Greenland Ice Sheet and received M.S. degrees in Atmospheric Science (University of Houston, 2012) and Glaciology (University of Montana, 2015). He is currently on the Jackson Hole Ski Patrol, and is co-owner of Inversion Labs, completing data analysis and instrumentation design for the earth sciences.



DEEP SLAB

in the BIRTHDAY CHUTES

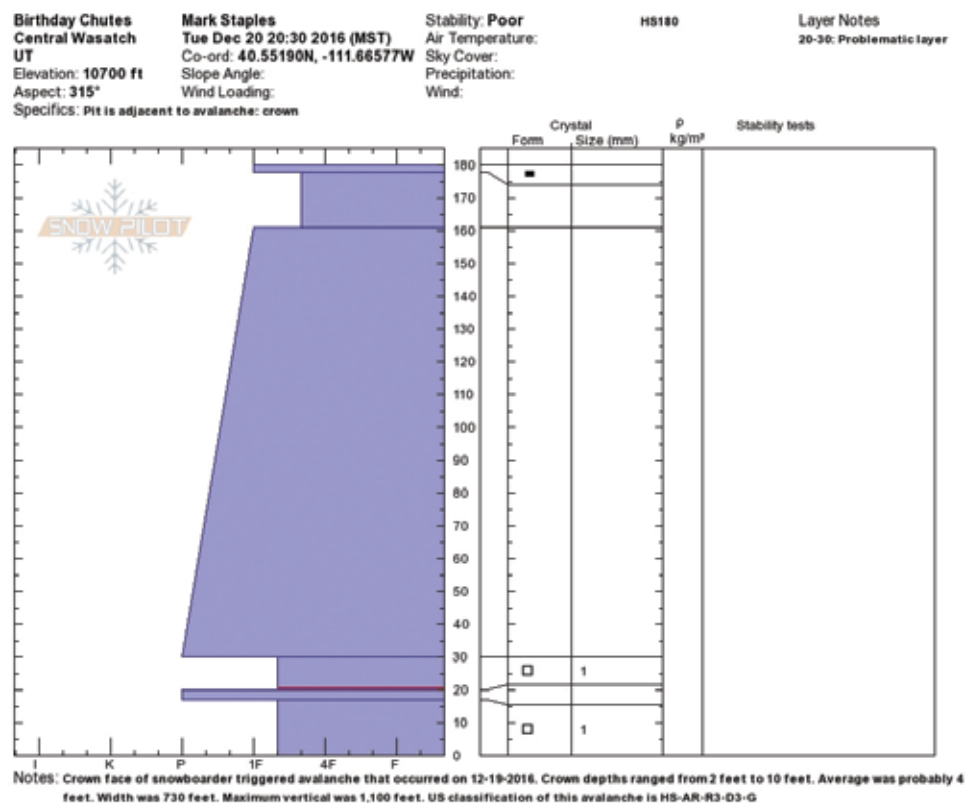
Close-up of the crown in the Birthday Chutes on December 19, 2016. Photo Mark White

We were finishing up a full day tour and decided to drop into Birthday Chutes to get back to White Pine Trailhead. We had been on all aspects during the day and the only red flags we saw were warming on the south slopes and some wind loading mostly on east faces. The top of the northwest side of the Red Top Mountain was scoured and cornices were formed on the east side of Temptation Ridge. We saw no signs of wind loading into Birthday Chutes so we decided to drop in. The snow surface was very soft and seemed safe. After my partner rode the top couple hundred feet, he moved over close to the trees on the skier's left of the chute. As I started forward into the chute I saw snow start moving slowly about two feet in front of my board. I immediately dove back and grabbed a small tree. The slide picked up a ton of speed and propagated way farther west than I thought possible. The crown broke all the way to the ground from the top. The slide went all the way to the hill on the west side of Columbine Bowl where a couple hundred foot cloud of snow shot into the air. I immediately radioed my partner but the radio kept shutting off due to the cold. I tried calling him but his phone was off, I could not find a safe route to the debris pile so I called 911 and asked for rescue crews. My partner was able to dig out his feet and call 911.

