35.3
FEBRUARY 2017

THE AVALANCHE REVI

BEAM TESTS

Ten years later...
page 35

AVALANCHES as Art

A late February storm had delivered multiple feet of new snow on top of a suspect layer in the North Cascades. At the end of a ridge called Rooster Comb lies a hanging snowfield which is a prime site for heavy wind deposits. Given enough snow, avalanches on this face have the capacity to run all the way down a drainage and into the Stevens Pass Ski Area, endangering the skiing public and multiple chairlifts.

Ski patrol planned a heli-bombing mission for early the morning before the opening of the resort and invited me to view the events from an opposing ridgeline. The third bomb hit a tender spot on the convexity toward the top of the slope and created a monstrous avalanche that ran nearly the entire path and shattered long standing trees.

— Scott Rinckenberger

See more photos on page 24

THE AVALANCHE REVIEW

The Avalanche Review is published each fall through spring by the American Avalanche Association, Inc., a nonprofit corporation. *The Avalanche Review* welcomes the submission of articles, photographs and illustrations.

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AMERICAN AVALANCHE ASSOCIATION

AAA STATEMENT OF PURPOSE

The American Avalanche Association promotes and supports professionalism and excellence in avalanche safety, education, and research in the United States.

Subscription: $30 per year (4 issues). Subscription is included with membership dues to AAA. For subscription and membership information, see **www.AmericanAvalancheAssociation.org**.

Contributions: Please submit material eight weeks prior to publication date. Include address and telephone number. Please submit typed manuscripts by e-mail or disk (CD or DVD), using any popular word processing program. Submit any figures as an EPS (preferred), PDF, TIFF or JPG file (300 dpi resolution at 100%). We will return materials if you include a stamped, self-addressed envelope.

Articles, including editorials, appearing in *The Avalanche Review* reflect the individual views of the authors and not the official points of view adopted by AAA or the organizations with which the authors are affiliated unless otherwise stated.

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35.3
FEBRUARY 2017

CONTENTS / CROWN PROFILES

CONTENTS / DEPARTMENTS

CONTRIBUTORS

Scott Rinckenberger is a Seattle based fine art landscape and adventure photographer specializing in capturing the most pristine and wild places his legs will carry him. Scott's work has been featured in art exhibitions worldwide. His commercial clients include REI, Apple, MSR, Powder and Outside.

Doug Chabot, director of the Gallatin National Forest Avalanche Center (GNFAC) in Bozeman, Montana, received his B.A. in Outdoor Education from Prescott College in 1986. Since 1995 Doug has worked for the GNFAC as an avalanche specialist. He's also a mountain guide and climber. Doug has been on numerous climbing expeditions to Alaska, Nepal, India, Afghanistan, Tajikistan and Pakistan.

After wrapping up his Master's degree in Bozeman, a young and impressionable **Zach Guy** flirted with the margins of the cougar den (Aspen), working for Irwin Guides and the CBAC. Six years later, he is wiser to the fact that these aren't friendly tabby cats in Colorado and they play for keeps, so he's retreating back to a more maritime snow climate in the Flathead this spring .

Liam Bailey is currently the lead forecaster for the Kirkwood Ski Patrol, closing in on 20 years working at Kirkwood. He spends winters practicing avalanche hunting, although he doesn't drink as much rye whiskey as he used to.

Karl Birkeland is the Director of the Forest Service National Avalanche Center. His years of looking at the snow have included time as a ski patroller, grad student, backcountry avalanche forecaster, and avalanche researcher. He loves skiing with his two teenaged daughters, but is finding it more difficult to keep up with them every year!

FROM THE EDITOR

BY LYNNE WOLFE

I've been thinking about Ed LaChapelle's essay *The Ascending Spiral* as I often do during avalanche season, first because my buddy Jud (Art Judson), at 82, hadn't seen it before last week, and then because I am seeing the spiral in action yet again. Ed described the spiral for TAR more than eleven years ago in 24.1:

> *Here is one contribution to the perpetual questions of how to evaluate avalanche hazards, consider human factors, and communicate (or execute) decisions. Here is what I mean by the title. Rather than seeing our mastery of snow and avalanche science and decision-making as linear progression, I see it as the same issues and ideas coming around again and again, but each time at a more sophisticated and technically advanced level, hence the ascending spiral.*

In his essay on the history of the beam tests, Karl Birkeland invites young researchers, forecasters, and practitioners to stand on this generation's shoulders to devise even better snowpack tests (page 35). Further within the beam test focus, I found generous insight from following the thought paths of the researchers among us from fracture theory into practical and useful tests that forecasters, guides, and recreationists use every day. Thanks to Craig Sterbenz, Ron Simenhois, Dave Gauthier, Bruce Jamieson, Michael Conlan, Ian Hoyer, Ned Bair, and Alec Van Herwijnen for sharing their perspectives on how those tests evolved. Mark Staples represents the practitioner arm with his eminently practical essay on page 45.

More of the material from this issue sent me along the ascending spiral. Liam Bailey worked on the problem of organizational awareness, importing some very applicable insights from the wildland fire world as he explored viewpoints of the workers, the supervisors, and the management in his essay *Elephants in the Room* (page 32). In his characteristic down-to-earth style, retired Montana forecaster Dudley Improta takes us from the theoretical world of human factors and heuristics to the practical applications that are crucial to minimize exposure and advance smart travel in the mountains (page 34). In both essays, respectful debate, discussion, and the dialectic between the authors and the editor or other critics brought clarity and further insight to the product.

In Crested Butte forecaster Zach Guy's tale of a close call on Red Lady (page 26), I am unsure of the spiral. His story has many levels: one person's willingness to trust in luck as a decision-making mechanism, perhaps? Or a forecaster's frustration with trying to get a challenging message—how to respect a long-time deep persistent slab—to stick? Or a third: is there a difference between community disapproval and the culture of shame that Drew Hardesty has written and spoken about in TAR and elsewhere (but not in this issue)? **Are we as a culture pushing our risk tolerance with better tools but less honesty in thinking that since the avalanche's subtleties can be better detected, we concurrently assume they can be better managed?** How can we gain the real messages of close calls and free lessons without thinking ourselves invincible?

In the end, we continue to fight the same battles as our mentors against impulse and uncertainty, but the tools change, our approaches change, our resolve to provide the best tools and information to our communities only hardens. Thanks to Ed and to all of you for your dedication to pushing the spiral continually upwards.

Stay on top, friends. ▲

First level 1 of the year, checking out the basal facets up on Togwotee Pass.
Photo Brendan Nolan

AAA LOGO USE BY MEMBERS AND OTHER ENTITIES

In recent months, the AAA has been receiving more and more requests to use the AAA name and logo for various purposes. We're excited about this and hope that it indicates people like the now year-old refreshed logo. In light of this uptick in requests, we wanted to remind folks that this is an option available to current AAA members and that the AAA has some specific policies about how and by whom our name and logo can be used. Note, you can also find the following information on the "Ethics & Awards" page of the AAA website (www.americanavalancheassociation.org/ethics-awards/).

The American Avalanche Association name has been registered with a service mark (similar to a trademark). We initially announced the following parameters of AAA logo and name use during the annual membership meeting during ISSW 2006 in Telluride, CO.

Individuals may use the AAA logo and name in the manner listed below. Each use must clearly represent an individual or individuals, not an entire business or school. Avalanche schools may list individual classes as being taught by AAA Certified Instructors or advertise adhering to AAA Guidelines for Level 1 and/or Level 2 courses. The name or logo cannot be used on its own without a qualifier such as professional member or member affiliate. The logo without a qualifier is exclusively for use by AAA for AAA applications only.

Pro Members: Professional Member AAA

AMERICAN AVALANCHE ASSOCIATION
PROFESSIONAL MEMBER

Member Affiliates: Member of AAA

AMERICAN AVALANCHE ASSOCIATION
MEMBER AFFILIATE

Certified Instructor: Certified Instructor AAA

AMERICAN AVALANCHE ASSOCIATION
CERTIFIED INSTRUCTOR

Please request the appropriate logo file and register your use with the Executive Director at aaa@avalanche.org. Exceptions to the above parameters will be considered by the AAA Governing Board on a case-by-case basis. ▲

FROM THE EXECUTIVE DIRECTOR

BY JAIME MUSNICKI

Greetings from the AAA office,
As we start a new calendar year and continue our journey through the 2016/17 winter season, I want to take a few moments to express gratitude to many different people for all they have been doing to engage with and support the AAA and our avalanche community through our ongoing and myriad projects..

First, many thanks to all of our current AAA members! We are over 1300 members strong and growing, including Professional and Affiliate members as well as AAA supporters who receive TAR. You, our members and supporters, are the heart of the AAA. Your engagement through the AAA is what makes the avalanche industry in the United States exist. We are incredibly grateful for all that you do in your jobs and for your support of and engagement with the AAA.

Thank you to all of our Industry Supporting Partners and TAR advertisers. The AAA would not be able to do nearly as much for the avalanche industry in the U.S. without your dedicated support. Page through TAR to see who is currently supporting the AAA in this way, and consider supporting these companies who clearly care about avalanche professionals and our community.

Thank you to everyone who has been working to make the AAA Pro Training Program a reality. Our founding pro course providers, industry advisory group members, the AAA Education Committee, the AAA Governing Board, key supporters who have specifically and significantly contributed to the pro/rec project, recent Pro Trainer Workshop facilitators and participants, and our Pro Training Coordinators have all worked tirelessly to envision, create, and support this program. We're over three years in the making and are excited to see the first new pro courses offered next season!

Thank you to the AAA Observations Standards Committee, our SWAG Revision Project Manager, and our ever-talented graphic designer for revising and creating a fresh, new layout for SWAG this year.

Thank you to our *Snowy Torrents* team (authors, editors, proofreaders, AAA Publications Chair, and, again, our graphic designer) who have been working for months to revitalize publication of *The Snowy Torrents*. The CAIC has also been an integral partner in this project, dedicating many staff and hours to helping us create a high quality book. We are excited to be in the home stretch of getting this new book published and into the hands of readers.

Thank you to all the avalanche professionals out there who work hard to explore, manage, research, mitigate, and teach about avalanches and avalanche hazard. You provide invaluable resources and services to winter recreationists and snowy mountain communities around the country and the world. We're all very lucky to have you looking out for our roads, communities, winter recreation playgrounds, businesses, and loved-ones.

Thank you to our current AAA Governing Board members. These busy people volunteer their time to help guide and support all projects and programs at the AAA. I am especially grateful for their recent commitment and dedication to making the AAA the best organization it can be by pursuing thoughtful organizational change that truly benefits the entire avalanche community in the U.S.

Finally, a special thank you to our TAR team - Lynne (editor), Blase (Publications Chair), McKenzie (that aforementioned talented graphic designer), Johnson Press of America (our printer), and all of our past, current, and future TAR contributors. If AAA members are the heart our organization, *The Avalanche Review* must be the blood coursing through our veins circulating vital, life-sustaining "nutrients" to even the furthest reaches of our community.

I hope your 2017 is off to a fine start. Thank you for your involvement with the AAA. ▲

THE SNOWY TORRENTS UPDATE

The AAA is nearing the finish line in publication of the first new volume of *The Snowy Torrents* in two decades! *The Snowy Torrents* team has been hard at work attending to final details and striving to produce a high quality product for you.

While we were planning to have the book to the printer on December 1st (hoping to get books to all our pre-order customers before the holidays), this goal proved to be unrealistic. The final stages of editing, fact-checking, and proofing are taking longer than we anticipated. We are now aiming to have "books in hand" for all our pre-sale customers by late February. We apologize for the delay.

Ultimately, we're committed to publishing a high quality book that will be packed with accurate, useful, well-organized info for readers. As this is our first go-around with publishing *The Snowy Torrents*, we're certainly learning a LOT along the way that will inevitably lead to a smoother process next time around.

If you have not yet ordered your copy, you can still get on the "pre-order" list by visiting **"*The Snowy Torrents* Pre-Publication Sales Event"** at the AAA database (https://aaa19.wildapricot.org/event-2386694). Both printed and e-book versions will be available. We will transition to offering *The Snowy Torrents* through the AAA's online store as soon as we publish. ▲

AAA GOVERNING BOARD TRUSTEE VACANCIES

The Governing Board of the American Avalanche Association is seeking qualified and interested applicants for a few board vacancies this winter. After many years of dedicated service to the AAA our Research Committee, Publications Committee, and Education Committee Chairs will be moving on from their respective positions in the coming months. All three of these positions are appointed trustees to the AAA Governing Board. Appointments are approved by a majority vote of current Governing Board members.

All trustees on the AAA Governing Board are voting members of the board who volunteer their time to help guide and support the mission and operations of the AAA. Board members are not compensated and are responsible for their own travel costs to any AAA meetings or events. In addition to committee-specific responsibilities, all trustees are expected to:

- Positively represent the AAA to colleagues and other interested groups/individuals - answer questions, encourage membership/support, refer people to other Board members or staff as needed;
- Listen to and pass along feedback, input, concerns, or questions from AAA members to the appropriate Board and/or staff member;
- Participate in bi-monthly board meetings—one in-person meeting each fall, plus five additional web/phone meetings throughout the rest of the year;
- Stay informed of and provide input on current AAA topics and issues under consideration by the Board;
- Respond in a timely manner to Board-related emails;
- Follow through on commitments to other Board members, committees, and *The Avalanche Review*;
- Effectively navigate technology (e.g. email, Google Drive, Dropbox, other online tools) to stay engaged and collaborate with Board and committee members; and
- Help with specific projects and/or initiatives on request from the Board or staff (e.g. membership recruitment, fundraising efforts).

Each Committee Chair is also responsible for comprising and leading their particular committee. Committees assist and advise the AAA Governing Board on topics as requested, sometimes recommending a particular course of action, though they do not make decisions for the AAA on their own.

Look for more thorough position descriptions for each position that include committee-specific details in the employment listings on avalanche.org (avalanche.org/employment). Interested individuals should submit a letter of interest and resume to the AAA Governing Board for a particular position by February 15, 2017. The Executive Committee of the Board will review interested applicants and be in touch with further questions as needed. New appointments will be approved at the AAA's April Board meeting and announced shortly thereafter. ▲

This Winter in History

BY DALE ATKINS

1866–67

150 years ago. US avalanche deaths tallied 56. Fifty-five deaths occurred in four accidents along the Central Pacific Railroad's track and tunnels crossing California's Sierra Nevada Mountains in the Donner Pass area between Cisco and Truckee. Most of those killed were Chinese laborers, and their numbers were likely under reported. At Kearsarge City in the eastern Sierra an avalanche destroyed much of the town and killed one resident. At the time, the winter of 1866–67 was the "worst on record" with snow depths reaching "40 feet."

1916–17

100 years ago. Avalanches claimed 22 lives with the winter's first fatalities in December with a mineworker death each in Alaska and Montana. In January a mining company accountant and a lineman were killed near Juneau, Alaska, as they inspected an area for a future electrical plant. The season's worst accident saw 17 killed at the North Star Mine, 12 miles northeast of Hailey, Idaho, when struck in the middle of the night. During the previous three days, 2.5 feet of snow fell but the snowfall turned to rain resulting in widespread avalanching. That same day at the nearby Independence Mine another person was killed.

1966–67

50 years ago. Four fatal accidents killed two each in Colorado, Utah, California, and Idaho. Six of the victims were climbers, and two victims were ski patrollers at Skyline Ski Area (now called Pebble Creek), Idaho. Two accidents are notable. In the Utah accident, rescuers failed to follow tracks away from the avalanche and one survivor wandered off and died of hypothermia. At Skyline an avalanche rescue exercise turned deadly when 16 ski patrollers were caught; two were buried and killed. Only moments before the avalanche the course instructor became distressed about the situation and ordered the patrollers off the slope. Tragically, the avalanche released before his message could reach all participants.

AAA GRANT AWARDEES:

The following applicants have been awarded funds from the AAA grant monies to further their research.

Bill Hoblitzell currently is a watershed scientist at Lotic Hydrological in Carbondale, CO. When his friends are really scraping the barrel, he is also a cat skiing guide and AIARE instructor in central CO. In his salad days, he was a ski patroller, river guide, EMT, and a bootfitter, but clearly he's riding on past glory now. Bill believes strongly in short-radius turns and really milking the hell out of ski lines.

Diana Saly is a Master's student in Snow and Avalanche Research at Montana State University. Her research studies how skiers, snowboarders, and snowmobiles affect the mountain snowpack in high-use backcountry avalanche terrain. She has worked as a ski patroller and in backcountry avalanche forecasting.

BILL HOBLITZELL: User Patterns in Colorado Resort-Access Backcountry

While backcountry, and especially resort-accessed backcountry, use has increased greatly, reliable quantitative estimates of use and demographics are frequently absent. Deployment of backcountry sensor networks to monitor traffic and risk mitigation choices may illuminate portions of these data gaps. East Vail is a popular lift-accessed backcountry skiing venue on public lands easily reached from one of the busiest resorts in the US, comprising an excellent research opportunity. We plan to deploy automated traffic and beacon sensing loggers at the primary access point in order to describe daily traffic patterns in relation to easily-obtainable environmental variables including daily hazard rating, new snow and weather, and resort traffic levels. This information will be paired with in-person skier surveys that are designed to provide a brief demographic profile of typical venue users, including avalanche/backcountry education level and safety equipment usage.

DIANA SALY: Using Time-Lapse Photography to Study Avalanche Terrain

Winter recreation in mountainous terrain has noticeably increased in recent years. Popular backcountry areas are seeing so much use that uncontrolled backcountry avalanche terrain resembles avalanche-mitigated terrain at a ski area. Backcountry avalanche terrain adjacent to ski areas presents compounding challenges in that uncontrolled avalanche terrain is both easily accessible and excessively tracked out, sometimes more than inbounds terrain. Understanding the processes and change the snowpack undergoes as a result of this compaction is a challenging task due to the dynamic nature of the snowpack, but a critical component in understanding snowpack stability.

This project uses time-lapse photography to capture skier terrain use in backcountry avalanche terrain. Time-lapse images can be useful to first responders in avalanche emergencies and also in avalanche research: to study terrain use by backcountry users, natural avalanche cycles in remote terrain, and characteristics of start zones. Incorporating GIS and spatial data, this project documents skier usage in backcountry avalanche terrain in an effort to study group and individual terrain choices and classify terrain based on usage, slope, and conditions, and gain insight on the effect of skier compaction on snowpack evolution. This knowledge will foster a better understanding of how instabilities in the snowpack are affected by different levels of compaction. Such information could improve avalanche forecasters' ability to communicate avalanche hazard to the public in areas of intense use and compaction.

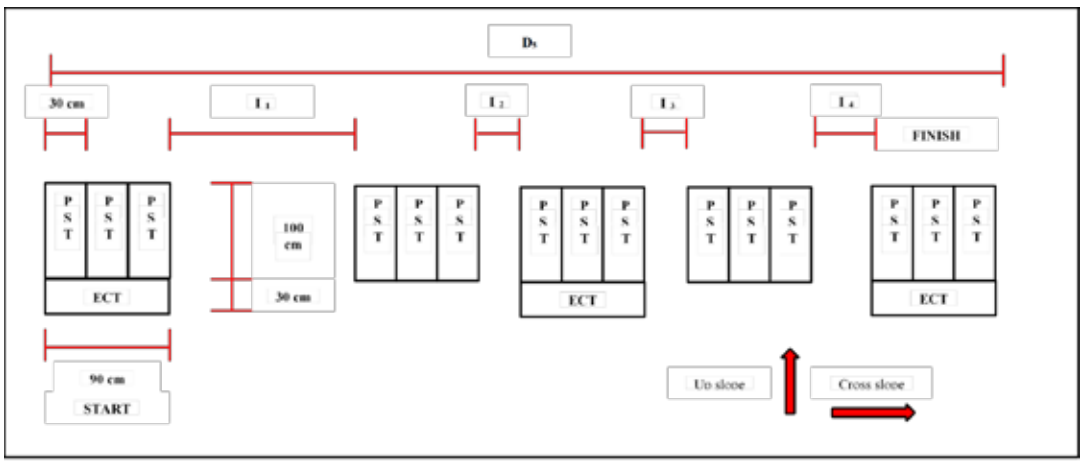
CHRIS BILBREY: The Effect of Slope—Scale Spatial Variability of Slab Characteristics on Propagation Saw Tests

Understanding propagation in complex, non-uniform terrain is critically important for avalanche forecasting and mitigation with terrain effects being recognized as a major source of uncertainty (Hägeli and McClung, 2004). Currently our understanding of how propagation varies at the slope – scale is limited, particularly on complex wind loaded slopes with a wide variation in slab properties. Guy and Birkeland (2013) investigated the spatial variability of snow structure in complex terrain, but did not definitively tie that variation back to stability. This study investigates the variability of slab properties (depth, SWE, hardness), and how that variability affects Propagation Saw Test (PST) cut lengths.

Research Questions

- Can we quantify how the variability of slab distribution and slab characteristics, from wind loading at ridgetops to within complex, non-homogenous terrain, affects PST results at the slope – scale?
- Can Structure from Motion (SfM) photogrammetry be used to quantify the temporal changes and spatial variability of snow depth contributing to snowpack instability?
- Can these temporal changes and spatial variability of snowpack observations that contribute to snowpack instability be visualized within a GIS?

Winter Field Season 2015–16: We collected data from eight transects on seven slopes in southwest Montana during the 2015 – 16 winter (Bilbrey et al., 2016). We sampled transects either downslope or cross slope, depending on which direction offered the greatest variability from wind loading. Each transect consisted of five pits, and we determined spacing between individual pits by changes in snow depth and/or slope angle (Figure 1). We used two metrics to determine the variable spacing d between pits: 1) an increase or decrease in height of snow (HS) ≥ 10 cm or 2) an increase or decrease in slope angle ≥ 3 degrees. In each pit, we performed three PSTs and one Compression Test (CT), as well as one Extended Column Tests (ECT) in the first, last, and middle pit of the transect.



Cross slope transect layout. Dimensions (meters) of d will be determined after sampling height of snow with a standard avalanche probe. Same layout can be utilized for a downslope terrain features.

Winter Field Season 2016–17: This season, we will utilize thin – blade penetrometer measurements (Borstad and McClung, 2011) to index properties of the weak layer to hopefully help explain some of the variability we are observing (Bilbrey et al., 2016). Transect sampling will occur in locations where the slab is thin and move towards deeper areas of the slab. Capturing the tapering effect of a slab could provide better understanding of potential trigger locations where slabs and terrain features are highly variable. In addition, we plan to utilize (SfM) data to build surface models of field sites with and without snow to quantitatively evaluate the spatial variability in height of snow change across such terrain. Combined with additional statistical analyses, we hope this work will help us better understand the variability of crack propagation in complex, non-uniform terrain. ▲

References

Bilbrey, C., et al. (2016) The Effect of slope – scale spatial variability of slab characteristics on propagation saw tests. International Snow Science Workshop, Breckenridge, Colorado.

Borstad, C. P. and D. M. McClung (2011). "Thin-blade penetration resistance and snow strength." Journal of Glaciology 57(202): 325-336.

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Chris Bilbrey is currently pursuing a M.S. in snow science from Montana State University in Bozeman and is the Education Coordinator for the Friends of the Gallatin National Forest Avalanche Center. He is currently involved in an internship with the GNFAC and worked 11 seasons as a professional ski patroller at Wolf Creek Ski Area in southwestern Colorado as Lead Avalanche Tech and Forecaster for the snow safety program. He loves spending countless hours in the mountains, in remote river canyons, and landing big fish. He and his wife are anxiously awaiting the arrival of their first daughter at Christmas.

AVALAUNCHER SAFETY BULLETINS

At Avalanche Mitigation Services (AMS) we pride ourselves on exclusively offering documentable advice. Gates is one of the world's largest manufacturers of hydraulic hose. Per their literature: "Gates is known as the world's most trusted hydraulic hose assembly manufacturer." Gates confirms below that under no circumstance should hydraulic hose be used in any regard on your Avalaunchers. That is why AMS has always used Teflon cored high pressure pneumatic hose, never rubber hydraulic hose. Compressed gas and explosives are not to be trifled with- don't wait for an accident before using the correct product for the application.

Another safety item that continually comes up concerns loading protocols for Avalaunchers. The designers of the Avalauncher and Avalanche Mitigation Services both insist upon loading projectiles with just the standard 50 psi storage pressure in the machine. In a worst case scenario, one that has never occurred to our knowledge, if an Avalauncher were to misfire during loading you would much rather have 50 psi escaping than full Target Pressure. Some insist that a projectile is inside the machine for less time if the launcher is brought up to Target Pressure prior to loading- this is not a valid argument to either Avalanche Mitigation Services or the machine's inventors.

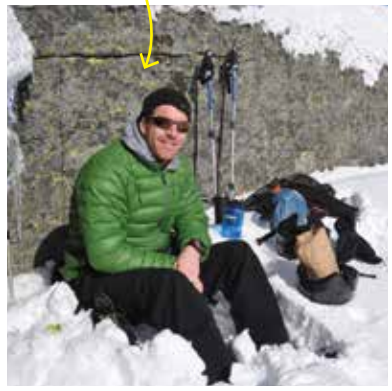
Please contact John Brennan with any comments or concerns:
jb@avalanchemitigationservices.com

INSTRUCTOR IMPACT ON RECREATIONAL AVALANCHE EDUCATION

INTERVIEWS PERFORMED BY SEAN ZIMMERMAN-WALL

Moving into the heart of the season, the AAA is diligently working through the finishing touches of the Pro/Rec Split. The machine is starting to take shape as the cogs are being put into place, and each piece is vital to its overall operation. The oil pumping through this machine is represented by the pool of instructors currently teaching recreational avalanche education. These individuals range from the first year course instructor to the multi-decade veteran.

In order to understand the varied perspectives of educators currently teaching or organizing recreational courses, the AAA reached out to a subset of instructors to see how they are preparing for the changes to come. The following interviews were collected from: Eeva Latosuo of Alaska, Bruce Engelhard of Utah, Tom Carter of the Sierra, and Jeff Lane of the Northeast. Their careers as professional educators, guides, and/or forecasters allows them to see the importance of raising the bar for avalanche education and how it will benefit the industry and the public in the long run.



AAA: *Where do you teach the majority of your recreational avalanche courses and what are some of the nuances of your region that are taken into consideration when instructing?*

Eeva: I teach most of the courses within an hour of Anchorage. We use two common backcountry area; Turnagain Pass and Hatcher Pass. Alaska is its own type of beast since there are numerous places where people recreate that do not have any sort of forecast or even observations available. It is important that we teach our students good travel techniques and ability to observe signs of instability so that they can make good decisions without outside information.

Bruce: I teach the majority of my classes in the central core of the Wasatch Range/the Tri-Canyons. This area offers the opportunity to utilize lift access, which appears to help address the user styles that many folks around Utah want to use for much of their backcountry travel. In general, it is becoming harder and harder to find suitable teaching terrain that is not being overused.

Jeff: In our area, most avalanche courses take place on Mt Washington. Two big challenges in this area come to mind. First, the number of people in a small geographic area on any given day is staggering, Second, the terrain makes it difficult to access avalanche terrain without first exposing yourself to complex terrain issues, such as multiple paths converging into your approach.

Tom: Mainly in the Tahoe area. It has a Maritime snowpack with long periods of stability and multiple ski areas in the vicinity. There is also access to large backcountry venues in challenging and complicated terrain.

AAA: *What do you see as the biggest challenge facing recreational avalanche education in the United States?*

Eeva: At least still in Alaska, we are struggling connecting with the motorized users. We have good curriculum and more outreach to this audience, but it has been a hard sell to get snow machiners on courses.

Bruce: Along with challenge of being able to adjust to the vast and wide varieties of user groups, probably the other major challenge is getting the public to buy into the important concept of having a stand-alone companion rescue course. Not only may this create a financial challenge for some, it also presents a challenge for others that has to deal with adjusting to this mental shift in the expected requirements.

Tom: Realistically our students have had little time in the mountains, have not been mentored, and need the very basic skills. They need to begin to understand the avalanche bulletin, how to plan and consider how groups work/don't work together. They need to understand risk, their personal and group uncertainties.

AAA: *How do you view this update overall and how do you hope it will benefit the end user?*

Bruce: The changes are obviously going to help both instructors and students get so much more out of the 24 hours recommended in a Level 1. Congruently this will allow both instructors and students to have Level 2s be more productive in the time spent addressing more advanced curriculum materials.

The use of online/preliminary materials also appears to be essential with regard to making these changes as successful as possible.

Eeva: It is important to make the public aware how the avalanche rescue is now given its separate focus. It is inspiring to learn about super effective companion rescues, like in the Avalanche Canada interactive feature "Rescue at Cherry Bowl." We really want to help students master all the rescue components through rigorous go-speed scenarios. Being able to offer Level 2 customized for recreational users is also a welcome update.

Tom: This is the list of skills we've all taught. It's the Nuts-an-Bolts. The questions become what should be culled? What is missing? And how do we stuff all of this into the 24 hrs of a Level 1? Anything we can do to assist the instructors in delivering these courses will result in higher quality education throughout the industry.

Jeff: I think it's a big step in the right direction overall. I don't think we should be content to sit

back and stop innovating though. To that end, I wish there was more room within the new guidelines for additional courses that fall outside of the normal progression.

AAA: *Given the regional differences that exist across the United States, how can instructors nationwide focus their courses to add value for the students while staying within the scope of the new guidelines?*

Tom: Work on assembling a selection of "accidents," outcomes, etc that occurred outside your local zone. Dig into the archives and bring up weather, snowpack, and avalanche reports to give the students a continuum. We owe it to everyone to make sure the basics are clearly delivered. Science is exciting and has its place, but our early students need a foundation. It is about their decisions.

Bruce: The key to overcoming this supposed challenge presented by regional differences lies in helping students to understand all kinds of conditions whether they are actually currently present in the daily actual conditions. This requires educators with imaginations and insight on how to help students to look at specific terrain features with open minds. And specifically, this will tie back to the classroom sessions and how important it is to make sure students understand the basics of the avalanche types, avalanche terrain, and avalanche problems.

Jeff: If we are going to have a standard that is recognized around the country, it needs to be applicable to any regional snow climate. For example, planning a route in the Northeast is very different than in the Rockies. But we should still be giving people the info they need for understanding how to plan a route. The fundamentals are the same, but the application is different.

Eeva: It always comes down to delivering a solid curriculum adapted to the specific audience. It will be a little hard to edit away some of the curriculum that we are accustomed to teaching, and letting go of the more sciency topics is hard for some of us.

AAA: *How can the AAA assist recreational avalanche course providers in order to ensure the highest level of education is being provided and that the instructors are well suited for adapting to the updated guidelines?*

Eeva: It would be nice to see a push to the public on recreational changes like we've seen on the pro side. I think it should be up to the providers to make sure that the instructors are capable of delivering solid programs while complying with AAA expectations on lead instructors.

Jeff: I think instructors need to step up and get themselves ready. For many, that won't be a problem at all. But I know there are some instructors who may be stuck in a bit of a rut, and for them it might be harder to adapt to the updates.

Tom: This is really a simple re-organizing that is going on. Keep communicating with the public and the pros. Let them know what's in the pipe. It not that big a change, it's just re-structured and we will all benefit.

Bruce: It will be important for all recreational avalanche course providers to have multiple avenues of oversight embedded into their programs so they can continue to offer suggestions/tips and training opportunities to their instructors.

Looking closely at these responses we can see there are common threads that unite the varied viewpoints of instructors nationwide. They do recognize that this is a work in progress and that it will be an iterative process that will take collaboration on all fronts. They also see that the challenges that we collectively face are not insurmountable and that there are support structures already in place to assist in meeting the goals of the project. Providers across the country are encouraged to reach out to the AAA for additional info and to keep reading TAR for additional updates as we get closer to launch. ▲

Sean Zimmerman-Wall continues to work with the AAA on a variety of projects for the Pro/Rec split and spends a majority of his time in the mountains of Utah with his young family. In the summer, he heads south to Argentina to guide for Patagonia Ski Tours and keep his snow skills sharp.

METAMORPHISM

Zach Guy: New Director at the Flathead Avalanche Center

The Flathead National Forest is pleased to announce Zach Guy as the new Director of the Flathead Avalanche Center (FAC). Zach is currently the Director of the Crested Butte Avalanche Center in Crested Butte, Colorado. Zach comes to the FAC with a Masters of Science degree from Montana State's Snow Science department and six years of forecasting and snow safety experience working for Irwin Guides and the Crested Butte Avalanche Center. Zach will be stepping into his new position later in the season, coming in behind Erich Peitzsch, of the U.S. Geological Survey (USGS), who is stepping down as Director to pursue his Ph.D. research in snow and avalanche science. Erich will continue to support FAC part time and maintain an applied research collaboration with the USGS and FAC.

Until Zach arrives, Todd Hannan, who is in his 4th year as an Avalanche Specialist with FAC, has stepped in as Interim Director and will lead the FAC and the daily forecasting operations, along with Avalanche Specialists Mark Dundas, Erich Peitzsch, and Seth Carbonari. Guy Zoellner will provide support to the FAC as an observer, along with Jenny Cloutier as the education coordinator for the Friends of the Flathead Avalanche Center (FOFAC). FOFAC helps support FAC financially as well as promoting avalanche education programs in northwest Montana and beyond.

WSDOT New Hires

After a number of years in Utah (GREATEST SNOW on EARTH ™) working with UDOT, **Matt Primomo** is psyched to be back in Washington (the land of glaciers, great coffee, beer, and salmon) with his sweetie. He is an AMGA Certified Ski Guide, and working his way through the rest of the IFMGA guide track. After the month of December in the Evergreen State, he can say it definitely only rains here.

Ryan Zarter was born in Kansas and moved to Colorado in 2000 to pursue what he thought would be a career as a plant biologist. After finishing his graduate studies at the University of Colorado in 2005, he did what any sensible biologist would do and got a job as a ski patroller, starting first at Eldora Mountain Resort and then moving to Arapahoe Basin in 2008. In addition to ski patrolling, Ryan's avalanche experience includes working as an AIARE instructor, a couple of seasons avalanche forecasting at a gold mine in Chile, a season in New Zealand, and a stint avalanche forecasting for an oil company in Kurdistan Region of Iraq. Ryan's interests include skiing, photography, backpacking, and a good cup of coffee. He's excited about his move to Snoqualmie Pass, and he looks forward to truly wrapping his head around the concept of Cascade Concrete.

Mt. Shasta Avalanche Center New Hires

The US Forest Service Mt. Shasta Avalanche Center, entering its 19th year of operation, is excited and proud to announce the on-boarding of Andrew Kiefer.

Andrew Kiefer graduated from Prescott College in 2013 with a B.A. in Environmental Studies and Wilderness Leadership. He has professional experience guiding in Washington, Alaska, Colorado, Wyoming, and Idaho, including guided ascents of Rainier and Denali as well as numerous guided ski adventures in the San Juan Mountains, Central Idaho, and the Teton Range. In addition to guiding, he has worked as an avalanche educator teaching courses for Prescott College and for the American Institute for Avalanche Research and Education (AIARE). Andrew holds AMGA Aspirant Ski Guide status, an AIARE Level 3 certification, and is a Professional Member of the American Avalanche Association.

In addition to Andrew, the Friends of the MSAC applied for and received a California State OSV grant that allowed the hiring of **Aaron Beverly** as a MSAC Field Observer. Aaron brings a wide array of knowledge and skills to the table. He has a robust ski patrol background as well as many years of alpine guiding on Mt. Shasta and as a whitewater river guide around Northern California. Aaron also has some great web skills to round out his talents.

Thus, the MSAC has three employees this season, the most ever in its history. Seven day-a-week forecasts, an always improving website, monthly avalanche awareness and companion rescue courses, and snowmobile-specific avalanche and rescue workshops will keep the center hopping. The thriving Friends group continues to host the annual Snow Ball party, the Mt. Shasta Ascension Backcountry Ski Race, and several movie nights to support the MSAC and promote winter backcountry safety and stoke.

CHRIS LANDRY:
CELEBRATING HIS RETIREMENT FROM A STELLAR AND VARIED CAREER

BY DON BACHMAN

Avalanche professional Chris Landry is almost a year into retirement from a life of snow that followed naturally from his ancestry; his father served in the WWII Tenth Mountain Division and Mom loved to ski. This family managed The Big Mountain Ski Area while raising Chris near Whitefish, MT in the 50s. They later moved to Carbondale, CO where high school and collegiate ski racing brought him the skills to make the famous first descent of the east face of Pyramid Peak (14,018') on Mother's Day, 1978, soon to be known as the "Landry Line." (Chronicled in the March 30, 1981 issue of Sports Illustrated). Chris soon followed this with another accomplished line on the North Face of the East Summit of nearby Sopris Pk., known locally as the "Laundry Chutes." Epic ski descents followed in the Sierra Nevada Range, Liberty Ridge on Mount Rainier, and on Denali.

Chris worked as a finish carpenter and wood worker in the Aspen area in the 80s while his continued fascination with skiing, avalanches, and snow brought him to a challenging avalanche forecasting circumstance which he met with innovative and meticulous response.

In 1990 the Colorado Yule Mining Company reopened the marble quarry near Marble, CO. The quarry portal was located up a 3.5 mile county spur road above town which had been developed in the 1890s. The quality of the rock was such that it had been used for the Lincoln Memorial, Tomb of the Unknown Soldier, and hundreds of other monumental structures and sculptures in the US and Europe. The company recognizing the history and topography of the area, contracted with Art Mears, P.E. to map avalanche terrain potential and assess the hazard. Art recommended a program of stability forecasting, evaluation, and travel management. After the 90/91 season with an unsatisfactory internal program, professional avalanche assistance was again recommended and Chris was contacted and formed a consulting company, Yule Creek Avalanche Services. He developed a program plan based upon study plot instrumentation, avalanche path observations, snowpack analysis, weather forecasts, and client communications. Risk management was primarily by avoidance of the access road, 40% of which was subject to burial by avalanche debris. A five-level rating system with operational rules was put in place.

"Conventional" roadway avalanche programs are generally augmented by active control measures. Explosive use in the Yule Creek starting zones was prohibited due to their location in the Raggeds Wilderness Area. The meticulous management program he developed continued through 1998 documented over 700 natural avalanches (U.S. class 2 or larger), 71 of which reached the quarry road with only one minor incident. That program record of risk management is an exemplary accomplishment and a testament to operational risk management which, in the absence of explosive or structural control, is probably unparalleled in the avalanche universe.

In 2000 the quest for knowledge and desire to further contribute to snow science and operations led Landry north to Bozeman, MT to enroll at Montana State University in the snow studies graduate program of the Department of Earth Sciences. There, in a program uniquely geared to interests in avalanche-related learning, the academic mentorship of Kathy Hansen of MSU and adjunct professor Karl Birkeland, with the USFS National Avalanche Center and contribution from active avalanche workers, resulted in a 2002 thesis "Spatial variations in snow stability on uniform slopes: Implications for extrapolation to surrounding terrain."

Upon graduation with a MSc degree, the quest for a useful contribution to snow science led him, along with the encouragement and organizational help of Don Bachman, Chris George, and Boots Ferguson, to form the Center for Snow and Avalanche Studies in Silverton, Colorado, on January 31, 2003. The study location was to be adjacent to Red Mountain Pass. This proximity was recognized by the University of Colorado Institute of Arctic and Alpine Research Director Jack Ives and avalanche consultant Ed LaChapelle in 1971 upon formation of the San Juan Avalanche Project, funded by the Bureau of Reclamation (cloud seeding/avalanche impact study), as "…a superb natural laboratory for the enlargement of an important segment of the United States (UNESCO) Man in the Biosphere Program. This (future studies) should be pursued in three forms: basic research, applied research, and in training and education."