—a member of the party involved

INVESTIGATION:

Avalanche: White Pine
Observer Name: Mark Staples
Observation Date: Monday, December 19, 2016
Occurrence Date: Monday, December 19, 2016
Occurrence Time: 5:00pm
Region: White Pine
Location Name or Route: Birthday Chutes, White Pine
Elevation: 11000
Aspect: North
Slope Angle: 38
Trigger: Snowboarder
Trigger: additional info: Unintentionally Triggered
Avalanche Type: Hard Slab
Avalanche Problem: Deep Slab
Weak Layer: Depth Hoar
Width: 700
Vertical: 1000
Carried: 1
Caught: 1
Buried—Partly: 1



FORECASTER NOTES:

Weather and Snow information: From December 14 to December 16, the Alta Guard Station three miles NNE of the avalanche site, received snow containing 2.5 inches of snow water equivalent. On Thursday, December 15 and Friday, December 16, winds at 11,000 feet averaged 31 mph and gusted 47-62 mph from the southwest. By late Dec 16, winds at 11,000 feet were averaging 50 mph gusting to 75 mph from the WNW. Those winds were a significant factor in this avalanche for two reasons:

First, winds easily doubled the load on this slope with wind-blown snow adding significant stress to faceted snow at the ground. Faceted snow is very tricky. It can support a tremendous load without fracturing and producing an avalanche. However, as soon as a very small crack or failure is started, it can quickly fracture across the entire slope. The snowboarder who triggered this avalanche likely rode over a thin spot of the slab where he initiated a crack in the faceted snow layer which fractured and released the slab.

Second, winds built a slab that connected across both chutes. This stiff, cohesive slab is what helped carry the fracture across both chutes and fracture over such a wide area.

Snow that formed the weak layer in this avalanche fell in the fall and was preserved on this slope because of the high elevation and northerly aspect while snow melted off other slopes. This snow metamorphosed and became weak, faceted snow crystals. See the photo below from video footage taken on November 14, 2016. Notice that other aspects exposed to more sun did not have snow on the ground.

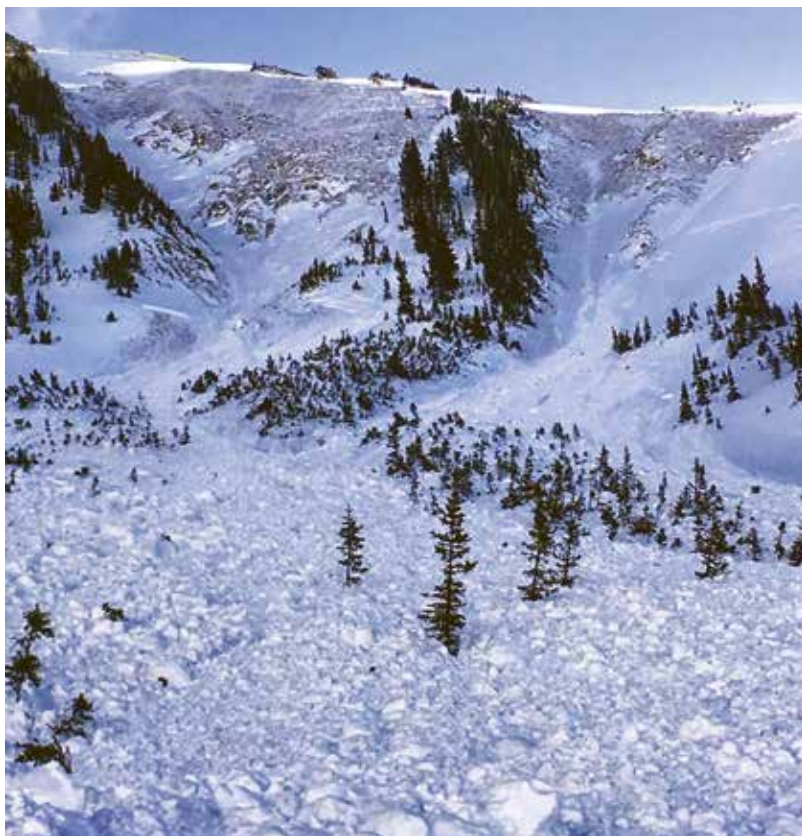
Avalanche information: This party had been reading the avalanche advisory for most of the season. On the day of the avalanche, they had been looking for signs of instability during their tour in Mineral Basin, in Mary Ellen Gulch, over Silver Creek Peak, over American Fork Twin Peaks, and over Red Top Mountain. They noted warming on south aspects and were carefully monitoring wind speeds and direction. Winds were relatively light in the Birthday Chutes and not depositing snow at the time. Unfortunately, winds on Thursday, December 15 and Friday, December 16 heavily loaded this slope.