With start-up grants of $2,500 from the AAA, matched by the Janss Family Foundation of Sun Valley and other contributions including (in part) from the San Juan County (office space), legal services of Holland and Hart, and from Chris himself in the form of first year salary, instrumentation, and other expenses, the CSAS began to take shape. The Senator Beck Study Plot area under Trico Peak in the San Juan Mountains, on the Uncompahgre National Forest, was formalized through Special Use Permit. In early 2004 the CSAS was awarded an $80,000 Rural Development Grant from the U.S. Forest Service.

Over the years funding has come primarily through water resource agencies in recognition of the CSAS mission statement (In part): "Understanding the seasonal delivery and distribution of mountain snowcover, the snowpack storage and release of water, and the effects of climate on those processes, are clearly of increasing importance to the American West and snowmelt-watered regions everywhere."

Chris Landry explains instrumentation at the CSAS Swamp Angel weather station to field trip participants on a site visit during ISSW 2006, Telluride, CO. *Photo Keith Roush*

An emerging area of interest for Chris and CSAS has been dust on snow, generated by the southwesterly flow of strong winds across the vast Four Corners Region, entraining particles from this desert area then deposited with associated precipitation in downwind mountain ranges. CSAS endeavors to generate and host research associated with this phenomenon. Landry has contributed as co-author to 13 peer-reviewed journal contributions out of the 21 papers which have utilized CSAS observations. Several hosted programs have benefited from his mentorship of graduate student researchers. He has participated in numerous presentations in this field and has generated funding from water resource agencies across the southwest.

For a full view and profile of CSAS go to: www.snowstudies.org. The organization is now, after a transition season of 2015/16, competently lead by Jeff Derry, an arctic observation specialist with years of experience in this realm.

Chris Landry's vision, determination, broad mountain knowledge, technical skills, physical ability, meticulous data acquisition, and communication and writing competence have served him as an outstanding science and avalanche practitioner. He will be graciously spending his retirement from CSAS adjacent to the mountains he loves. ▲

Don Bachman has had a long and interesting career in the avalanche world. He keeps up on current topics by reading TAR, participating in continuing education seminars, and through email correspondence with other crusty avalanche veterans like Art Judson and Ron Perla. He still has some nice coffee mugs from ISSW 2000 in his garage; his wife would love it if you'd take one (or two, or three, or the whole box).

SLIDE:
THE AVALANCHE PODCAST

BY DOUG KRAUSE

Slide: The Avalanche Podcast is an endeavor to provide continuing education on decision-making in avalanche country. You can subscribe to it on iTunes or Android, or listen to it on your computer via Soundcloud. The Googler will take you there.

The podcast is targeted towards both pro and recreational users. I'd love input on what folk want to hear and feedback on what I'm already putting out there, so hopefully some more croaking emerges from the sea of crickets.

Early season content included topics I've covered in these pages, like communication and situational awareness. I'm picking away at bias, heuristics, and various other cognitive traps in a weekly segment called **Brain Traps**, and, inevitably, by the time you read this I'll have had some fresh adventures and misadventures to share with y'all.

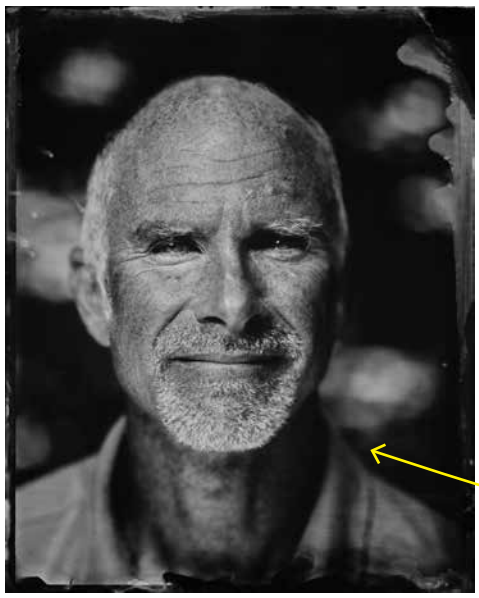
I'm trying to set an example of embracing and sharing failure so we all can learn from it. Error holds tremendous value, but only if you capture that error and leverage it productively. Send me your confessions, if you have the courage to walk that walk. I've got an email account at avalanchepodcast@gmail.com. There is also a Facebook page at Slide: The Avalanche Podcast.

Pray for snow.

PAUL DIEGEL STEPS DOWN FROM FRIENDS OF UTAH AVALANCHE CENTER

Paul Diegel will be stepping down as the Executive Director of the non-profit Utah Avalanche Center (formerly Friends of the Utah Avalanche Center) at the end of the 2016-17 season. Paul joined the UAC in 2001 as a volunteer and became the Executive Director in 2007. Paul restructured the Friends of the UAC, building on the past growth of the organization and partnering with Bruce Tremper and the rest of the UAC team to apply marketing, finance, operations, public relations, and strategy business skills to radically increase public engagement around avalanche safety. Paul increased non-profit revenue by 450% during the recession to now provide 2/3 of the total state-wide operating budget and a significant quasi-endowment fund. Most recently, he lead the team redeveloping the Know Before You Go awareness program to provide introductory avalanche awareness across North America.

Paul's entry to the avalanche community was circuitous—with degrees in Mechanical Engineering and Biomedical engineering and an MBA, his pre-avalanche professional life included directing engineering efforts on artificial heart and other medical device programs, building Formula One race car and advanced aircraft carbon fiber components, serving on the management teams of four start-up high-tech businesses, and remodeling an old ranch house. Skiing wound through all of that, starting on Mount Hood in Oregon, going through junior racing, the early days of freestyle (think long hair, sideburns, and red, white, and blue sunglasses), and speed skiing. He started backcountry skiing by getting caught (and released unharmed) in an avalanche on his first turn of his first tour on his new telemark gear in 1983. In a successful 2007 mid-life crisis career move, he became the Executive Director of the Utah Avalanche Center.



Paul intends to continue his involvement with the Utah Avalanche Center in a way that involves more skiing, boating, and travel and fewer spreadsheets. ▲

SAW REPORTS:

REGIONAL SNOW AND AVALANCHE WORKSHOPS

Professor Tad Pfeffer makes a point at CSAW in his inimitable style. TAR can imagine how intellectually stimulating it must be to study under his tutelage. *Photo Bill Cotton*

USAW: Utah Snow and Avalanche Workshop

BY PAUL DIEGEL

About 500 people attended the 9th annual Utah Snow and Avalanche Workshop on November 5. We tried a new format this year, opening the entire program to the public, based on demand from an increasingly educated and aware recreational backcountry community. We were able to reduce the cost by simplifying the food service and eliminating the concluding happy hour. As in years past, the morning sessions were more technical, focusing on common professional decision traps, reconstruction of accidents involving skilled riders and professionals, snow science, analysis of fatality data, thermal imaging and detection technology, and review of an interesting avalanche cycle. The afternoon was more human factors-based, with a past season review, presentations on increasing user interactions in a finite area and dealing with backcountry trauma, and a panel discussion and presentations providing different perspectives on decision-making,

Results from the new format were mixed. About two-thirds of the audience self-identified in a show of hands as primarily recreational backcountry users, with the remainder pros. There were clearly fewer pros in attendance this year, possibly driven by the decision by at least one resort to no longer pay for snow safety personnel to attend and the decision of the local resort community to have a free, more resort operations-based half-day meeting the week before. Response to the new format from attendees was uniformly positive. Are we developing a recreational community more interested in snow science and human factors than pros? Is that a good or bad thing?

Hard to say. The USAW organizing team is already working on a more inclusive agenda for next year's USAW. The proposed format for next year's event is an early morning session strictly limited to and run by the local professional community to address topics specific to commercial operations, with the remainder of the day open to all to network, dig deeper into the application of new science and theory, discuss lessons learned from recent accidents, and continued improvement of how we interpret conditions and make critical decisions.

We once again deeply appreciate the support from our sponsors, especially the American Avalanche Association. Huge thanks to speakers **Mark Staples, Mike Erickson, G.R Fletcher, Brian Pollick, Jeremy Jensen, Greg Gagne, Brett Kobernik, Mark Saurer, Matt McKee, Jake Hutchinson, Craig Gordon, Titus Case, Joe Royer, Dave Kikkert, Shaun Raskin, Alicia Peterson MD, Jimmy Tart, Todd Leeds, Dr. Preston Lear,** and **Roger Atkins**.

CSAW: Colorado Snow and Avalanche Workshop

BY DAN MOROZ

This year's CSAW held at the Riverwalk Center in Breckenridge, Colorado (10/01/2016) was a roaring success as it was a prelude to the International Snow Science Workshop being held from October third through October seventh, 2016 also in Breckenridge. Snow workers and researchers attending from all over the world made this CSAW very fun, diverse, and interesting. As usual, the conversations that occurred outside of the conference were as poignant as the discussions held in the venue.

This year's format was different than previous sessions as it was split into morning and afternoon panel sessions. Each panelist gave a brief lecture describing their "take" or opinion on the subject matter at hand.

The morning session topic was **Future Challenges in Avalanche Operations**. The speakers and panelists for this session were:

- **Bill Nalli**, Utah Department of Transportation
- **Will Barrett**, Breckenridge Ski Resort
- **Grant Statham**, Park Canada
- **Henry Munter,** Chugach Powder Guides
- **Cale Osbourne,** Summit County Sheriff's Office (Search and Rescue)

The afternoon session's topic was **Future Challenges in Avalanche Research**. The speakers and panelists for this session were:

- **W. Tad Pfeffer,** Institute of Arctic and Alpine Research
- **Bruce Jamieson**, Professor Emeritus University of Calgary
- **Hans-Peter Marshall,** Boise State University
- **Juerg Schweizer**, WSL Institute for Snow and Avalanche Research
- **Karl Birkeland,** USFS National Avalanche Center

Each individual lecture and panel session was very thought provoking as well as informative. Without paraphrasing each talk I will focus on one noteworthy topic or theme from each session. In the morning session, Billi Nalli (UDOT forecaster) brought up an interesting point of conducting highway avalanche control efforts with the potential of backcountry users already in the areas of concern before UDOT had performed its necessary road avalanche hazard mitigation work. With the advent of powerful and long lasting headlamps coupled with an almost over use of the backcountry, intrepid BC users are starting their backcountry tours well before sunup (dawn patrol) and the necessary closing of the roads. UDOT's window to perform their work is shrinking and the risk of causing a slide in occupied areas may cancel a day's mitigation. By having to postpone or cancel a mission vital to highway safety for users and the economic concerns if the road is not open, the issue has many facets (no pun intended). The problem is amplifying for many highway programs across the west and new statutes (unpopular for sure) may have to be written to close access to backcountry areas adjacent to county and state highway hazard mitigation operations.

During the afternoon session, W. Tad Pfeffer had about the most controversial topic and statement of the workshop as he professed that "winter as we know it has changed!" With the advent of climatic change research identifying a general warming of the earth's atmosphere, the weather patterns are showing a significant transformation. The rain/snow elevation line is grad-

Morning panel discussion at CSAW: L to R Grant Statham, Will Barrett, Cale Osborne, Bill Nalli, and Henry Munter. *Photo Bill Cotton*

ually rising. Since the early 2000s it has become more frequent to see rain up to the resort base areas and even mountain tops in western United States, Canada, and Europe. This is having a negative influence on the snowpack stability as rain on dry snow is not a good mix. Buried rain crust becomes quite an impendence layer for vapor transfer during the temperature gradient process forming weak facet layers above and below crust. This buried rain crust can also become a great bed surface for slab avalanches. This author suggested that perhaps we may need to rethink our classical boundaries and characteristics of maritime, inter-mountain, and continental snowpack/weather regimes. Our collective mindset on how to mitigate avalanche hazard may have to evolve with the changing climate.

One of Pfeffer's conclusions also was a bit alarming as the rain/snow elevation line may become higher than the current ski resort base elevation. This has been noted in Europe already but resorts like Aspen, Colorado, and areas in Montana and Idaho are seeing a much later start to their season and earlier spring closures as skiing to the base is difficult. Downloading lifts is becoming a standard of resort operation for certain lower elevation resorts. As time goes on resort operations may have to change with climate change. The bright spot in this research was that Summit County, Colorado where I live, might weather (again no pun intended) the rising of the rain/snow line well as its elevation is above the projected elevation change. Guess I have a few more years of turning to the base area!!

All and all this was a very well attended and interesting CSAW. The change in format went well and will probably be seen again in the future. Bravo CAIC for a great day, and thanks to BCA for sponsoring the post-event happy hour kegger.

Dan Moroz was one of the fortunate ones whose mentors were Ron Perla, Rod Newcomb Ed LaChapelle, Onno Weiringa, Liam Fitzgerald etc. in his youth. His first avi course was from Rod in 1977. Rod showed up in Leadville in an old pickup with a camper top, a roll of det cord, kinestick in a lock box, and some chalk and flip paper boards with magic markers. This started Dan on a long career (having just turned 64, he can officially call himself a dinosaur). Dan can say with experience "Remember in the old days when the continental snowpack was cold: 65% facets, 30% wind slab, and 5% something else!"

WYSAW: Wyoming Snow and Avalanche Workshop

BY DON CARPENTER

WYSAW 2016 was a very worthwhile day indeed! The main focus of the morning was on human factors.

Here are highlights from a few of the talks that stuck with me:

Blase Reardon: Blase spoke of uncertainty in the snow and avalanche world. It is an environment where we often do not know the probabilities of something going wrong. There is a huge amount of information, and few definitive clues as to whether or not a slope is stable. And, to make the situation more challenging, being wrong can often feel right… ie. we ski a slope that was dangerously close to avalanching, but doesn't avalanche. We may never know how lucky we got, and it just felt like great powder skiing. This pattern and lack of good feedback can reinforce bad habits.

Blase referenced a personal story from early in his backcountry ski career in which he was wrong in his assessment and got good direct feedback. The senior guide was taking them on a circuitous route to avoid slopes above them. Blase was frustrated that they were not traveling more directly to their intended destination. Just as he was about to speak up and complain about the wide detour, the slope avalanched, and crossed over his intended, more direct route.

Blase talked about the fact that we cannot process every observation or piece of information around us in the backcountry. We need to simplify by using a "limited search" and focus on the most important data. If we have recent avalanches or collapsing in the snowpack, we don't need all the other data. Our decision should be easy. This is called "satisficing"—limiting your search and focusing on the most important information.

Blase closed with five points for a long life of traveling in the backcountry:

1. Rely on rules, ritual, and checklists. Simplicity works. If you are going to break a rule, break one at a time.
2. Don't ride solo, or not often. There is no back-up and no partner to call you out on a bad decision.
3. Keep learning—which is a form of humility.

4. Don't try to outsmart the danger— we don't really know the odds/ probabilities.
5. Play not to lose. Satisfice, focus on the important information.

Roger Atkins: Roger is a longtime heli-ski guide in Canada and has offered some great insights on the human mind and influences on decision-making in avalanche terrain.

Roger referenced two questions by a ski client early in his career that he still thinks about 25 years later. After a ski run that he deemed an aggressive terrain choice for the day, a female client asked, *"How did you know it was safe to ski there?"*

Later that same day they skied through an aspen forest. Roger swatted some aspen branches out of the way and steered clear of other branches that would have knocked him over like a baseball bat. The client asked him, *"How did you know which branches to break and which to avoid?"*

He used these questions as a springboard into how we gather and interpret information and how our mind stores and uses that information. The first question referred to choosing to ski a slope in which timely feedback is rare. In the aspen scenario, feedback was ongoing.

He drew a distinction between the conscious and unconscious brain. We can overestimate how much our conscious/rational mind is in control. In reality, our decisions are often influenced by our subconscious brain. The subconscious brain is heavily influenced by emotion.

Roger then spoke of his development of strategic mindsets, which is part of the morning guide team meeting at his heli operation.

When the avalanche danger rises, it is rational to adjust the objectives and choose safer terrain. But, Roger argues we need to go deeper and adjust our desires to fit the conditions. This is a change in mindset. When we change our mindset, we change the way we see the world. Roger and his team have a spectrum of "strategic mindsets" that they choose each morning to help them dictate their desires and objectives for the day.

Roger closed with these take-home points:

- Get out a lot
- Look in the snow
- Seek mentorship
- Think subjectively. Not, *"what is the exact amount of snow?"* But, *"did we get a lot or a little snow?"*
- Be aware of avalanche character
- Expand your selection of desires
- Use strategic mindsets

Iain Stewart-Patterson: Iain has written about the challenge of developing expertise in an environment with inconsistent feedback and high consequences. Feedback allows us to react and modify our decision making. In the avalanche world, lack of feedback can fool us into thinking we are making good decisions. This can be a dangerous trap. This lack of an incident, when in fact it was a bad decision, is known as the illusion of validity.

Iain referred to a near miss as a gift. It is direct feedback, which is rare. Direct feedback allows us to learn, adjust our decision-making, and potentially avoid an accident with high consequences.

Conclusion: An emphasis on human factors and decision-making was a continuation of highlights from this year's ISSW in Breckenridge, CO. There were two references at WYSAW to an ISSW paper by Russell Costa from Westminster College in SLC. He researched the top selling avalanche reference books and determined that an overwhelming part of the content was on snow science with much less focus on decision-making. An "ah ha" moment for me was the revelation that snow science expertise and decision-making expertise are two different skills. They develop at different rates and are not necessarily directly connected. It is an important distinction for all of us to be aware of, as decision-making skill is what will ultimately keep us safe.

Don Carpenter is a guide, outdoor educator, and co-owner of the American Avalanche Institute. He has been guiding and teaching in the mountains since 1998 and an owner of AAI since 2009. Developing curriculum and running avalanche courses for novices and professionals has proven fascinating and challenging. His winters are busy with logistics and avalanche courses at AAI and ski guiding. Spring, summer, and fall find him guiding, running rivers, packrafting, and chasing elk. Don and his wife Sarah live in a strawbale home they built on the westslope of the Tetons.

WYSAW EDITOR'S NOTE

From your editor, who was also on the WYSAW steering committee (as well as the MC for the event):

In addition to the three human-factors presenters noted by Don Carpenter to the side, we welcomed a stellar list of speakers whose work you can find in TAR. Thanks for your insights to **Doug Krause** on Operational Awareness (*TAR 34.2*), **Matt Schonwald** of the AAA on the Pro/ Rec education tracks (*ongoing in TAR*), **Don Sharaf** with his ISSW highlights (*TAR 35.2*), **Ned Bair** on the role of collapse in avalanche release (*TAR 34.3 and 35.3*), **Bob Comey** with the BTNF season in review, and **Emery Rheam** on Teenagers in the Backcountry (*TAR 35.2*). TAR looks forward to future articles from other speakers: **Drew Hardesty** on Shame, **Elizabeth Lamphere** with her powerful personal story from the Sheep Creek avalanche in 2013, and a panel revolving around the current and potential power of the media in reporting on avalanche incidents.

ESAW: Eastern Snow and Avalanche Workshop

BY JONATHAN S. SHEFFTZ

The sixth annual Eastern Snow & Avalanche Workshop ("ESAW") on November 5 attracted approximately 150 attendees at Fryeburg Academy, just across the state border from New Hampshire's Mount Washington in the White Mountains' Presidential Range.

Former MWAC Lead Snow Ranger Chris Joosen kicks off the sixth annual ESAW. *Photo David Lottman*

This year's ESAW was, as always, a collaborative effort. The organizing partners included the Snow Rangers of the USFS Mount Washington Avalanche Center ("MWAC") and the Mount Washington Volunteer Ski Patrol ("MWVSP"). ESAW once again relied on a grant from our lead sponsor the American Avalanche Association (AAA), to be led here soon by Eastern Representative-elect Mark Renson, with your faithful correspondent as AAA Member Representative. Additional support came from our headline industry sponsor Outdoor Research. Registration fee proceeds over and above hosting costs benefited the White Mountain Avalanche Education Fund, which provides avalanche education to youth of the Northeast.

ESAW kicked off the prior Friday evening with a social event hosted by the Friends of MWAC and fueled by Moat Mountain Smokehouse & Brewing at the International Mountain Equipment shop and guide service. Then Saturday morning the avalanche presentations started up at Fryeburg Academy.

Chris Joosen, MWAC former Lead Snow Ranger (only the third since its 1951 formation) and outgoing AAA Eastern Representative, flew back east from his new Oregon home to serve yet again as our MC. Also flying out east was our first presenter, **Simon Trautman** of the National Avalanche Center (NAC), who introduced us to *Avalanche Danger Scales and How Forecasters Use Them* including data to compare/contrast ratings distributions across the forecast centers of different nations.

We then retreated well below treeline as **Tyler Ray** of the newly formed Granite Backcountry Alliance (i.e., for the "Granite State" of New Hampshire) joined MWAC Snow Ranger **Helon Hoffer** for *Backcountry Skiing on Public Lands: The Creation of Legitimate and Sustainable Glades*. Although New England backcountry skiing guidebooks reference only official ski trails (many cut by the famed Civilian Conservation Corps during the Great Depression) plus the avalanche terrain at and above treeline, much of the backcountry skiing here actually takes place on the down low: glades illicitly cut on public lands for forest fire prevention and other in-the-know euphemisms. This was brought into the open in 2007 when two would-be Vermont backcountry skiers were criminally charged with felony-level violations for chainsawing a prominent line (aka Jailhouse Chute). But recent collaboration in Vermont with the USFS between non-profit groups has

created glades that are both nicely skiable and legitimately accessible. The increasing availability of such terrain can offer a safe alternative to skiing at and above treeline when avalanche danger is elevated. And fortuitously for the Granite Backcountry Alliance, the off-season position for Snow Ranger Hoffer is as the USFS Trails Manager for much of the Presidentials Range.

Next, AAA's Executive Director **Jaime Musnicki** returned to her native Northeast to make good on her plan to attend as many regional SAWs as possible, and also to present on *Personal Reflections: Making Sense of Our Own Close Calls in Avalanche Terrain*. As if the incident she described in detail weren't already harrowing enough, her partner had been her new boyfriend at the time, out on their first ski tour together. And not only did Jaime come out on top of the debris, four years later the two of them are still together.

On a similar note, **Jon Miller**, of Dogy Down Films, although unable to attend in person, presented to us on *Risk, Rewards, and the Balancing of Mountain Experiences and Goals* via a tailored video introduction and debriefing for us to sandwich his film *Season on the Brink*. His life-threatening fall this past spring in a Mount Washington couloir was extensively written up at the time, but the video footage he showed us—from both a partner and his own helmet cam—was especially terrifying. Just as memorable were the assessments from the party members of "*What really sticks with me is that we just shouldn't have been there*" and "*A series of little details and little errors that added up.*" After a helicopter airlift, Jon spent a month in hospital care before regaining the ability to talk and walk normally.

Dallas Glass, our fourth Western presenter of the morning, here to lead the avalanche instructor training the following day for the American Avalanche Institute for Research and Education (AIARE), presented on *Blue Skies, Powder Days, and Las Vegas: Minimizing the Role of Luck in Avalanche Terrain*. For ESAW regulars over the years, Dallas's presentation was the perfect follow-up to the 2012 presentation to us by Blase Reardon (then of the Sawtooth Avalanche Center, and now of the Colorado Avalanche Information Center). Back then, Blase had emphasized that the backcountry snowpack does not provide a consistent environment with regular feedback, but rather its feedback is inconsistent and often fatal. (Remember Bruce Tremper's analogy of playing soccer in a mine field?) "Experts" are often just those who have gotten lucky over time, like many stock pickers who have beaten the market over a selected time period. This year, Dallas explained how debriefing your day is the feedback loop that completes the risk management process. Professional guides always hold a debriefing as part of their standard operating procedures. To help recreationalists aspire toward this goal, Dallas quoted an incentivizing line from his fellow Pacific Northwest guide Larry Goldie: "Why having a beer at the end of the day could save your life." It (the debriefing, not necessarily the alcoholic content!) allows us to identify when we got lucky and thereby recalibrate, so that on future trips we aren't relying on "luck" to stay safe. We have all gotten lucky in the mountains, but we need to recognize when that occurs so that we don't need an incident to provide us feedback, and instead we can use "no event" days to learn from and grow as backcounty travelers.

After lunch, **Jaime Musnicki** explained the upcoming split between recreational versus professional tracks in U.S. avalanche training. Fortunately the details need not be reiterated here, since you, the dear reader, have of course already carefully read every single prior TAR article on this subject. (Right?) This fed into a panel discussion on avalanche education with Jaime Musnicki, Jeff Lane (previously a MWAC Snow Ranger for ten years), Simon Trautman, and Dallas Glass, moderated by MWAC Snow Ranger Frank Carus.

Thus far we had been getting off lightly on the technical side. To ratchet everything up several notches, we can always rely on **Dr. Sam Colbeck,** retired from the U.S. Army's Cold Region Research and Engineering Laboratory (in Hanover, NH) after three decades of groundbreaking cold lab and field research in snow crystal bonding and wet grain relationships. In his fifth year of ESAW presentations, this time Sam explained *Why Skis Slide on Snow.* The answer is not simply "because it's fun" since that's why we use skis to slide on snow, as opposed to why they are actually able to slide so well.

And those skis slide especially well on very steep terrain with lots of blown-in snow, which was the focus of the presentation by **Frank Carus** on *Forecasting Avalanche Danger in Inherently Dangerous Terrain*, regarding the couloirs in the at-treeline glacial cirques on our Mount Washington. Next, **Simon Trautman** presented on *What are we doing now at the NAC?* following up on the presentation at the 2014 ESAW by the NAC's Director Karl Birkeland.

And finally, **Chris Joosen** wrapped up with *Reflecting on a Life with Avalanches*, reviewing his 26 years working on Mount Washington. His conclusion was followed by a standing ovation from all attendees. And from all us who have depended for so many years on Chris's work and his direction of the MWAC Snow Rangers, thank you!

We concluded with our annual expo, including rep displays for AAA, AIARE, Backcountry Access, Black Diamond / Pieps, Catamount Trail Association, Bryce & Ronnie Athlete Safety & Security ("BRASS") Foundation, DPS Skis, Friends of MWAC, Granite Backcountry Alliance, La Sportiva, Maine Adaptive Sports & Recreation, Mammut / Barryvox, MWVSP, Mount Washington Weather Observatory, Petzl & Adventure Medical, Salomon, Northeast Mountaineering guides, Ortovox / Deuter, and Outdoor Research. Throughout the day we had raffled off and auctioned donations from these sponsors plus ARVA, Dynafit, Hagan, MSR, Pomoca, Ski the East, and Toko.

Jonathan Shefftz patrols at Northfield Mountain and Mount Greylock in Western Massachusetts, where he lives with his wife and daughter (who notched her first-ever October ski outing this season). He is an AIARE-qualified instructor, NSP avalanche instructor, and AAA governing board member. When he is not searching out elusive freshies in Southern New England or "coaching" his daughter's skiing (i.e., picking her up off the snow), he works as a financial economics consultant and has been qualified as an expert witness in state and federal courts. He can be reached at JShefftz@post.harvard.edu or just look for the lycra-clad skinner training for his NE Rando Race Series.

SAAW: Southcentral Alaska Avalanche Workshop (and bonus off shoot!)

BY ALEPH JOHNSTON-BLOOM

The 4th annual SAAW brought regional avalanche professionals together for a day of continuing education and networking with a unique twist. For the first time the afternoon session was open to the public, modeling after events like USAW and NSAW. The morning session had 120 professional participants and by the afternoon at least 200 snow enthusiasts filled the room. Both sessions had a packed agenda ranging from Alyeska Snow Safety Director **Scott Hilliard**'s perspective on the unusual glide avalanche cycle last winter to an overview of the Teton Gravity Research safety program by Mountain Safety Logistics owner **Kent Scheler** to **Conrad Chapman** talking about historical avalanche accidents in the Eastern Alaskan Range and efforts to start a backcountry forecast program there.

It's important to note that Alaskan avalanche professionals always have a long way to travel for ISSW (except for 2012!) and many professionals don't get the opportunity to attend. Having this regional workshop is a really valuable way to keep the local avalanche community abreast of current discussions and research and the organizing committee works hard to have it be modeled on merging theory and practice. Subsequently, **Eeva Latosuo**'s ISSW Highlights Talk was mentioned by many as a "highlight" of this year's SAAW.

Our guest star/speaker Utah Avalanche Center avalanche forecaster **Drew Hardesty** traveled up for the weekend to share his wisdom and philosophy with the local audience. His two talks *Expert Intuition, Uncertainty and Pattern Recognition* and *Freedom and Anarchy in the Backcountry* were thought provoking and very well received. After his Freedom and Anarchy talk in the afternoon Drew engaged the audience in a discussion about the state of the South-central AK backcountry. It generated some thoughtful audience comments and may have spurred some safety culture awareness and change.

Guest speaker UAC Forecaster Drew Hardesty engages the crowd.
Photo Heather Thamm

The next morning a local sledder who attended SAAW posted this comment on an Alaska snowmachine Facebook group forum.

David Harris
19 hrs

I spent the day at APU for the Southcentral Alaska Avalanche Workshop, it wasn't an avalanche awareness class, it was a gathering of snow professionals for a day of learning, presentation, discussion, and networking. I really enjoyed the presentations from Eeva Latosuo from APU & the AK Avalanche School about the impact of and the importance of social media in the backcountry snow environment. She talked about how millennials use social media to communicate and share experiences. I related it to how I and the guys I ride with use it to discuss snow conditions, weather, riding areas and avy risks.

There was also a presentation from Drew Hardesty from the Utah Avalanche Center where he talked about the Skiers Responsibility Code. For those of you that ski at Alyeska you've probably seen this printed on your lift ticket. It's a list of seven points to your responsibility code for using the mountain. These are the seven codes:

1. Always stay in control, and be able to stop or avoid other people or objects.
2. People ahead of you have the right of way. It is your responsibility to avoid them.
3. You must not stop where you obstruct a trail, or are not visible from above.
4. Whenever starting downhill or merging into a trail, look uphill and yield to others.
5. Always use devices to help prevent runaway equipment.
6. Observe all posted signs and warnings. Keep off closed trails and out of closed areas.
7. Prior to using any lift, you must have the knowledge and ability to load, ride and unload safely.

This got me to thinking about the "code" the guys I ride with use, we are pretty tight and don't usually ride with people we don't know or trust because they don't know the code and can potentially put us at risk in the mountains. Our circle of riders have all had avy training, both classroom and in the field training, many of us came from a skiing background and had previous training and experience. We never ride above one another, don't all ride on the same slope at once, don't go up to help another sledder get unstuck from an exposed slope, we wear our tethers, carry beacons, avy rescue equipment and wear avy bags. We spot each other, don't lose sight of each other and communicate with each other- it may just be eye contact, a hand gesture or an on mountain discussion.

So why don't we have a rider's code of responsibility? Because we've all been high marked over by another rider, had someone cut above us while we're on an avy prone slope, seen a sled ghost ride down a mountain because the rider didn't have their tether attached, etc... Weekends at Turnagain can get pretty crowded and downright crazy sometimes.

So what's everyone's thought on this? Should we come up with a code of responsibility for sledders? Not everyone out on the mountain has had training, mentoring or the same experience some of us have. What are some of the Points to our Responsibility Code we should use? Friends of the Chugach National Forest Avalanche Information Center Alaska Mining and Diving - AMOS

The Mountain Sledders Responsibility Code (DRAFT)
1. Don't ride above another rider
2. No more than one at a time on avalanche prone slopes
3. Don't assist a stuck rider on an avalanche prone slope
4. Spot one another on high risk climbs/descents
5. Pack out what you packed in (don't litter)
6. ?
7. ?

David Harris was born and raised in Anchorage, grew up alpine skiing, started riding snowmachines in 1999, raced the Iron Dog 3 times, enjoys mountain riding with friends in the backcountry and has a following in the social media world from many years a moderator for a popular snowmachine site called dootalk.com. His post generated many comments from the Alaskan snowmachine community and prompted the CNFAIC to host a safety discussion at a local snowmachine shop, Alaska Mining and Diving Supply that drew a crowd of over 120 people. This also was the impetus for CNFAIC forecaster **Graham Predeger** to write an article in the December *SnowRider* magazine on the topic, *A Mountain Rider's Responsibility Code*.

Freedom and anarchy in the backcountry…. This was the title of a recent talk given at the 4th annual Southcentral Alaska Avalanche Workshop (SAAW) that spawned some great discussion and later conversations within our community.

I've heard it echoed over the years that some people will not ride many of the busier zones such as Turnagain Pass because of the illusion of 'anarchy in the backcountry'. This idea that there are too many riders with little or no respect for the mountains let alone the safety of their fellow riders around them. I have seen this on occasion but I also recognize the Alaska snowmachining community as one of the most kind and generous user groups in the mountains. Time and again strangers will come together to search for a missing rider, lend a tool or a gallon of fuel to get back to the trailhead, even throw caution into the wind to ride straight back into a winter storm to recover one of their own after tragedy strikes in the backcountry. Consistently, I've seen this thoughtfulness and charity from our community, more so than any other group of outdoor users!

So, when I see a lone snowmachine high marking above a stuck sled or side hilling across a steep avalanche-prone slope where a photographer is setting up for a shot, I don't think this is a malicious act. I think these riders are uneducated in what I'll refer to as the "Mountain Riders Responsibility Code," the unwritten code that many savvy and seasoned backcountry users simply adopt within their group of friends and riding partners to ensure they make it back to the parking lot everyday.

Mountain Riders Responsibility Code (DRAFT)

1. Always wear and know how to use your avalanche rescue gear.
2. Be aware of changing snow and weather conditions.
3. Ride one at a time in avalanche terrain (slopes > 30 degrees).
4. Don't expect help if stuck in avalanche terrain. Refer to #3 above.
5. Utilize true "safe zones" to spot fellow riders in avalanche terrain.
6. Do not park in avalanche run out zones or block major trails.
7. Communicate intentions within your group and adjacent groups if appropriate.
8. Always wear your tether cord.
9. Leave tracks, not trash. Pack it in, pack it out.

As avalanche professionals up here in AK we have been working hard to try to spread a safety message to the snowmachine community and it's ex-

citing that one guy listening to a day of conversation about safety culture, mentorship, and responsibility started a shift that may ultimately save some lives. This unexpected result is just another reason that we are so thankful that the American Avalanche Association has chosen to support small workshops in remote places like Alaska!

Aleph Johnston-Bloom is an avalanche specialist for the Chugach National Forest Avalanche Information Center in Girdwood Alaska. Over the past 16 years she has garnered experience as a highway avalanche forecaster, a backcountry avalanche forecaster, a patroller and a ski guide. She is an American Avalanche Association Certified Instructor, Professional Member and Co-Chair of the Ethics Chair on the Governing Board.

CAW: California Avalanche Workshop

BY DAVE REICHEL

For the second year in a row the California Avalanche Workshop took place during a rain-soaked weekend. Canceled climbing and mountain biking plans are a bummer but very helpful for indoor seminar attendance. Ironically, a wildfire near Emerald Bay and the ensuing landslides added time to the morning commute around Lake Tahoe for many. Sacrificing saddle time or a day of rocktober was rewarded with strong presentations.

Local pro-skier **Hazel Birnbaum** started us off by recounting a close call during a Freeride World Tour competition run. Aided by alarming POV footage of a slide taking her out during her run, Hazel shared her thoughts on what went wrong. Additional television style footage featuring snarky "play by play" commentary while Hazel was tumbled in the slide brought out the real tensions in competitive skiing in a big mountain environment. Speaking candidly, Hazel discussed differences between competition versus non-competition skiing. Hazel closed her talk with photos of fellow FWT competitors, Estelle Balet and Matilda Rapaport, who passed away in avalanches in April and July. Several local ski team representatives expressed interest in having Hazel address their kids.

Steve Reynaud, Forecaster with the Tahoe National Forest Sierra Avalanche Center, provided a seasonal snow review. Despite a strong El Niño, the 2015-2016 season was most notable for smaller, colder early season storms that buried multiple surface hoar layers. Steve discussed how these layers formed and survived burial. One of these PWLs likely played a role in the Tahoe region's lone avalanche death of the season. This skier was solo and not carrying a beacon when caught, and likely trying to sneak in some powder before ducking back in bounds.

Nate Greenberg, President of the Eastern Sierra Avalanche Center, provided a great update on the significant changes at ESAC. After ending its relationship with the Forest Service, ESAC is experimenting with the flexibility it now enjoys, benefiting from community support while it works towards providing the best services possible. Nate is also the co-author of the guidebook *Backcountry Skiing California's Eastern Sierra*. He shared current work to offer this guide in a mobile friendly package that incorporates the advisory and facilitates appropriate terrain selection tailored to current conditions. (See page 22 in this TAR for more information on this app.)

After traveling the furthest distance to attend, AAA Professional Training Coordinator **Matt Schonwald** presented the latest on upcoming changes to professional avalanche training in the U.S. There were a few questions from professionals in attendance about how these changes might impact the cost of training and what these changes meant for previously taken courses.

Sharing a few greatest hits from the 2016 International Snow Science Workshop in Breckenridge were Tahoe National Forest Sierra Avalanche Center Forecasters **Brandon Schwartz** and **Andy Anderson**. Brandon shared his take on Todd Guyn's talk *10 Common Missteps of Avalanche Practitioners*. Andy zoomed through several different talks, including a summary of fracture mechanics and implications for practitioners, using time lapse video to monitor avalanche terrain, social media in the backcountry, learning from incidents, and rescue at Cherry Bowl. Their talks produced quality dialogue after the formal presentations.

Adding some Andean variety to the day, **Alex Taran** shared her experiences as founder of the South American Beacon Project, where she promotes avalanche education in Chile and Argentina. It was interesting to learn about different cultural customs regarding acknowledging/denying avalanches. The South American Beacon Project is addressing the challenge faced by South American avy professionals working in avalanche terrain but not provided with appropriate equipment.

Cody Townsend wrapped up the day discussing how he applied the theory of Normalization of Deviance to his travels in the mountains. Using beautiful photos and video, Cody showed his crew backing off from a tempting objective due to rapidly warming conditions. It was an ambiguous decision; Cody explained how if they had pushed it and then gotten away with it, they'd be more likely to support future deviations from best practices. Within inherently dangerous activities, such deviance is highly problematic.

The American Avalanche Association and the Nickolay Dodov Foundation provided significant financial support for the workshop. The Sierra Avalanche Center lent very helpful marketing outreach. The California Avalanche Workshop completely sold out the venue this year; we'll need to search out a larger space for the future. This year's success also left us with a surprise financial excess which we chose to dedicate to a scholarship for a woman to attend an AIARE Course Leader Training in Tahoe.

Audience member Anthony Rabinowitz has a question during this year's CAW.
Photo Matt Bombino

As soon as possible after college, **David Reichel** moved to the mountains. He took his first avalanche course that winter in the Rockies, and he's been exploring snow covered peaks ever since. Based in the Sierra, he has taught a bazillion AIARE courses, guided and splitboarded around Tahoe, the Cascades, and South America. In 2014, he founded the California Avalanche Workshop.

NSAW: Northwest Snow and Avalanche Workshop

BY FOREST MCBRIAN

After two years at the University of Washington's Hub building, where NSAW took on the academic and progressive feel that permeates the campus, the Northwest Avalanche Center took a chance and changed venue. Seattle Town Hall is a 1930s Christian Science church repurposed as a cultural event center. For the bleary-eyed avalanche professionals who turned out at 7am on an October Sunday, the Roman Revival church must have offered an odd sequel to the dark, leaf-strewn mountain highways of the Cascades. It's the least church-going big city in the nation, but the mountain people here are spirited, if not spiritual, in their pursuit of mountain wisdom.

NSAW began at such an early hour this year in order to make time for a new offering–a panel discussion among avalanche professionals. The audience was, in theory, entirely composed of people who work in and around avalanche terrain. **Margaret Wheeler**—mountain guide, educator, and pillar of the Northwest avalanche community—skillfully moderated the discussion.