The person who was caught in this avalanche initially made three or four turns, thought he heard something, began traversing to the looker's right, and made five or six turns before the avalanche broke. He never saw the avalanche coming and said that it felt like he was hit by a freight train. The person on top of the ridge had to jump back to avoid being caught. He commented that the avalanche did not make any noise when it fractured and seemed to pull away very slowly for the first 50 feet before accelerating.

This avalanche was approximately 730 feet wide, four to five feet deep on average with a minimum of three feet and a maximum of 10 feet deep. It ran 1,100 feet vertical. U.S. classification is HS-AR-R3-D3-G.

Rescue: This avalanche occurred at about 5 p.m. Once the avalanche happened, this party was in a very difficult situation especially with the fading daylight. They both had radios with dead batteries from being on all day, thus

View up from the huge debris field. Photo Mark White



UTAH AVALANCHE CENTER

ADVISORY: SALT LAKE AREA MOUNTAINS Issued by Drew Handeely for Monday - December 19, 2018 - 8:29am

BOTTOM LINE
A MODERATE danger exists for longer running dry... and potentially wet loose snow avalanches... in steep terrain today. These sluffs may, in turn, pop out some lingering storm snow instabilities from our Thursday/Friday storm, resulting in a larger avalanche debris pile. Shallow pockets of wind slab in lingering storm snow avalanches are possible in extreme terrain if the winds pick up beyond expectations.

LIKELIHOOD
1. LIKELY
2. UNLIKELY

SIZE
LARGE
SMALL

TREND
INCREASING DANGER
SAME
DECREASING DANGER
OVER THE NEXT 24 HOURS

DESCRIPTION
If needed to slopes approaching 40° and steeper today, plan on triggering shallow but longer running sluffs. These will be dry in the morning, but are likely to transition from dry to damp to wet sluffs in the steepest sunlit slopes by late morning/early. These sluffs, in turn, may pop out some still-existing storm snow slabs left over from last Thursday/Friday's storm.

DESCRIPTION
If needed to slopes approaching 40° and steeper today, plan on triggering shallow but longer running sluffs. These will be dry in the morning, but are likely to transition from dry to damp to wet sluffs in the steepest sunlit slopes by late morning/early. These sluffs, in turn, may pop out some still-existing storm snow slabs left over from last Thursday/Friday's storm.

DESCRIPTION
Lingering storm and wind slab instabilities may be triggered still in very isolated terrain. Typically very steep, unsupported terrain in the high elevations but not tilted to any aspect. Mid-pack and basal instabilities seem to have gained a great deal of strength over the recent days and are unlikely to be human-triggered now but in very steep thinner snowpack areas on slopes in the high shady terrain.

The avalanche broke on old facets at the ground. Crown depth averaged 4-5 feet with a maximum of 10 feet and minimum of 3 feet. It was 730 feet wide and ran 1,100 feet vertical. Photo Mark White



Cheers.

You've earned it.

No close call stories to tell, just good times—and good decisions.
Our avalanche safety products are reliable and easy to use.
We hope you never use them, except for practice.

Jeff Crisco Photography



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they were not able to communicate. They could not see each other either. Both feared that the other had been caught and was buried.

The person on top of the ridge was unsure he could descend safely to his partner whom he thought was dead. Because of the late hour and what he thought was an unsafe situation, he decided to call 911. He was on top of the ridge for about an hour and a half in the dark. When his phone battery died, he finally descended a ridge and the White Pine drainage ultimately reaching the White Pine trailhead. The whole time he thought his partner was buried and dead. It wasn't until reaching the parking lot and talking with Search and Rescue personnel that he discovered his partner was alive.

The person caught in the avalanche survived and amazingly was not injured. When the avalanche stopped, he was on top of the debris only buried to his knees with his face down. As he looked up, he saw a powder cloud of airborne snow roll over top of him. Because he and his partner had not explicitly discussed a plan for riding this chute, he assumed the worst. Also, he was unable to communicate with his partner due to dead radio batteries and figured his partner was buried. He also contacted 911. For the next hour and a half he searched the debris field with an avalanche transceiver. Ultimately a helicopter was sent to the scene and transported him to Alta.

Forecaster comments: On the day of the avalanche the danger was rated Moderate at this elevation. The avalanche problems listed in that day's advisory were Loose Dry avalanches, Loose Wet avalanches, and Storm Snow avalanches.

This was a difficult situation for all involved including Search and Rescue who received two separate calls from someone stating that their partner was buried in an avalanche. Sorting the details in these events can be very difficult. For the two people involved, it was also a very difficult and confusing situation as well. This event highlights how difficult avalanche rescue can be and that many events can happen at the end of the day in darkness. Luckily no one was buried. This emphasizes the need to practice companion rescue skills and be familiar with terrain because many avalanches occur under difficult conditions. If you are in unfamiliar terrain, that can be an additional risk factor.

Deep slab avalanches are by far the most difficult avalanche problem to deal with. Even professional operations armed with explosives struggle with these

types of avalanches. Because the weak layer is buried deeply under a thick, hard slab of snow, impacting the weak layer with enough force to trigger an avalanche is not easy to do. There's a decent chance this party could have descended the chute without triggering this avalanche.

Information from this report comes from a visit to the avalanche by Mark Staples, Greg Gagne, Mark White and two members of the Snowbird Ski Patrol on December 20, 2016 as well as a phone interview with the two people involved in the avalanche.

This report was compiled by Utah Avalanche Center Director Mark Staples with help from other UAC staff.

A big chunk from a dense hard slab. Photo Mark White



#nothingbadhappened

Saturday, December 24, 2016

Drew Hardesty

I cribbed the name from an essay by Iain Stewart-Patterson, a mountain guide and faculty staff member of Thompson Rivers University in British Columbia. His dissertation: *The Role of Intuition in the Decision Process of Canadian Ski Guides*. You can find his essay in issue 34.4 of *The Avalanche Review*, the publication of the American Avalanche Association.

I imagine most of you reading this are familiar with the very close call in the Birthday Chutes from last Monday. I've added Mark White's photos and the full accident investigation report by Mark Staples, Greg Gagne, Mark White, and Snowbird ski patrol can be found before these companion essays. Long story short, a party of two triggered a very large avalanche to the ground in mid-White Pine canyon of Little Cottonwood. One of the two was caught and carried for over 500' and was uninjured.

That night, we received an email from a backcountry skier who that same day had skied the north-west face of Red Baldy—the steep open face lording over upper White Pine canyon in LCC and sitting just up-canyon from the Birthday Chutes. As I respect and value his self-reflection, I thought it might be of interest to share his email and my thoughts back to him.