Our panelists were chosen for their experience, insight, and diverse backgrounds: **Larry Goldie** guides touring and helicopter skiing in the North Cascades; **Sarah Carpenter** crafts avalanche curriculum at the American Avalanche Institute and ski guides in the Tetons; **John Stimberis** tries to keep I-90 mostly open in the Cascadian winter (when he isn't presiding over the AAA); **Angela Seidling** wrangles anfo and printer ink as Assistant Snow Safety Director at Stevens Pass Ski Area; **Colin Zacharias** helps operations manage uncertainty by helping them build good systems and

training their employees; and **Simon Trautman** is an avalanche specialist at the USFS National Avalanche Center.

NWAC Executive Director **Scott Schell** dreamed up the Professional Panel while watching discussion after discussion at ISSW. In order to optimize the experience (for everyone), we provided structure by assigning the participants some preparatory questions on sub-topics. The result was a very coherent, engaging conversation around workplace safety. As an avalanche center, we feel this event spoke directly to our core mission by critically addressing the decision-making and risk management of those most at risk. We're looking forward to expanding our professional offerings at the next NSAW, even while we ponder how best to unite the broader avalanche community and meet its need for new ideas, community, and fun.

Our general session, which began at a more reasonable hour, took place in the Great Hall with its dark wood pews and forest-like lighting. A good balance of scientific research, reflection, and practitioner perspective made for an engrossing time. All of these presentations–including the professional panel–can be viewed in high quality video on the NWAC YouTube channel.

Highlights of the general session included:

- **Jeff Deems** from the National Snow and Ice Data center shared his work mapping snowpack at Arapahoe Basin using lidar. His three-dimensional fly-throughs had the audience captivated. You could easily make out individual bomb craters, and see the subtle growth of wind slabs on cross-loaded ribs. Futuristic is a word that comes to mind.
- **Sarah Carpenter** shared the evolution and application of her backcountry checklist, a tool for ensuring that a robust and thorough decision-making process prevails over ambition and endorphins.
- **Colin Zacharias** presented some distilled wisdom in his presentation Keep it Simple and Come Home Alive, illuminating the need to respect bigger sources of uncertainty and the pitfalls of trying to address them with unrepresentative, poor quality, or unverified data.
- **Matt Schonwald** updated the audience on the evolution of the avalanche education framework at the AAA, and especially on the nuances of the professional track.
- The NWAC forecaster team, represented by **Kenny Kramer** and **Dennis D'Amico**, fielded questions on the weather and avalanche forecasting program, and especially on our forthcoming data visualization project.
- **Jeff Campbell**, a PhD student at the University of Washington, presented his fascinating research into ski binding release. Everyone was glued to the stage, and the upshots are worth considering for ANYONE who skis. Check out his presentation on our YouTube channel.

In my new role as Education and Operations Manager, I am grateful to be a part of an organization so engaged in change and so willing to experiment with new programs and educational products. NWAC is a community supported safety resource for anyone who travels in the Cascade and Olympic mountains in the winter time. That broader mission–supporting a deeply held community value–makes for a unique and metropolitan avalanche workshop. I encourage TAR readers to experience it online, or better yet, plan to join us next year. ▲

As the Education and Operations Manager, **Forest McBrian** oversees a range of community education projects from free awareness talks across the region to our Going Deep lecture series for experienced backcountry users. He also directs the Professional Observer team. Forest has worked in mountain safety for 13 years and holds IFMGA certification as a mountain guide. His experience encompasses a variety of roles, including touring and heli ski guide in Alaska and Europe, pro ski patroller at Crystal Mountain, and co-author of Backcountry Ski and Snowboard Routes in Washington State from Mountaineers Books.

AVALANCHE TRANSCEIVERS—OUT WITH THE OLD, IN WITH THE NEW!

BY MAURA LONGDEN

Avalanche safety gear is changing rapidly as new technologies emerge and innovative designers tackle old problems. The American Avalanche Association recommends that avalanche professionals and winter recreationists retire old analog transceivers and upgrade to three-antenna digital transceivers.

Warning! Gain competency with your new transceiver BEFORE you rely on it in avalanche terrain! Understand its functions, capabilities and limitations. Inspect, maintain and practice often, with all of your avalanche safety gear, as if someone's life depends on it!

The AAA recommends that you upgrade your transceiver for any of the following reasons:

- **2.257 kHZ:** This is the old frequency that was replaced by 457 kHz in the 1980s. If you still have one of these museum pieces, put it on a shelf.
- **Dual frequency:** from the 1980s transition era, these transceivers transmit and receive on both 457 and 2.257, but they don't do either well. Get a modern transceiver.
- **Earphones:** if your transceiver requires you to stick something in your ear, get one with a speaker.
- **No visual display:** if you don't have modern visuals, it's time for a new transceiver.
- **Analog transceivers:** Most analog designs (characterized by any of the features listed above), have transmit frequency drift, causing weak and confusing signals when received by a modern digital transceiver. These older designs also often emit background noise between pulses, leading to false multiple-burial indications on modern digital transceivers. In a multi-burial scenario, transmit signals often overlap, regardless of the type of device used. It becomes a significantly bigger issue with old analog transceivers in the equation: analog transceivers emit fewer but longer transmit signals. This increases the probability and length of the overlapping signals, often leading to failed marking, flagging, and suppression functions on modern digital transceivers. Since analog transceivers emit fewer pulses, modern digital transceivers are more likely to find each other in a multiple burial than they are to find an older analog transceiver. That means if two people are buried close together, the one with the digital transceiver is likely to be isolated first. Bad news if it's you under the snow wearing the old analog transceiver!
- **Single- and dual-antenna transceivers.** Three-antenna transceivers simplify the fine search phase by eliminating disruptive "spikes" and "nulls" within the last few meters of the victim. This is especially important in deep burials. While dual-antenna units aren't obsolete, they're dated and don't provide the search precision of three-antenna units. Most manufacturers recommend upgrading to three-antenna transceivers for optimal search performance.

Most manufacturers require preventative maintenance every three years to ensure that a transceiver is functioning properly. This is important because frequency drift, a broken antenna, or a myriad of other problems can affect performance, causing the transceiver to fail.

If you need to upgrade, but finances are truly a concern, you might consider buying a used three-antenna digital transceiver, but buyer beware! Used transceivers could be damaged internally and are often out of warranty.

Several manufacturers are currently offering special pricing on a new transceiver if you turn in your old one. Contact your manufacturer directly.

If you plan to head into the backcountry, sidecountry, or in-area avalanche terrain, evaluate your equipment carefully. Are you really going to use that old transceiver again this year?

Even in simple scenarios, search times are faster with a digital unit, but only when used by a well-practiced searcher! ▲

Maura Longden is an AAA Board member and Co-Chair of the Search and Rescue Committee. Her background includes over 35 years as an NPS climbing and search and rescue ranger; wilderness manager; avalanche forecaster, educator and ski patroller; mountain guide and search dog handler. She is the former Avalanche Program Director and Forecaster for Yellowstone N.P. and also worked in snow safety programs in Yosemite and Glacier National Parks. Maura is an avid climber and adventurer and when she is not in the hills, she and her husband have their home basecamps in Victor, Idaho and Moose, Wyoming.

BATTERIES FOR BEACONS

BY DAVE FURMAN

One of the questions we get frequently is about which batteries to use in Pulse Barryvox and Element Barryvox beacons. Originally, Mammut recommended using Duracell Ultra batteries. We made this recommendation because those specific batteries were widely available globally, were of reasonably good quality and exhibited acid leakage less than others, and seemed to be consistent in battery life from lot to lot. However, several things have happened:

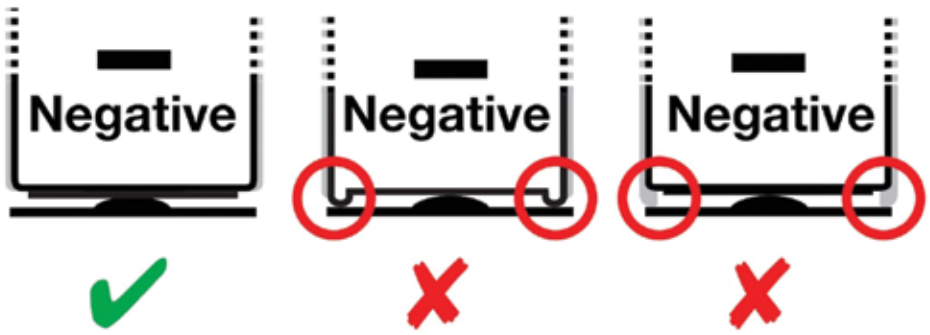


Fig 1This image shows 2 AAA LR03 alkaline batteries with different-shaped negative terminals

First, Duracell has since discontinued the Ultra, so many people contact us wondering what to use as a replacement; and second, the Pulse Barryvox, after one of the more recent firmware upgrades, is now capable of taking either Alkaline or Lithium batteries; and finally, there have been changes to the standards to which batteries are built, necessitating some adjustment.

Recommended Batteries

First, a note on why we recommended specific batteries. In addition to simply recommending what we felt was a higher-quality battery, Mammut uses a special battery contact so that under an impact the beacon never loses power. In an impact, the momentum of the battery against a normal spring-type contact can cause it to momentarily lose the electrical circuit and therefore lose power, having an potentially harmful effect on the search.

The flip-side of this coin is that the battery contacts are more sensitive to battery length and the shape of the terminals on the battery, so make sure to choose an appropriate battery SHAPE. On some AAA batteries, the negative terminal of the battery is recessed into the base of the battery or into the foil label the battery is wrapped in.

For the Pulse Barryvox we now recommend any high-quality LR03 Alkaline or LR91 Lithium AAA batteries AS LONG AS THE NEGATIVE TERMINAL OF THE BATTERY IS NOT RECESSED INTO THE WRAPPER OF THE BATTERY.

Lithium batteries have a much longer life (310 hours versus about 250) and eliminate the possibility of acid corrosion which can render a beacon unsafe to use. You can read more about alkaline vs lithium batteries at: www.mammutavalanchesafety.com/2012/12/alkaline-vs-lithium-batteries.html

The Element Barryvox cannot use Lithium batteries, so only high-quality LR03 Alkaline AAA batteries are recommended.

We define "high quality" as being a premium-level battery from one of the well-known companies such as Duracell or Energizer, as their consistency and quality is usually better than non-branded or house-branded batteries. We have not made specific model recommendations since these models change frequently.

General guidelines for batteries:

- The lower the remaining battery capacity, the higher the chance of a battery failure such as a sudden drop of voltage or reverse loading. When using alkaline batteries, the likelihood of acid leaking increases with decreasing battery life.
- When replacing batteries, always check that the contacts on the battery and on the device are not corroded and do not show signs of acid residue or battery leakage. If there is any sign of acid on the new battery, DO NOT use this cell and immediately check all batteries from the same purchase.
- ALWAYS remove alkaline batteries before longer-term storage, especially in humid environments or before shipping. It is better to leave Lithium cells in the beacon until they require replacement.
- Batteries that show a sudden drop of battery power in SEND mode or do not show 99% when they are first inserted should be immediately replaced. However, a major drop of remaining battery capacity may take place when the device is used for a prolonged duration in SEARCH mode, particularly in cold temperatures. ▲

Dave Furman is Mammut Hardgoods Category Manager.

RAKKUP

A new digital guidebook platform for improved terrain decision-making

BY NATE GREENBERG

In 2008 I set out to create a comprehensive and modern guidebook for California's Eastern Sierra Nevada. After several years of skiing in the range, I was awestruck by the quality of skiing, and overall ease of getting into 'real' mountains - quickly. I, together with Dan Mingori, gathered combined years of first-hand experience to write *Backcountry Skiing California's Eastern Sierra* (BSCES). In 2013, after five years of successful sales, we released the 2nd Edition with two goals:

1. Increase the terrain covered in the book
2. Implement a classification and iconography system to help users quickly look at terrain and make Go/No-Go decisions

As an avid backcountry skier and co-founder of the Eastern Sierra Avalanche Center, my interest in writing a ski guide was more than just publishing popular descents and promoting this region. Rather, I am keenly interested in helping people make better decisions and terrain choices in the backcountry. I hoped that by providing the community with a variety of descents, classified by relevant characteristics, it would afford people options that they may have previously overlooked. While the 2nd Edition made inroads in this area, I have always wanted to do something more.

It's worth noting that I'm a geek. My background is in Geographic Information Systems and today I serve as Director of Information Technology for Mono County & Town of Mammoth Lakes, CA. Bottom line—I spend a lot of time thinking about the intersection of information and technology, particularly as it relates to open data and geography. Since the day the first edition of BSCES was released, I have dreamed of taking the content digital and opening up a whole new way for users to interact with information.

In some ways, it is remarkable to me that in 2016, when there are more mobile devices in the world than personal computers, that the avalanche industry is still at its current technological level. While there is an ever-growing landscape of digital tools pointed at improving information dissemination and decision-making, for the most part we struggle to figure out the best (and unified) path forward. This is not to say that there aren't promising approaches out there—MountainHub for real-time data sharing and trip planning, AvyLab for data collection, and a litany of industry-driven mobile-friendly utilities to help us access avalanche center data.

About a year ago I was introduced to the small, Seattle-based app start-up, Rakkup. With a passion for climbing, the two partners at Rakkup set out a few years ago to transform the guidebook industry, and send it kicking and screaming into the digital world. Over the past 12 months, we have set out to rebuild their digital guidebook platform to accommodate winter backcountry

Filter panel

Descent list with characteristics

Descent details screen

Interactive map with GPS location

content. The result of that effort launched on December 1st, 2016 with Rakkup v20 for iOS and two guidebook titles – *Backcountry Skiing California's Eastern Sierra*, and *Teton Pass Descents* (authored by Jamie Weeks).

The catalyst for this project and moment defining my path forward came to me while visiting my wife in Boulder, CO last year. Being a Sierra skier, I am naturally terrified of skiing in the Rockies, while simultaneously being drawn to the impressive steep terrain of places like Rocky Mountain National Park. As a trained and responsible backcountry skier, the natural thing to do was to pick up Mark Kelly's guidebook and thumb through it, highlighting the obvious descents and making a short list for the weekend. The real challenge, however, came when I tried to apply the information coming out of the CAIC to the actual terrain that I wanted to go ski, and seeing if those nasty persistent weak layers lined up with my list.

It turns out this is a challenging pursuit, even with all the resources and technology we typically have access to. Despite pins dropped on interactive maps showing recent observations, and some of the best avalanche forecasting in the US, relating information coming from avalanche professionals to the real-world terrain that we want to ski is a real chore. Especially as an outsider. Sure, the forecast says "avoid north facing terrain above 10,000," but who in today's world ventures out randomly to seek out non-north facing terrain below 10k? We want a list of objectives (with directions and definitions) of where we can, and should go.

This experience, matched with a concern over the proliferation of apps promoting user generated content (like Powder Project), drove my objectives for the initial product launch of Rakkup v20:

- Establish a platform - that clearly displays content and provides users with interactivity - on which multiple guidebook titles could be authored
- Provide a set of search, sort, and filtering tools to help users quickly 'Red Light' terrain based on avalanche forecasts, and target terrain based on where the best skiing could be found
- Work offline, on USGS topo maps and aerial imagery with approach/descent lines overlaid alongside your current GPS location
- Display multiple photos with route lines, written descriptions, and other information that helps users find their way
- Leverage a business model that encourages and monetizes authoritative content development with easy to use authoring tools
- Begin a conversation around developing standards for how we classify and categorize backcountry terrain features relative to difficulty and hazard

We hope, and honestly believe, this app will change the way terrain selection is taught, while simultaneously empowering users with a digital medium where everyday conditions can be applied to make solid terrain choices. The app is currently available for iOS devices. As additional titles are written, and new perspectives added to the Rakkup team, we envision a long list of added features and functions. In the near term, we strive to develop the ability to consume data coming out of avalanche centers and other real-time data sources, contribute observations and conditions back to local centers, and effectively engage the community via social media.

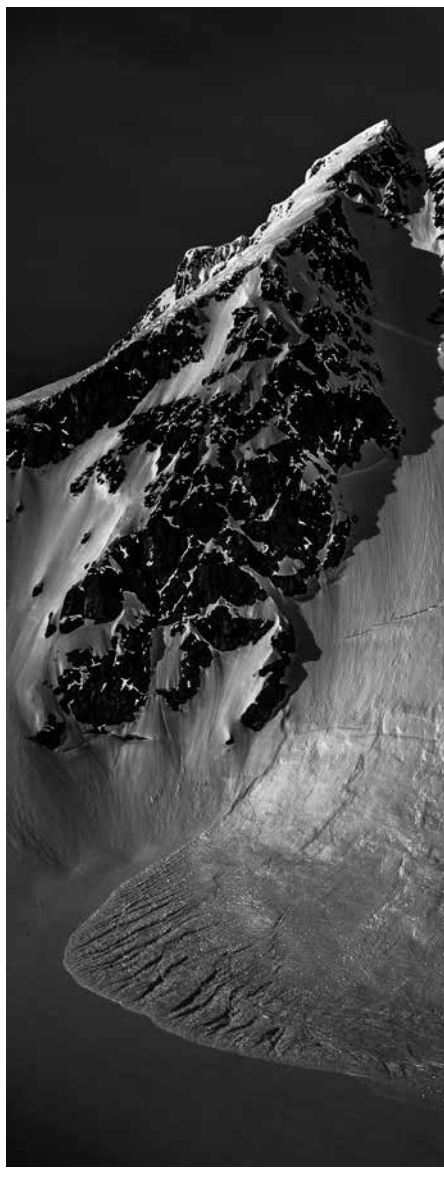
For more information contact Nate Greenberg (nate@rakkup.com) or visit www.rakkup.com. ▲

Photo of Nate at CAW by Matt Bombino

Nate Greenberg has called Mammoth Lakes, CA, home for the past 16 years. After a short stint competing in big mountain telemark, Nate took an AAA Level III avalanche course and turned his sights to the backcountry. He helped form the Eastern Sierra Avalanche Center in 2006 and today serves as its President.

AVALA

An exploration of avalanches from an aesthetic standpoint. Focused on the capture and exhibition of images of avalanches in action.