Hello UAC,

I'm wondering if someone would help me analyze my decision to ski Red Baldy on the day that the Birthday Chutes slid.

In hindsight, I still feel it was a reasonable decision. But if someone is inclined, I'd like to know if you see any mistakes in my process, so I could avoid repeating them.

Before I hit the snow:

- I'm a regular bc skier
- carrying beacon, shovel, probe and 10 essentials
- familiar with the terrain
- familiar with the weather and this season's snow in the central Wasatch, but not upper White Pine
- had a goal—NW Red Baldy—but not set in stone
- Strategy for making good decisions under stress: go w/ the most conservative judgment
- read weather and avy reports from UAC and other sources that morning and each day since the most recent storm
- was on a similar aspect and elevation the day prior, Argenta.

On the approach:

- looking around a lot/keeping awareness focused on physical environment
- specifically looking for signs of recent avalanches, sun and wind effects, effects of prior skiers' travel
- observed no signs of recent avalanches, only infrequent sightings of point releases below cliffs, trees; no cracking or collapsing on skin up
- Looked at the BDays from the summer road skin track: suspected it would be loaded in parts and scoured in others—could see westerly winds transporting snow up high—sensitive and have the potential to slide leaving no easy escape.
- no noticeable effect from sun on snow

On Red Baldy:

- wind was stiff and swirling with a slightly west prevailing direction above the forest at the base of RB.
- NW face had up to half a dozen faint, wind buffed ski tracks, some starting just under the ridge line rocks, others going only half way up the face, and running down the center of the face. No sluffing seen near any of the old ski tracks.
- NW face showed only small, isolated areas of wind loading. Mostly, swirling wind transporting snow in all directions. The only drifts encountered were avoided by changing the path of the skinner.
- just below the top of the NE ridge, I traversed west below the ridge line rocks. Rocks above were scoured and not holding much snow. Transitioned in a rock outcropping mid-way across the NW face
- First turn was a fast, left cut to the bottom of the summit rocks. Looked over the shoulder for trailing snow. 2nd turn was the same, traveling over to the rocks that form the skier's left boundary of the face.
- Skied the far skier's left (west) side of the face reasoning it would've been sheltered from prevailing westerly winds and sun by the rocks.
- Looking back up at my tracks from the flat, nothing slid or even sluffed. One and done.

Lastly, while the Red Baldy face and the BDays are a similar aspect and elevation and location, while planning my tour I felt RB would be in different and safer condition than the BDays b/c of the contour of the terrain—a flat, open face versus funneling gully chutes—and that the line I planned to ski, the far west side abutted by the rocks, would be sheltered from wind effect whereas the BDays were hammered.

Thanks for helping me cover my blind spots, if you can!

Thanks for writing in. We've all had our close calls out there and we've all had times when we got back to the car and realized that maybe we got away with something. I appreciate your self-reflection and awareness of how you "go about the work" in order to make good decisions and avoid the avalanche problem. Seems you're as diligent as they come in regards to your approach to the mountains. Sometimes, however, we feel like we do everything right and then still something bad happens. (It's driven me to read more of the Old Testament over the past couple of years, but I digress.) After a well-publicized avalanche fatality in the Tetons a few years ago, I wrote at length about it for *Backcountry Magazine*; here's the link: backcountrymagazine.com/stories/mountain-skills-understanding-the-avalanche-problem/.

The avalanche in the Birthday Chutes may have been one of the most surprising avalanches that I've seen in almost 20 years of avalanche forecasting. I know that I'm not alone in that sentiment. As far as I know, only a few avalanches ripped to the ground during the storm with only one or two that stepped to the ground (on Saturday) with explosive control work. These were of similar aspect and elevation, but there are times when we feel that while storms, explosives, very large cornice fall, etc may trigger deep slabs, a single skier on the slope will not. Or it's very unlikely that they will. I made a slight mention of this on that Monday mostly in the fine print of Storm Slab in the advisory. **Still, certainty is the enemy of wisdom, and this is what makes this profession or pursuit so compelling. Risk and uncertainty are always a part of mountain travel.**

At some point, one must decide (or not) that the poor structure is now dormant. Recent human triggered slides? Cracking? Collapsing? Tests? These are all part of the calculus. It's my personal view that none of this type of information was evident. It was conveyed to me that the Birthday Chutes avalanche took out previous tracks on the slope, but I can't confirm this. What I do know is that depth hoar has bedeviled avalanche practitioners since before it was even called depth hoar...and it will continue to do so. You simply cannot trust it. When you enter this terrain with this type of snowpack, you're playing the game...and it's just a matter of odds—or risk—and then it's a matter of understanding your own level of acceptable risk. 1:10? 1:1,000? 1:10,000? Most of us are prematurely grey because we are tasked with helping the public reduce their odds or exposure.

But before I get back to your original question I want to say that I particularly appreciated your use of the term hind-sight...because in my view, the hind-sight bias is nearly always damning because the outcome is already known—How could this person miss all of the obvious clues leading up to the incident? My opinion is that if you could go back and re-live that Monday 100 times and ski Red Baldy, you would come back to the truck at the end of each of those days.

—Drew Hardesty

20/40 OVERSIGHT



TOP: Investigating a big slide can be sobering, but less so when no-one is caught or injured.

BOTTOM: Hard wind slab reached uphill as far as it could. Photos Mark White



BY DREW HARDESTY

*All too often, we find ourselves unable to predict what will happen; yet after the fact we explain what did happen with a great deal of confidence. This “ability” to explain that which we cannot predict, even in the absence of additional information, represents an important, though subtle, flaw in our reasoning. It leads us to believe that there is a less uncertain world than there actually is, and that we are less bright than we actually might be. For if we can explain tomorrow what we cannot predict today, without any added information except the knowledge of the actual outcome, then this outcome must have been determined in advance and we should have been able to predict it. **The fact that we couldn’t is taken as an indication of our limited intelligence rather than of the uncertainty that is in the world.***

—Daniel Kahneman/Amos Tversky

The Event

On December 19, 2016, two young backcountry riders exited the Snowbird access gates to enter the backcountry. They skied one steep line and then paused above the Birthday Chutes of White Pine Canyon. The Birthday Chutes sit at just over 11,000’ and face north-northwest. They had seen one other avalanche from two days prior on their tour. They had observed no cracking or collapsing of the snowpack. Many, many steep lines in similar, representative terrain had been ridden with impunity. The small depth hoar crystals at the base of the snowpack—long suffering holdouts from the late fall storms—had been dormant or asleep to human triggering for weeks. Snow tests had indicated that the snowpack was stable or that the snow was too deep to allow for triggering a full-depth release. The avalanche danger for the day was rated as Moderate, though the fine print relayed that, “Basal instabilities seem to have gained a great deal of strength over the recent days and are unlikely to be human-triggered now but in very steep thinner snowpack areas on slopes in the high shady terrain.”

You can imagine what happened next. Person A drops in, makes 10 turns and sees the snowpack come alive around him. Person B, still near the top, imagines an earthquake has occurred as the earth itself cracks open 6-10’ deep right at his feet. He later recalled diving back to grab a tree to avoid being engulfed and swept down the mountainside. Person A rockets 500’ down the slope, getting bashed and hammered by hard slab blocks almost twice his size. When the enormous pile of debris finally comes to a rest, Person A stands up, dusts himself off, and walks away.