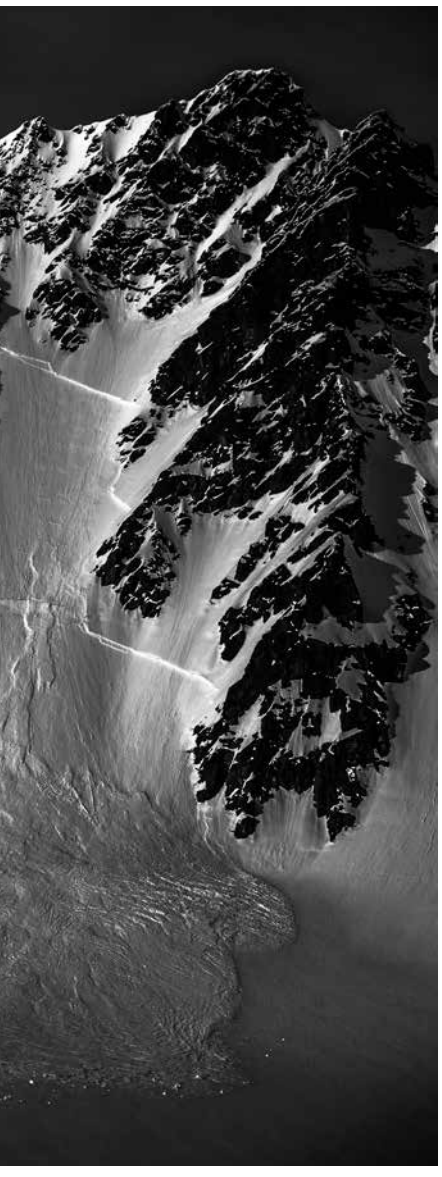


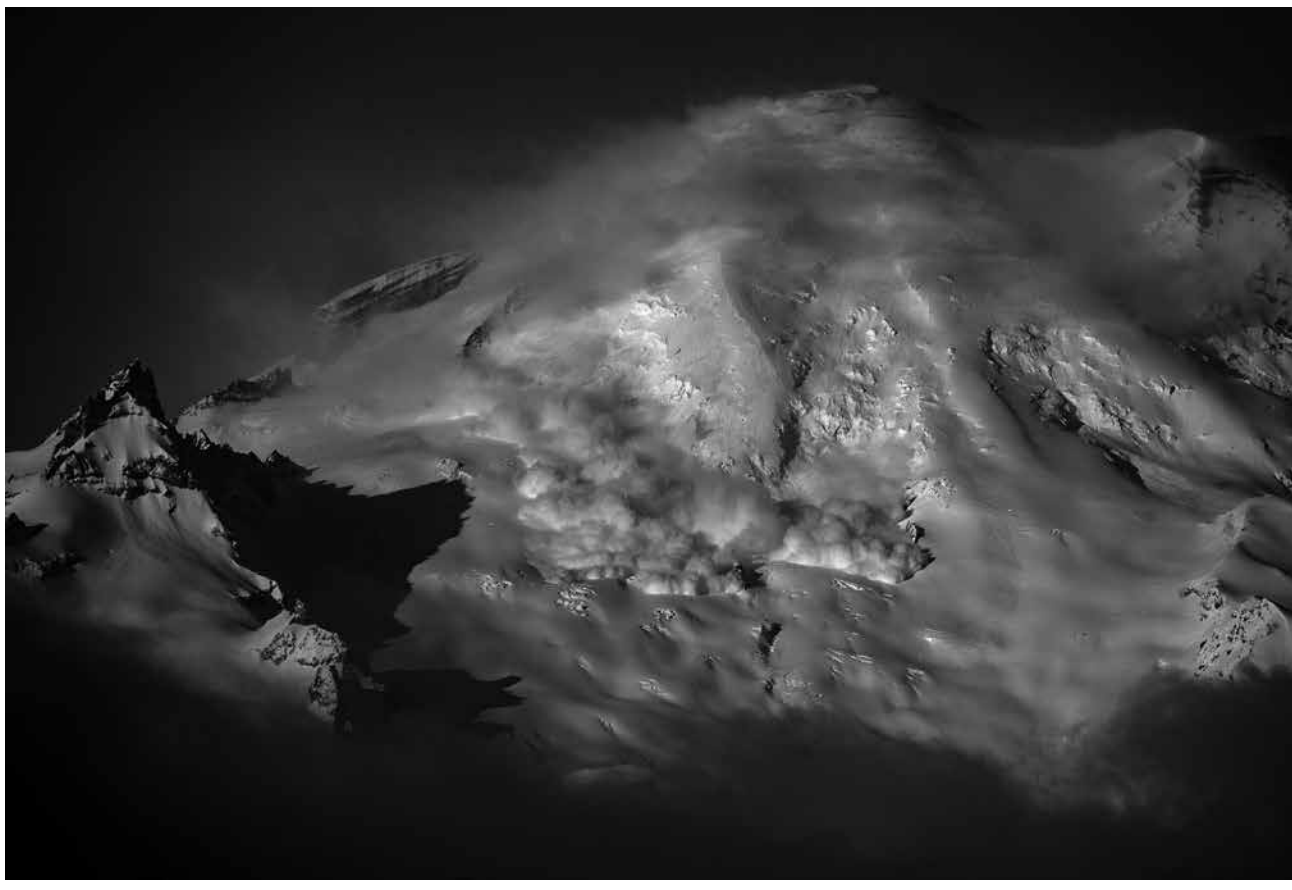
photos by Scott Rinckenberger

UPPER LEFT: The avalanche from the cover continues into the forest below.
LOWER LEFT: A raging river of snow on the granite faces of the Ruth Gorge in Alaska.
CENTER: A full value slide in Norway's Lyngen Alps.
UPPER RIGHT: Recent snow shedding in Denali National Park.
LOWER RIGHT: An avalanche of mammoth proportions on Mount Rainier.

Editor's Note: Avalanches as Art is an ongoing project which will result in a body of work to be shared with the avalanche community, featured in ski publications, and exhibited in fine art settings. His work is featured on the cover of this TAR as well as on the cover of the upcoming *The Snowy Torrents*. Thanks Scott, from the avalanche community, for the beautiful images! Scott continues to seek opportunities to work with avalanche control professionals around the world to safely access vantages of avalanches in motion. Please contact scott@scottrinck.com if you are interested in collaborating in any way.

NCHES as Art





Artist Statement:

The moment you find yourself caught in an avalanche, everything changes. Your body enters a different state. I recall time slowing down and my sense of hearing muting out all but the most pertinent sounds; skis scraping on rocks and the click of a ski binding releasing. As I experienced the speed, darkness, and immense weight inside of the avalanche, I knew with all certainty that my life was no longer in my hands. For reasons far beyond my control, I walked away from that day in Austria, my body no worse for the wear, but my mind permanently altered.

Since that day many years ago, I have seen too many people enter the same situation and never return. In this Eden that is the alpine backcountry, there lurks a reckoning, which is the price that must sometimes be exacted for the infinite joys that exist among those who have learned to love this environment. As a result, the avalanche is vilified, hated for its seemingly arbitrary wrath and its immediate impact.

Yet, if you remove the human element from the equation, the avalanche becomes just another step in the hydrologic cycle, a brilliant and captivating piece of movement in the endless metamorphosis of the planet. From a safe distance it is wonderful and awe inspiring to see nature shrug off a thin veneer of tranquility and show its boundless power.

As a photographer, I've often focused on the apparent tranquility of nature: the first rays of light on freshly fallen snow, the romantic rhythms of glacial ice formations, he artful way in which subalpine trees populate the areas of relative safety. And yet, each of these scenarios is inextricably linked to less subtle forces. Sunshine on fresh snow is a red flag for avalanche danger, glaciers are slow moving but immensely volatile and destructive forces, and for each tree that has found an island of safety in the mountains, there is another that was made into kindling by a massive avalanche.

Experience proved long ago that I could not ignore these destructive forces as a skier and climber. The feelings that I have harbored since my own run-in and the deaths of some of my dearest friends have now proved to me that I can not ignore these destructive forces as an artist either. Realizing that the physical movements of the planet are neither good or bad, and have no sense of justice or violence, I have set out to record avalanches in all of their transformative beauty. My goal is to see past the negative associations that make this phenomenon an enemy, and instead capture these moments of immense beauty and power in a timeless context beyond the human narrative. ▲

CLOSE CALL on Red Lady

Red Lady at first light, with fresh avalanche surrounding skier tracks. *Photo Ben Pritchett*

CRESTED BUTTE AVALANCHE FORECAST

December 18, 2016

Sun, Dec 18, 2016 at 7:08 AM

Issued by: CBAC

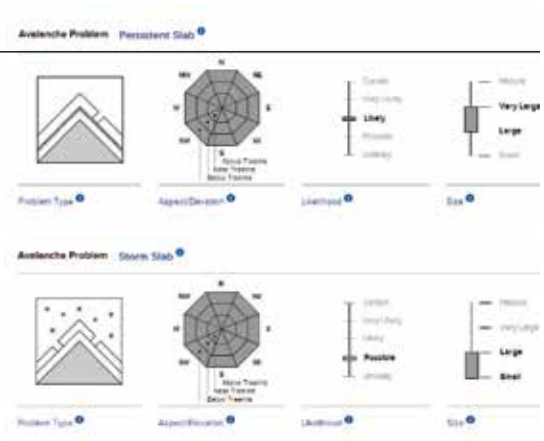
Culture clash. Like when this mountain-town guy took a trip to Seattle last summer and was overwhelmed by things like Uber, punk-rockers and grungers, hipsters on fixies, and 5-lane interstates jammed with commuters hopped up on 3 cups of Starbucks. It felt like a dangerous situation.

The same applies to our snowpack. The Pacific Northwest paid a visit to our Colorado weak layers the last few days. We saw intense snow loading of warm, wet, heavy snow over facets, depth hoar, and crust/facet layers. A culture clash of maritime and continental snowpacks. The result was a natural avalanche cycle. We'll get a better idea of the extent once skies clear up over the next few days. Email us photos (cbavalanche@gmail.com) or submit an observation of what you see.

As is often the case in the Pacific Northwest, storm instabilities will heal quickly, and the upper snowpack will feel pretty solid under your feet. But don't be fooled, the monsters in the basement are still reeling from a huge and rapid load, and collapsing a buried weak layer on a slope steeper than about 33 degrees could result in a D2 or D3 avalanche today, large enough to kill you, snap trees, or destroy a car. Lets put the size of avalanches we're dealing with in perspective. This is a great video about an avalanche that caught and beat up a pro snow boarder. He got caught in an 8"-10" soft slab. In the backcountry today, you can easily trigger a 2 to 4 foot, dense slab, or even larger on the most windloaded slopes, such as this avalanche on Mt. Owen. These aren't conditions to take lightly.

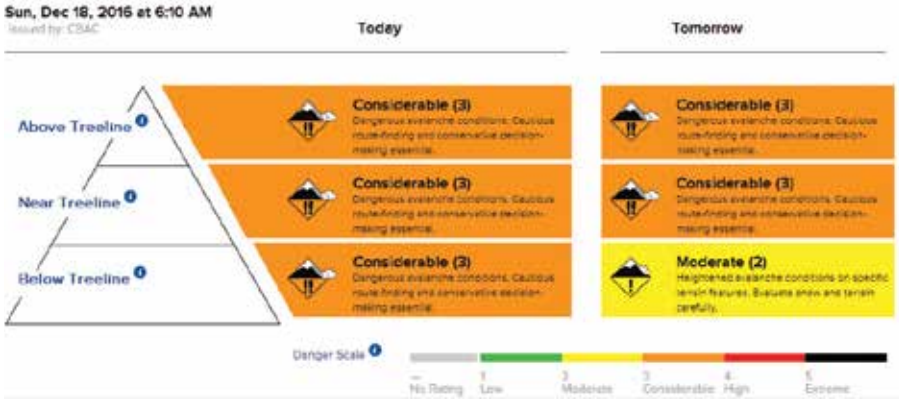
Enjoy the fresh powder but travel conservatively and carefully choose your terrain!

Reported by Zach Guy



Sun, Dec 18, 2016 at 6:10 AM

Issued by: CBAC



Dangerous avalanche conditions exist at all elevations today in the wake of the powerful storm that brought several feet of dense snow to the Elk Mountains. The storm left thick, wide slabs that are capable of producing destructive avalanches. On many slopes, these slabs sit above layers of old, weak snow and can be triggered remotely or break in unpredictable ways. In the past two days, we have observed numerous natural and human triggered avalanches (see this video or our observations page), and these problems remain sensitive to human triggers triggers. Safe backcountry travel today will travel will require conservative decisions and careful route selection. Avoiding slopes steeper than about 30 degrees is a simple way to manage this risk of triggering a deadly avalanche.

2" to 5" of snow water equivalent, (or 20" to 30" of dense, heavy new snow) in 36 hours is a large and rapid load. The stiffening upper snowpack won't be barking at you with glaring signs of instability today, but all it takes is one collapse somewhere on the slope. Give our those buried weak layers a chance to catch their breath. Pour an extra cup of coffee in the warmth of your house and come up with a solid route plan before the cold temps force you into nasty decisions.

BY ZACH GUY

Mt. Emmons, (or Red Lady as locals endearingly call it), is an iconic peak that towers above the quaint town of Crested Butte and catches the first glow of sunrise on the Elk Mountains. Red Lady Bowl beckons to everyone in town with a thirst for powder or an eye for ski lines. Red Lady has a rich history in Crested Butte. Locals have been battling the development of a major molybdenum mine on her for the past 40 years, and just last month, a local ballot passed moving Red Lady one congressional step away from a permanent mine-free solution. Although it is earn-your-turns here, Red Lady Bowl has become the Saddle Peak of Crested Butte. A quick and relatively safe skin track takes dawn patrollers, ski bums, visitors, and weekend warriors to the summit in a matter of hours. Following a storm, it's not uncommon to watch the first tracks go down as the rising sun is just hitting the summit, and by the end of the day, dozens of skiers and snowboarders have followed suit. Sometimes our forecasters have to grit their teeth when we tout dangerous avalanche conditions in our advisories and watch this prominent showpiece get plastered with tracks in the face of the colorful coffee shops, restaurants, and bars that line downtown Crested Butte. Is our credibility as an avalanche center being compromised by this single slope?

Last winter, a major storm in December wiped out the bowl wall to wall, in the silence of the night, leaving Red Lady free of the basal crust/facet layer that plagued similar aspects into winter. This December, we weren't so lucky. We saw a similarly impressive storm hammer the Elk Mountains from December 15th -17th. In a mere 36 hours, 2" to 5" of snow water equivalent (or about 20" to 30" of unusually dense snow), accompanied by strong, jet-supported winds came down hard on our basal weak layers. We issued avalanche warnings on the 16th and 17th, and clearing skies on the 18th gave view to dozens of natural D2 to D3 avalanches in the peaks surrounding town .

That Sunday, I spent the morning driving around documenting some impressive slides, and then went for a short, low angle ski tour on Snodgrass to enjoy the fresh powder with friends and snap some more photos of the carnage. At 3:30 p.m., I was back at home, halfway into a beer and a plate of way-too-spicy quesadillas with Scott, one of my ski buddies that day. Well, to be honest, I was writhing in pain on the floor of my bathroom, sweat pouring from every square inch of my body, because Scott had gone way overboard with a bag of XXX peppers. I still haven't forgiven him. At that moment, my phone began rattling out of control as dozens of text messages came pouring in. "Red Lady just slid wall to wall, at least 5 tracks going in."

We host a free community beacon and rescue training event every December, and one of the scenarios we designed this year is a very wide and extensive debris pile with multiple unknown burials. My worst nightmare, but a scene that Ben had crafted up, no doubt specifically thinking of Red Lady Bowl. This ran through my head as I tried to collect myself from the XXX quesadillas and hopped into the car with Scott to drive into town for the best vantage point. We both gazed at the massive crown in horror and in awe as Red Lady began to cast her dark shadow over the bowl and over town. What do we do now? The same question was surely running through the minds of anyone who glanced up from their daily routine to see numerous tracks now wiped clean by the avalanche. Our forecast center made a quick plea for more info or observations on our social media sites as a standby call went out to our local volunteer search and rescue members to prepare for the worst. Shortly after, we got this email:

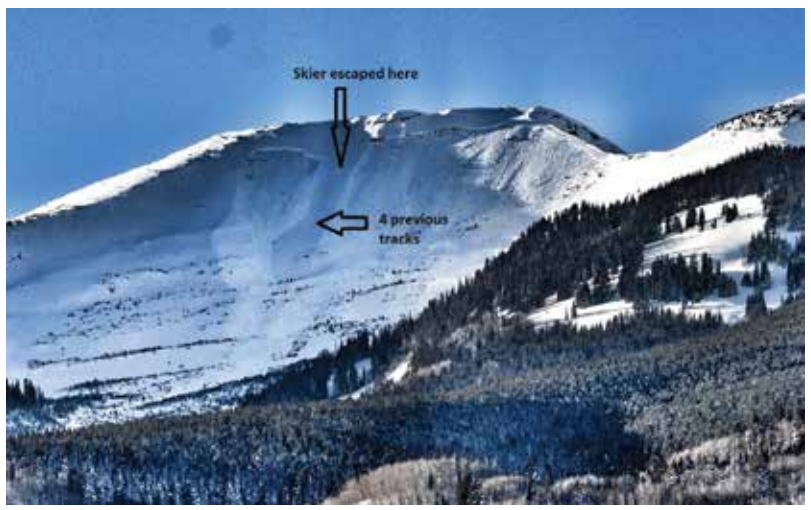
"Watched 4 skiers ski the bowl from my house via a telescope around 12:30 PM. Their ski down looked excellent and it appears they didn't encounter any stability issues.

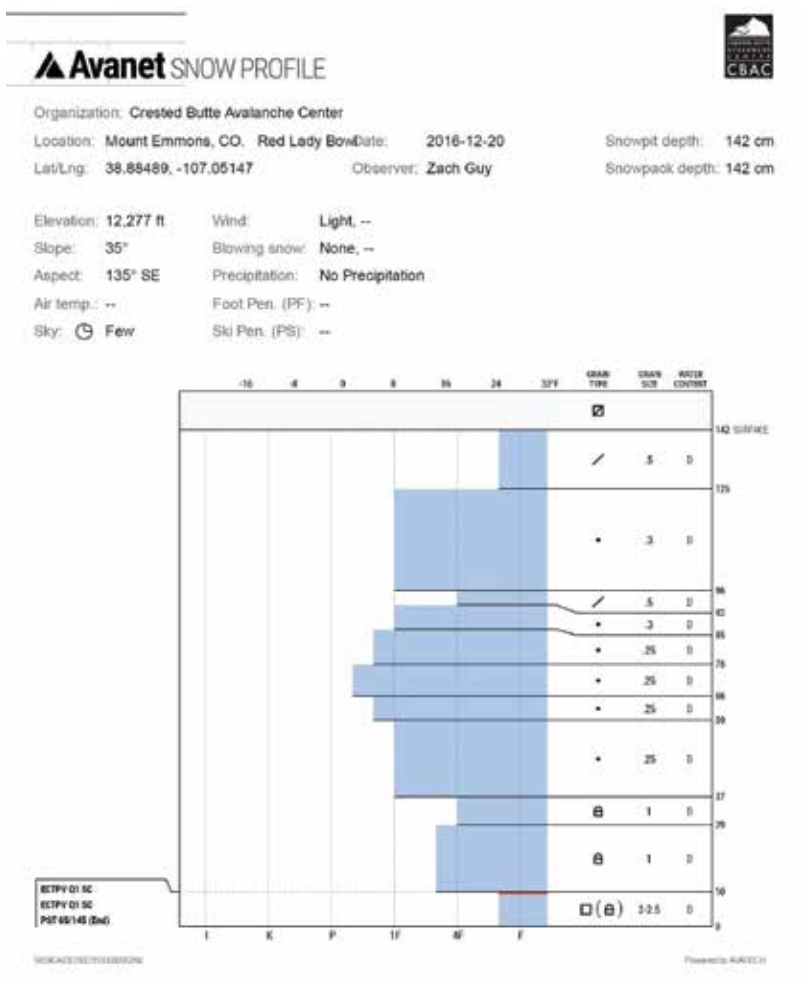
Then watched a lone skier top out at 3:20 PM. He traversed another 50 or so yards east along the summit ridge past the entry point of the 4 earlier skiers, and then dropped in. He had made 10 or so turns, and then it happened; a majority of the bowl ripped out above him, almost edge to edge. Luckily at this point he had skied skier's right of his drop in point, and had re-joined the 4 tracks from earlier.

It appeared he was 'slightly' caught in some sluff before skiing down to a narrow island of the slope that didn't slide (that spot is very visible). He stopped in the middle of all the chaos as the slide ran on both sides of him, far down the slope where it eventually reconnected as it continued down the bowl.

The slide was well past him and he was skiing down when I lost sight of him (looked to be OK/out of danger). Close call."

We all speculated and tossed around our nerdy ideas as to why that middle island of snow held tight that day. Slab properties, slope shape, fracture mechanics, weak layer characteristics, etc. etc. We know it has ripped out plenty of times before, but we can't say for sure what kept that patch of snow





A big avalanche in a big terrain feature. Why didn't the middle ribbon slide?
TOP: Red Lady casting her shadow on a frightening day in Crested Butte. *Photo Chris Miller*
CENTER: Investigating the crown. *Photo Zach Guy*
BOTTOM: Crown profile. *Courtesy CBAC*

December 19, 2016

CRESTED BUTTE AVALANCHE DISCUSSION

in place for that lone skier... that lone skier who was surrounded on either side by a crumbling slab three to six feet deep, that propagated over 1,700 feet around him and ran over a half of a mile below him, snapping trees and leaving massive debris piles in its wake. What we do know is that Red Lady was smiling upon us that day, perhaps showing her appreciation for the Crested Buttians' long fight to keep her slopes pristine and mine-free. For the small price of replacing some soiled underwear, she painted some valuable lessons that we hope our local and visiting community will take to heart, not only for her bowl, but for the backcountry that surrounds her. We took this eye-opening slide as an opportunity for a teachable moment by creating a short video about the slide and publishing some thoughts about it in our forecast discussion the next day (right.)