Using the United States avalanche classification system, this avalanche is described as an HS-ASu-3.5-O or a hard slab unintentionally triggered by a skier that broke to the ground. Its destructive force could have taken out a something between a large vehicle and a house. (It was 4-10’ deep and 700’ wide.) The subscript “u” de-



This was a low likelihood event (see Drew's blog) that had high **potential** consequences but low **actual** consequences. Is that the definition of luck? Photo Mark White

notes unintentional. It should really denote unpredictable or unmanageable. In the aftermath, everyone looked back at the events leading up to the avalanche to try to understand what went wrong. "Facets were on the ground," some said; others said "There was way too much wind 48 hours before. Of course the Birthday Chutes are suspect with this set-up: How could you not have seen this coming?"

Expert Intuition

In their powerful, collaborative essay *A Failure to Disagree*, the world renowned behavioral psychologists Gary Klein and Daniel Kahneman describe the circumstances that may enable one to develop something called expert intuition. They argue that two fundamental criteria must exist:

1. The environment must be one of high validity.
2. The individual has an adequate opportunity to learn the environment (they recommend roughly 10,000 hours).

High validity refers to a stable relationship between cause and effect. Children learn early on. In fact, they become experts at not putting their hand on a hot stove-top. The stove coils are red, they are hot, you put your hand on them, you get burned. There is a direct correlation between the hot coils and the immediate pain of your hand on the stovetop. Klein calls this "recognition-primed decision making" (RPDM). We see a situation, our cerebral hard drive searches for a similar situation from past experience, and we follow the course of action that produced a favorable outcome or avoided a terrible outcome from the previous times.

A Wicked Environment: The Subconscious Mind Does Not Know Death

But what if we are in an environment that is not

highly valid, or one that promotes the illusion of validity? An environment where we are actually getting feedback, but learning the wrong lessons? Imagine the rooster looking over his shoulder, the sunrise behind him on the horizon, and—in a cocky way—saying, "You're welcome." What about inconsistent feedback? And finally, what if the lesson is both surprising and tragic? The business and statistics researcher Robin Hogarth has a name for this: A *wicked* environment. A wicked environment is one where feedback may be X until it's Y, and Y may be death. For most of us, this can be viewed with a great deal of skepticism, because the subconscious mind does not know death. To wit: who among us has died and returned with great enlightenment?

The Role of Expert Intuition in Low Probability, High Consequence Events

The risk management consultant Gordon Graham parcels out four different situations:

- Low Probability, Low Consequence
- High Probability, Low Consequence
- High Probability, High Consequence
- Low Probability, High Consequence

In avalanche terms, the first situation might be a LOW avalanche danger day. The second situation is arguably a MODERATE to CONSIDERABLE avalanche danger day, but with avalanche types where avalanche professionals may develop expert intuition: storm slab, wind slab, loose wet and dry snow avalanches. The third situation may best describe a HIGH or EXTREME avalanche danger. The fourth situation, however, is, as Graham writes, when "the bells of Saint Mary ought to be going off in your head."

The Low Probability, High Consequence environment. An environment where ski cuts in one place produce an avalanche in another. Or the 5th or 25th person on the slope brings the whole face

down. Or walking in the drainage, one collapses the slope and pulls the whole mountain of snow on top of them. The argument here is that with these types of avalanches—deep slab, persistent slab, wet slab, glide avalanches—and particularly the first and the last—these types of avalanches fall neither into a high validity environment nor the one where we can gain the figurative 10,000 hours. This helps to explain why—in Utah anyway—an estimated 95 percent of the avalanches are of the type where we can hypothetically develop expert intuition...but the second kind account for more than 70 percent of our avalanche fatalities, well illuminating the stark contrast between the high probability low consequence events...and their opposite.


The question is not whether these experts are well trained...the question is whether their world is predictable.

—Daniel Kahneman/Amos Tversky

But back to the Birthday Chutes. In the end, we may try to reverse-engineer a problem to try to make sense of the world because an uncertain world—one that we don't fully understand—can be a frightening and humiliating place. So that "after the fact we (may) explain what did happen with a great deal of confidence." The confidence that comes with hindsight. The problem, however, is that we may be taking home lessons to understand the world, but sometimes they may be the wrong ones. ▲


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