Good judgment comes from experience and experience comes from bad judgment.

–Mark Twain

FORECAST DISCUSSION BY ZACH GUY

Anyone who has spent a lot of time traveling through or recreating in avalanche terrain has probably had a close call with avalanches at some point in their life. I certainly have had numerous close calls (and I gave a talk about one of them recently at Avy Night). We're human, we're not perfect. We are grateful that everyone is OK after yesterday's close call on Red Lady, and take this as a cost-free learning opportunity. This brings to mind a Mark Twain quote, "Good judgment comes from experience and experience comes from bad judgment." If we can collectively take home a few lessons and gain some experience from this accident, then we will be all the better as a backcountry community for it. Permit me to grab the drawing board for a moment to highlight some valuable lessons from a forecaster's perspective.

1. **Tracks on the slope don't mean that it is stable,** especially with persistent slabs. Red Lady Bowl had four tracks down it before the 5th rider triggered the slide. It easily could have been the 3rd rider, or the 10th rider, or the 50th rider. The culprit weak layers are buried several feet deep, and it takes a collapse of the layer to cause avalanche failure. Weaknesses in the snowpack, or "trigger points," become increasingly isolated as the slab becomes deeper and more uniform. It can be challenging to identify those trigger points, and just because other folks descended a slope without finding one, it doesn't mean that it is safe.
2. **Persistent slabs can break quite wide and behave unusually.** This avalanche broke while the skier was about 10 turns down the slope, and showed impressive propagation. The other skier triggered avalanche on Red Lady Bowl this year was remotely triggered. Tricky stuff, and quite challenging to assess, especially in the alpine, where variable wind and snow loading make for uneven distribution of slabs and weak layers.
3. **Traveling solo through avalanche terrain increases your vulnerability** if something goes wrong. Despite this highly visible path from town, CB Search and Rescue didn't get to the trailhead until an hour after the slide, and even then, they weren't launching a rescue until more information became available. Had this avalanche resulted in a burial, it wouldn't have ended well. Having a partner watching from a safe location helps facilitate rescue responses quickly.
4. **The last two close calls on Red Lady occurred the day that we lowered the danger from High to Considerable.** The majority of avalanche fatalities occur during Considerable danger. We rate the avalanche danger based on our overall travel advice for a particular elevation band while considering the potential size, sensitivity, and distribution of avalanche problems. Instabilities during Considerable danger may not be quite as glaring as you might encounter during a High danger day, which often lures people into more dangerous terrain. Can you trigger a slide during moderate danger? Yes, of course. On low danger? Yes. But you are far more likely to get yourself in trouble during a Considerable day.
5. **The island of safety.** We watch the travel habits on Red Lady and know that a lot of riders choose their descent near the ribbon of snow in the middle of the bowl that didn't slide. There are some terrain characteristics to that portion of the bowl that seem to reduce the frequency of some avalanches there, but it is definitely not a safe line. That same swath of snow got wiped out by a similar avalanche last December, and I'm sure Red Lady's history has countless other slides where that terrain piece was wiped out. The failure layer in this accident appears to be near the ground, so skier compaction would have minimal or no effect. Those layers were probably well buried before the first tracks went down that slope. I can't positively explain why that patch of snow didn't rip out, but we're all grateful it stayed put, and don't count on it staying put next time. ▲

‘en echelon’ is a term also used in structural geology for closely spaced parallel things, like joints and veins and stuff. Google has a nice applicable definition as a military term that makes it clear why the geologists like it, if not the snow-ologists.

—Dave Gauthier

I think this particular application of “**echelon**” came from a conversation with Alec (who speaks French). However, I first heard the term (in a conversation in English) applied to roped glacier skiing in which each person was upslope and to the side of the person below.

BTW the most serious avalanche in which I I have been caught involved a series of fractures upslope of me, each about a second apart, each releasing much more snow above me. The echelon fractures are burnt into my memory.

For the slab avalanche with echelon cracks that I triggered and was caught in, the slab was about 35 cm in height and released on facets on a sun crust.

—Bruce Jamieson

EN ECHELON CRACKS

ABOVE: This ‘en echelon’ slab fracture photo is from the southern edge of the Tetons, 2008. It was 25 cm of soft slab (4F) on top of surface hoar on settled snowpack, 40˚ or steeper slope, NE aspect around 9000’. *Photo Lynne Wolfe*

LEFT: Look at that structure! An example of what Van Herwijnen (2005) and Gauthier (2010) refer to as ‘en echelon slab fracture.’ Location: Smoky Mountains, ID 2005. *Photo Simon Trautman*

BELOW: This is a photo of a series of slab fractures, each triggered separately, i.e. the slab fractures won the race. That is Dave Gauthier in the background and Antonia Zeidler in the foreground. This was a spring snowpack with several cm of wet snow on top and thick layer of depth hoar next to the ground. I’d guess the HS was about 1 m. The vertical displacement with each whumpf was about 5 cm. *Photo Bruce Jamieson*

For more information on en echelon cracks, please see this paper from ISSW 2010: *On The Sustainability and Arrest of Weak Layer Fracture in Whumpfs and Avalanches* by Dave Gauthier and Bruce Jamieson

arc.lib.montana.edu/snow-science/objects/ISSW_O-043.pdf

AVALANCHE FORECASTING IN AFGHANISTAN, PAKISTAN, AND TAJIKISTAN

A 100+ year avalanche cycle hit the Panjshir Valley of Afghanistan in February 2015 killing close to 200 people in one night. Survivors stand atop their home in a village that was hit from climax slides.

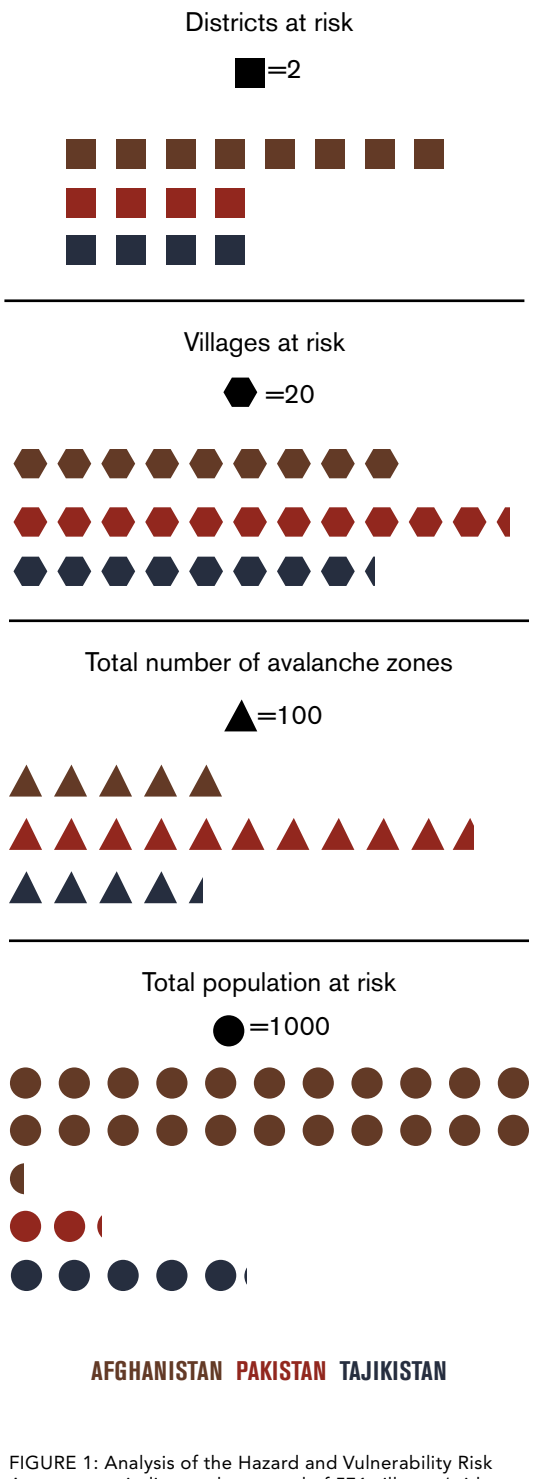


FIGURE 1: Analysis of the Hazard and Vulnerability Risk Assessments indicates that a total of 571 villages (with a population of 29,889, 75% in Afghanistan) are prone to avalanches across the three countries.

BY DOUG CHABOT, PHOTOS BY WAHIM KHAN

Home of the Karakorum, Hindu Kush, and Pamir mountains, Central Asia has a serious avalanche hazard. Mountain communities throughout Pakistan, Afghanistan, and Tajikistan experienced a widespread avalanche cycle in March 2012 and again in February 2015 that destroyed villages, killed livestock, and took the lives of hundreds of residents. In March 2012 an avalanche destroyed a village in the Badakhshan province of Afghanistan, killing at least 50 people. A week later an avalanche buried 13 families in eastern Nuristan province in Afghanistan, killing at least 45 people. A week later an avalanche killed four and injured three members of the same family in a remote village in northwestern Pakistan. The valley received heavy rain and snowfall over the 48 hours prior to this event. Five members of another family were killed by an avalanche on the same night near Chitral in Pakistan. As a result of record snowfalls, nearly twenty avalanches struck villages throughout southern Tajikistan during the last two weeks of March 2012, damaging and destroying several houses and other facilities and killing at least one person and fifty cows.

Focus Humanitarian Assistance (FOCUS), an affiliate of the Aga Khan Development Network, is a disaster risk management agency that helps vulnerable communities build resilience to natural and man-made disasters, mostly in south and central Asia. In response to the 2012 avalanche tragedy, FOCUS asked me to develop a strategy to reduce avalanche fatalities in these remote areas. The developed world has the financial and technical resources to effectively manage avalanche risk, but this is not the case in the rugged mountains of Central Asia. The avalanche problems are unique and deadly, requiring simple, sustainable, and inexpensive solutions.

First, using data from previous disasters, FOCUS conducted a hazard, risk, and vulnerability inventory in their area of operation in Afghanistan, Pakistan and Tajikistan, revealing 571 villages with a high avalanche risk *(Figure 1)*. Then I trained their field staff in basic avalanche awareness and created weather and avalanche alert thresholds *(Figure 2)* to warn them of impending danger. These thresholds trigger a response of contacting both their national weather service and me to help them determine if evacuations are needed.

Alert Thresholds

Recent Avalanches	Within the last 24 hours
New Snow Amount	30 cm or more in 24 hours
Snow Accumulation Rate	5 cm/hr or more for 6+ hours
Rainfall	Any rain
Range	Temperatures start below freezing to above freezing with snow in 24 hours
Rain/Snow Level	At or above avalanche starting zone elevations - temperature drops 6 degrees C for every km of elevation gain.
Above Freezing Temperatures	Above freezing temperatures at avalanche starting zone elevations at night for greater than 24 hours for the first 3 days

FOCUS HUMANITARIAN ASSISTANCE

FIGURE 2

In 2014 I wrote a community training manual on avalanches which has since been translated from English into Urdu and Dari. It was written to educate and train community members in the 571 high risk villages. The manual has seven chapters, each explaining a topic relevant to community members about avalanches. Even for the uneducated, the manual has sections of hands-on activities for trainers to teach avalanche basics.

For the 2015-16 season, FOCUS established Weather Monitoring Posts (WMPs) to aid in avalanche forecasting for the highest-risk villages. A total of 82 WMPs were activated in January 2015 (17 in Afghanistan, 45 in Pakistan and 25 in Tajikistan). Observers record daily weather and avalanche activity. Every morning the countries central FOCUS communication center calls each observer on his cell phone and immediately posts the data online which populates a map that I look at over morning coffee. I analyze the inputs and, if necessary, advise field units about current avalanche potential. Observations include avalanche occurrence, maximum and minimum temperatures, 24-hour snowfall amount, total snow depth, wind speed and direction as well as 24-hour rainfall amount. This new community-based weather program has allowed FOCUS, along with the communities it serves, to better understand weather and avalanche patterns which have never been identified or quantified.

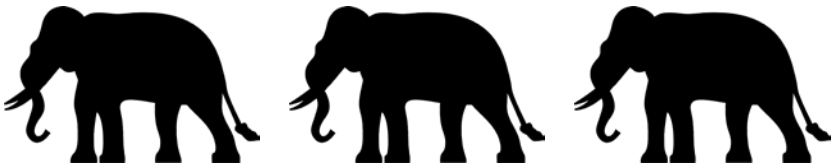
This holistic system of avalanche education, weather monitoring, and avalanche reporting allows me to help the field staff determine when avalanche danger is rising, when a village should be evacuated, and when people can return after an avalanche cycle. Since the program was implemented, villages have been evacuated hours before getting hit by massive avalanches, thereby saving lives. The people in these remote villages have experiences that are almost unimaginable to westerners, such as being blown to safety across rivers by the air blast of an approaching avalanche or knowing that herds of goats walking in starting zones early season (much like bootpacking) is a good thing. This entire community-based program relies on simple, low cost solutions: manual weather stations, rules of thumb, and basic avalanche awareness training at the local level. ▲

TOP: Villagers dig out homes, bodies, animals and salvage clothes in the aftermath of a large avalanche in the remote Wakhan corridor where access is only on foot.

CENTER: An avalanche in 2015 in northeastern Afghanistan hit a village that destroyed homes and killed eight, including a 12 year-old boy and an infant.

BOTTOM: Animals are the financial equivalent of a savings account. Avalanches kill many goats and cows every year, devastating the economics of a village. This avalanche was in the very remote Wakhan Corridor of Afghanistan.

ELEPHANTS IN THE ROOM



BY LIAM BAILEY

One of the panel discussions at the recent ISSW was directed toward worker safety. The panel was well done and well received, but to me there were two elephants in the room.

The first elephant I'll call transience versus complexity—Ski patrolling is a low paying seasonal job that most do as an interlude before moving on to a career that may or may not be around avalanches. Even resorts that have a legacy of minimal turnover are seeing that change. It seems that it is only a dwindling handful of patrollers who, for love of the job, have found summer work that pays well enough to fund a continued patrol addiction.

Snow, weather, and avalanches are complicated phenomena. Accordingly, professional avalanche work is a complicated field. A complicated field with few long term employees is not a recipe for reduced risk.

The second elephant: although there is ample evidence that ski patrolling is a dangerous job (Greene et al, 2014), it still doesn't appear to me to be clearly accepted or admitted as baseline fact that it is; even in a forum at ISSW full of people who are closest to the realities of the jobs. Unless/until that happens, some will continue to be surprised, feel betrayed, and simply look to assign blame when our peers are hurt or killed. It is far easier to allege that an incident was isolated and caused by negligence of those involved and then move on than to realistically and objectively evaluate the incident and contributing factors and risks. But finding faults in hindsight does not necessarily equal negligence or incompetence in real-time. Rather than accept the idea that many accidents are due to violation of rules and standards in a low risk environment, I assert that we get hurt because we are working in an inherently high risk environment where loss/injury is probable.

None of us want to get injured or worse but all of us make mistakes despite our risk reduction strategies and the consequences of a mistake in a high risk environment can be severe. This idea is explored in *"The Big Lie"* by Mark Smith, initially written for the wildland fire community, but applicable to every avalanche worker as well.

Greene et al, 2014 state "Our estimate of the fatal occupational injury rate puts the avalanche industry near the top of all industry groups. The fatal injury rate also puts avalanche work in the top ten most dangerous occupations in the U.S." Importantly, the study explains that the small number of workers makes it very difficult to correlate fatality numbers with man hours of exposure and translate this into an accurate expression of risk for one worker. This fact underlines a need for widespread industry participation in a near miss database. I hear that this database is coming (thanks to Ethan Greene, Scotty Savage, and others) and when it is available it will help our community with program assessments, baseline risk evaluation, and the ability to learn from our peers…which will reduce our risk. Most importantly, I think it has the potential to illustrate and personify the environments and risk that we face as snow and avalanche workers.

For a near miss database to be effective, it needs industry-wide buy-in and support. Our participation is fundamental, and I hope the old fears of liability and legality are muted by the proposed anonymity option.

I'd like to thank my mentor, Alan Plaugher, for all his knowledge, integrity, advice, guidance, and support. I still hope we're only experiencing a temporary hiatus. I'd like to thank Simon Trautman for improving the focus of this article.

The Big Lie—18.6—Truth and Culture in a High Risk Environment by Mark Smith, reprinted by permission of the author. We've excerpted sections of the essay due to space requirements; for the full article and references, please visit wildlandfireleadership.blogspot.com/2016/06/the-big-lie.html

I was 18 years old and "chuted up." Waiting for my first jump with my new unit after completing airborne school. Sitting on the drop zone waiting to board the helicopter, I watched two of my fellow Ranger candidates steer their parachutes into each other and become entangled. At 300 feet both their canopies collapsed and they plummeted to earth. Both suffered permanent serious disability.

As soon as the ambulance was away, one of the NCOs, our jumpmaster, walked back over. "All right Rangers, next stick. Load up!" As we were getting seated in the helo he said in a calm even voice. The smallest mistake will kill you and your buddies. Now you know why we train the way we do."

Some joined for adventure. For college money. For a job. But we were all told from Day One how dangerous our new world was going to be. It had not taken long for the concept to become visceral. There were no illusions about the path we had chosen. From that moment on, death and injury were going to be a normal part of my life.

A state fire chief I greatly respect recently asked, "Why are families so surprised or feel betrayed when their kids die fighting wildfires?"

I believe the answer to that is because of the Big Lie. The lie that wildland firefighting is safe. Young firefighters and their families are told that they have a "right" to a safe work environment. It is explicit in the Interagency Standards for Fire and Aviation Operations "Every individual has the right to turn down unsafe assignments."

The lie is so insidious that it permeates the thinking of many fire managers and agency administrators to the point of denial, despite a steady flow of coffins standing as evidence to the contrary.

I am always challenged during discussions about risk during classes and presentations to wildland audiences. "We're different than the military. We do not have acceptable losses."

"It appears you do," I respond. "It's almost 19 a year and for the most part the cultural fundamentals of trying to fight fire on the cheap with a seasonal militia-based model are unchanged."

The truth is that wildland firefighting, like any realm in which people, machines, and extreme natural forces collide, is inherently dangerous. One in which a seemingly small error, even being at the wrong time and place, can get people hurt or killed. How long do we try to "vector to zero" before admitting the data is telling us there is no such thing?

Merriam Webster has a pretty simple definition of safe: "Free from harm or risk."

It seems unrealistic one could be working on or above the fire ground and be free from risk. Here's the interagency standards' definition of safety: "A measure of the degree of freedom from risk or conditions that can cause death, physical harm, or equipment or property damage."

The big lie turned "Free from risk" into "A measurement of the degree of freedom from risk". The point of origin of the Big Lie. If interagency policy defines safety as a measurement of something that never gets measured... how can that mean anything?

If the definition of safety is meaningless, and in contravention of its true nature, so too will be all the policies, rules and checklists that flow from it. The garbage in, garbage out effect.

Nearly 19 firefighters a year are dying because they are operating, even after mitigation, in an inherently high risk environment. Not because they are just violating rules in a low risk environment.

I don't believe the Big Lie is the normalization of this reality. The Big Lie is in denial of it. It stands in opposition to the wildland fire leadership values of duty, respect and integrity.

What actually gives me great hope is that, slowly, more and more leaders are abandoning the Big Lie in favor of the harsh truth that wildland firefighting is a very dangerous profession. The reality that people are going to get hurt and they are going to die.

Many leaders have admitted to me in private that they know this. Yet they fear its admission is a license to ignore risks or abandon hard won safety standards. "We can't admit we have acceptable losses!"

A colleague, retired Marine Lieutenant Colonel Eric Carlson, puts it best. "Oh no." he says, "We accept the *risk* of losses. There are no *acceptable* losses." That's the crux. Our loss of 550 special operators was not acceptable. Each loss compelled us to introspection and improvement.

There is acceptable risk. There is no acceptable loss. But there will be losses. So where does that uncomfortable truth leave us?

Simply, with the sacred duty to keep that loss as low as *humanly* possible. With the obligation to tell the truth to our firefighters and families about the world they've become a part of. Of the risks they will face. With making imperfect decisions using the best art and science possible. With redeeming the values of duty, respect and integrity.

The Big Lie has begot a zero defect mentality whose main goal is not making any mistakes. Transparency and learning have become subordinate to covering one's rear end, resulting in chronic underreporting of near misses and other important lessons for fear of reprisal. We make culture. It is the result of choices, either conscious or unconscious.

Even the best model of probability and severity cannot diagram the exponential risk curve when multiple hazards and human factors begin compounding. Especially when the environment has the potential to change far more quickly than we can detect and react.

Because 26 or 18.6, or whatever the number may be, will never be zero, the objective cannot be a number. The objective must be a culture whose leaders have the critical thinking and risk decision tools worthy of people getting a very dangerous job done with limited means to do it.

Operational cultures that align to principles versus rules, conduct training and practice to communicate intent and support the use of professional judgment are much more agile and effective. These are safer than compliance based cultures because their operators are armed with the information, understanding, training and freedom required to make continuous risk decisions at their level.

For an organization to reach the difficult, but critical balance of safety, efficiency, and effectiveness in a high risk environment requires a culture that places great value on team result, trust, truth, initiative, improvement and decisions aligned to the end state trying to be achieved.

When the inevitable occurs, liability investigations can be quickly screened for willful violation or gross negligence. Everything else can be defended using professional judgment and the reasonable person principle. Maximum learning can be gleaned from near misses, accidents and other flawed decisions.

The road to a culture that can walk that kind of talk is extremely difficult to achieve and maintain. There will be ups and downs and setbacks. But until the Big Lie is defeated for good, we'll never get there.

The truth is a worthy anchor point to begin to honor both the living and the fallen. ▲

LEFT: I am standing under what is the smaller part of the crown, which went up to about eight feet outside the frame on the left. There was worse visibility on the ridge entrance than it looks from this photo. We had shot all these slopes from the ridge but couldn't see anything. Falling off of a five to eight foot crown upon entering the slope sure beats wondering if it would have slid with different shot placements. *Photo Kyle Powell*

RIGHT Proof that we do get persistent weak layers in the Sierra: an eight to nine foot crown of R4/D3.5 avalanche that slid on facets between a buried ice crust sandwich in Reuter Bowl. It was 31° at the crown. *Photo John Carnell*

Editor's Note: I like to send TAR submissions off for some of my peers to review. I chose to send Liam Bailey's article on risk culture, Elephants in the Room, *to Doug Krause, who writes quite a bit on the topic of Operational Awareness (TAR 34.2). This was the first 'off-the-cuff' response in a series of correspondence. A variety of perspectives were subsequently explored.*

COMMENTARY ON ELEPHANTS IN THE ROOM

BY DOUG KRAUSE

That's a good essay. I think the transience vs. complexity elephant points directly at the #nothingwentwrong effect from a managerial/operational perspective. Ski areas, etc. have been getting away with it for a long time, and they will probably continue to get away with it.

I disagree with this: "we seem to continue to be surprised, feel betrayed, and look to assign blame when our peers are hurt or killed." Maybe because I've been around long enough to not be surprised. When I was running a very busy mitigation program, I used to count on one to two season ending injuries and two to three significant but not season ending injuries among the staff per season. That's with a core staff of less than 25. Not avalanche related injuries necessarily, but that's not the point.

I certainly agree with the assertion that errors/faults/near misses, etc. are assessed in terms of the individual, not the organization, and that's messed up. It boils down to an operational refusal to accept responsibility. A pervasive operational refusal to accept responsibility.

Though obviously it varies with the operation, he's right, risk management culture in the avalanche industry is a nice thing that people like to talk about. Few actually walk the walk.

I don't want to be fatalistic about a near miss database, but I am. I don't think it will happen in a meaningful fashion. Learning from 'failure' is a hot topic for me lately. I was struck by this line from Black Box Thinking: "In aviation, failure is data rich." Imagine how better off we would be if avalanche failure was data rich. Although, we don't do the best job with the data on failure that we do have.

"The Big Lie" essay is particularly poignant. I also like this "We make culture. It is the result of choices, either conscious or unconscious." Right? I would add that we can't rely on leadership building culture. We all need to build it on an individual level. When the top down don't work, go bottom up. ▲

AN OPINION ON HUMAN FACTORS AND SIMPLE TRAVEL PROTOCOL

BY DUDLEY IMPROTA

I'm over human factors; there, I said it. Last spring I mentioned this to a well known avalanche center director at a workshop. His reply—"me too!"

We can discuss why humans (let's call them ambulatory variables) do what they do; but in the end most avalanche educators are not human behavioral psychologists and it's a bit out of our realm to delve deeply into that subject. By the way, not many avalanche specialists or educators are doctors of philosophy either. But that doesn't seem to stop them from espousing life lessons seemingly gained from working in avalanche terrain. If avalanche educators and specialists have some special insight into human behaviors and decision-making; perhaps they can explain why so many people woke up surprised on November 9.

A lot of human factor discussion in avalanche classes is based on research, observations, and theories from accidents. The vast majority of backcountry outings are successful; it would be almost impossible to dissect successful backcountry trips the way we do accidents and fatalities. For instance, if an accident occurs in familiar terrain, familiarity becomes suspect. During accident-free outings in familiar terrain; familiarity might well have been an asset in avoiding avalanche problems.

Yet,we love to ramble on about hard-to-define terms like human factors, risk management, and group dynamics. Loading and weak layers are what kill people (I believe Doug Chabot said this when discussing rapid warming); you can make all the bad decisions you want (generally) on a stable snowpack. I believe the rash of accidents within a short period last season, which was referred to as "clustering", was due to large numbers of people recreating in avalanche terrain and widespread instability; not necessarily an epidemic of bad decisions that were somehow related.

I'm suggesting sticking to what we know when teaching avalanche safety; keeping it simple. Learn to assess snow stability, understand route-finding, and use safe travel protocol. Rules of threes are easy to remember and easy to impart to students. Terrain, weather, snowpack—what's the weakest layer, how easy does it fail, what's the distribution, etc.—you get it, rules of three.

To that end, I teach a simple three-step approach to traveling in the winter backcountry:

1. One at a time
2. Get out of harm's way
3. Stay within striking distance.

I began many classes by telling students I assume they are in the class because they want to recreate on slopes 35 degrees and steeper in the backcountry. I go on to say that avalanches are not one hundred percent predictable; if steep enough, the slope could go. Therefore, on steep slopes, we should always travel as if an avalanche could happen.

After we've done our homework checking the weather and the snowpack and deemed it is relatively safe to ski, ride, or travel on a steep slope we can follow the simple three steps.

1. **One at a time**—everyone knows this right? The backcountry mantra; only expose one member of the party at any one time to avalanche hazard. We can spend time talking about WHY people don't do this or didn't do this or we can simple teach DO THIS when recreating on steep slopes. It works; if something does go wrong there will only be one person involved.
2. **Get out of harm's way**—again, something we have repeated many times. We do need to understand avalanche slopes, starting zones, flanks and runouts to make this work. We have to teach where the hazard is to avoid it. And sometimes we do make mistakes thinking we know where that boundary between safe and not safe lies. In a "surprise avalanche" seminar I attended some of the presentations were about professionals wrongly guessing where that boundary lay. There is risk in recreating in avalanche terrain and humans make mistakes. Okay, there is a human factor we do know—humans make mistakes. But, if we make the conscious effort, every time, to get out of harm's way after we have skied or ridden the slope, we will reduce accidents.
3. **Stay within striking distance**—in other words try to stay where you can reach your partner relatively quickly if something does happen. We do know you don't have much time if you're buried. We need to respond quickly and efficiently. Even if a person is on top of the snow and breathing there may be other injuries that require immediate attention. In bigger terrain or (for our Canadian friends) more complex terrain, getting out of harm's way and staying within striking distance gets more challenging. In larger terrain I've skied it just wasn't possible to ski to a relatively safe place and have a constant visual on my partners. Three step protocols have their limits and mountain travel is not always black and white; there are gray areas. We should be crystal clear with our students about that; skiing and riding bigger and more complex terrain necessarily requires the participant to accept more risk.

I taught last year with an instructor who had a degree in eastern philosophy. He claimed that education gave him an insight into human behavior. I meant to have him define specifically how that might help avoid avalanche accidents. We never got around to talking about that; so I did look for some philosophy that reinforced my ideas about human decision-making. Lao Tzu said "nature is not human-hearted." Snow stability is not dependent on human behavior. Good travel protocol can increase safety and reduce decision heartburn.

And if I'm wrong and you do have some special insight or knowledge about why humans do what they do; it's highly possible you could make a lot more money in marketing on Madison Avenue than in avalanche work. ▲

Nature is not human-hearted.

—Lao Tzu

Editor's note: When pressed on his dislike of human factors, Dudley replied:

I don't totally disregard decision-making in my classes. I agree with you that we should try to recognize our foibles. I appreciate your comments. I just don't necessarily buy into some of the FACET theories; and my comments were meant to encourage us to constantly analyze what we're teaching.

Dudley Improta is retired from the University of Montana and the West Central Montana Avalanche Center. He is a AAA certified instructor and teaches basic and Level 1 avalanche classes for Yurtski, a backcountry operation north of Missoula, MT.

BEAM TESTS

Ten years later...

KARL BIRKELAND

Experience with stability tests, from 1980 to the present

In the 35+ years I've been looking carefully at the snowpack our techniques for assessing snow stability have been constantly changing. My experience has been a progression from shovel shear tests to Rutschblocks, loaded columns, compression tests and the Stuffblock test. More recently, we've seen a transition from blocks to beams with the Extended Column Test (ECT) and Propagation Saw Test (PST), both of which measure/investigate crack propagation. I have no doubt we will continue to see these techniques evolve and be further refined in the coming years as we increase our knowledge of snow fracture and avalanches release.

My first formal avalanche education came in the late 1970s as a Junior Ski Patroller in a class taught by Knox Williams at the old Hidden Valley Ski Area in Rocky Mountain National Park. I don't remember much from that course other than looking at some depth hoar and a few layers in a pit. The test of choice in Colorado at that time was the shovel shear test (Greene et al., 2016). Transitioning to Utah in the early 1980s as a patroller at Snowbasin, then a small local ski hill, we continued to focus on shovel shear tests. I recall working with Tom Leonard as we fashioned our own shovels modified from Sears car shovels so that we had long, flat blades for our tests. Our idea was that these long flat blades would pry the snow less than some of the smaller curved blades allowing us to get more consistent results. I still remember popping out layer after layer (often layered wind slabs with graupel in between) that never responded to our explosive tests and thinking there had to be a better way of testing snow stability.

A much improved method arrived, at least for me, in the mid-1980s with the introduction of the Rutschblock (RB) (Föhn, 1987). This test had been in use in Switzerland for some time, but it wasn't until the 1980s that many folks in the U.S. started using it. It was great to see a test in which a skier affects the snowpack in much the same way that they might trigger a slope. Sure, it took some time to dig one out, but we were young and spending some time digging didn't seem like that big of a deal. Of course, it did become a bigger deal when the Utah snowpack got deep and we still wanted to test some basal facets. During these years with the shovel shear test and the RB we diligently noted not only what it took to get a fracture, but also whether our shears were "dirty" or "clean" (though no definitions for these existed). We knew intuitively that the way the tests broke was important, but I don't think we really grasped why.

I took a break from patrolling prior to grad school and received a different education by spending a winter in Chamonix. Here I spent long days covering a lot of ground with changes in elevation of 8,000 feet or more and aspects around the compass. Moving quickly with partners motivated me to find good skiing rather than trying to assess whether or not to open terrain to the public, I found RBs to be overly time consuming. I used a lot of shovel shear tests and I experimented with various ways of tapping, bending, pushing, and pulling my columns. I made it through that season with no major avalanche stories to tell, due a little bit to skill but probably more so to an oversized dose of luck.

Entering graduate school at Montana State in the late-1980s it was time to really drill down and look at the snow. I can't remember if it was here or back in Utah when someone introduced me to the idea of a "loaded column test," whereby we would cut out a 30 by 30 cm column and then gently place blocks on top of the existing column until a weak layer below fractured (Greene et al., 2016). We would estimate the amount of load added and then use that as a first guesstimate to the load it would take for us to get avalanches on that weak layer. As with all tests, this was pretty rough. One thing I noticed was that if I added a lot of snow to a column and then lightly tapped on the top, the dynamic loading of my tapping – even if it was light – was often enough to get the weak layer to fracture. The dynamic nature of the tapping seemed to be key. Soon I was simply tapping on columns with my shovel (what we called a "tap test") as another way to test the snow. Unbeknownst to me, the Canadians had been using what they called the Compression Test (CT) in a more controlled manner with specific loading steps since the mid-1970s (Jamieson, 1999). It wasn't until around 1990 that I heard more about what they were doing and adopted their taps from the wrist, elbow, and shoulder. Introducing the CT to my assessments was helpful, but we still took the time to dig RBs. Though the amount of force added to the RB varied between skiers and how they jumped, we knew the RBs were testing an area roughly 30 times larger than a CT

TOP: Karl Birkeland and Lance McDonald in a pit at Snowbasin Ski Area in the early 1980s. Photo Tim Flaherty

BOTTOM: Getting ready to jump on a Rutschblock in 2004. Photo Spencer Logan

Karl conducting a compression test (with a bit of a sloppy pit wall!) around 1990. Photo Lonnie Ball

We knew intuitively that the way the tests broke was important, but I don't think we really grasped why.

which we figured would give us more consistent results. Further, if a small jump fractured the whole block and you surfed into the pit on an intact slab, it definitely got your attention!

In the 1990s we continued to focus on the force it took to get a weak layer to fracture. Ron Johnson and I worked together at the Gallatin National Forest Avalanche Center and one challenge we faced was getting information from a wide variety of users over a large area. Ron first came up with the idea of loading a stuff sack with varying amount of snow and then gently placing the sack on the top of a column. If it didn't fracture, we'd put more snow into the sack, weigh it, and gently place it down again. This proved to be overly time-consuming and we found it was easier to get the weak layer to fracture if we put the sack on the column and then tapped on it with our hand. At some point Ron decided we should just fill the sack with a certain amount of snow and drop it from different heights. We were pretty excited about the Stuffblock (SB) test because it finally gave us a way to objectively add a quantifiable force to the snowpack with a test that was reasonably fast and did not add much weight to your backpack (Johnson and Birkeland, 1994; Birkeland and Johnson, 1996; Birkeland and Johnson, 1999). Granted, this "objective measure" was still a bit rough and depended a little bit on how tightly you packed your snow into the stuffsack. Chris Landry further refined loading small columns with some extra equipment and a force gauge to develop the Quantified Loaded Column Test, which he used for his MS work at Montana State (Landry et al., 2001).

Not long after developing the Stuffblock test, Ron and I began to formalize how we described the fractures in our tests. It seemed to me that any attempt to do this should be fairly simple and easy to apply. We decided that we'd call it shear quality, and that a Q1 would equate to what we formerly called a "clean and fast" shear (in essence, anything notable including a quick fracture through depth hoar) and a Q3 would be a "dirty" or "broken" shear, while Q2 would cover just about everything else. We collected some data and found that using shear quality could help improve our stability assessments, though certainly there was still room for improvement (Johnson and Birkeland, 1998; Birkeland and Johnson, 1999). Concurrent to our development of shear quality, Bruce Jamieson and some of his grad students were working on the development of the Fracture Character definitions (van Herwijnen and Jamieson, 2002; van Herwijnen and Jamieson, 2004; van Herwijnen and Jamieson, 2007). Both systems did essentially the same thing, focusing more on how a fracture occurred in a test rather than how much force was required for fracture. By changing this focus we acknowledged that how a weak layer fractures might well be related to the crack propagation part of the avalanche release puzzle.

Though the avalanche community was slowly embracing the importance of crack propagation, we still had no direct small tests to assess it. This soon changed with the advent of two new tests, each of which was developed independently. In Canada, the Propagation Saw Test developed out of the work of Crane Johnson, Alec van Herwijnen, Dave Gauthier and Bruce Jamieson. Crane did some tests on a level study plot for his MS work on remotely triggered avalanches (Johnson et al., 2000; Johnson, 2001) and Alec worked on a similar test in sloping terrain that he called a "cantilever beam test" for his PhD work on fractures in weak snowpack layers (van Herwijnen, 2005). This was followed up by Dave Gauthier who further refined and carefully validated this test, settling finally on the name "Propagation Saw Test" (Gauthier and Jamieson, 2006b; Gauthier and Jamieson, 2006a; Gauthier and Jamieson, 2008b; Gauthier and Jamieson, 2008a). At the same time this test was also being independently tested and developed by Christian Sigrist and Juerg Schweizer at SLF (Sigrist and Schweizer, 2007). Since its introduction, the PST has been used by practitioners – especially for deep slabs – and has found an especially loyal following among scientists working on crack propagation. The PST allows that latter group to look at propagation with an intact slab unlike other tests (like an ECT) where destructive force is applied to the column to initiate fracture (see van Herwijnen et al. (2016) for a list of many of the different scientific studies that have utilized the PST).

At the same time the PST was being developed, a ski patroller who spent his winters at Copper Mountain and his northern hemisphere summers in New Zealand had a new idea. When Ron Simenhois contacted me in the mid-2000s, he outlined his idea for a new stability test. At that time neither of us knew that the PST was in development in Canada. Our discussion was not a new one for me since I often had folks tell me they had an idea for a test. My next step is always to ask them how much data they have for their new test, and the answer I typically get is a bit of mumbling about how they have done it a half dozen times but it works really well. However, the answer I got from Ron was quite different: "Well, I don't have all that much data. So far I only have 243 tests." The essence of Ron's idea was to initiate a fracture the same way it is done in a CT, but then see if it would propagate across a small column. Dubbed the Extended Column Test, the idea was simple and clean and it made physical sense. I analyzed Ron's data and we used that analysis to refine the method and recording of results. Subsequently, we enlisted a large group of folks in different snow climates to comprehensively evaluate the test. After several ISSW presentations and TAR articles (Simenhois and Birkeland, 2006; Simenhois and Birkeland, 2007; Birkeland and Simenhois, 2008; Simenhois and Birkeland, 2009; Birkeland et al., 2010; Simenhois et al., 2012; van Herwijnen and Birkeland, 2014), the test gained a strong foothold amongst professional practitioners and recreationists across both North America and Europe. In fact, a 2012 assessment by Doug Chabot and me on SnowPilot data showed that the ECT had gone from an experimental test in 2006 to the most common test in 2012 (conducted in nearly 80% of pits) (Birkeland and Chabot, 2012). At the same time the number of RB and SB tests dropped dramatically (to nearly zero), CTs dropped off just a little (to being conducted in about 65 to 70% of pits), and the PST made inroads into the database (conducted in about 15% of pits). Though still not as widely used as the ECT, I'm betting that PST number may have risen a bit in recent years.

Though stability tests have come a long ways in the last 35 years, I'm convinced that better tests are still to be developed as we improve our understanding of the snowpack and how it fractures. The tests we have are not perfect, and are still plagued by false stable and false unstable results. One limitation of PSTs and ECTs is that we remove the lateral support when doing the tests, thereby amplifying the deformation of the slab. This might lead to misleading results, or at the least it complicates our interpretation of the results. Ultimately with stability tests we run into scale issues. We are only testing small samples, and—as Ned Bair has pointed out in some of his research—those small samples are subject to significant edge effects (Bair et al., 2014). Further, Ned's work has also shown that longer tests may not be the answer (Bair et al., 2015), perhaps because the lack of lateral support and increased slab deformation inhibits the ability of these long columns to sustain fractures. To get more accurate assessments we may well need to test much larger areas, or even entire slopes. However, that would involve

too much digging and might be too difficult to trigger. Unless, of course, you are working at a ski area and can use explosives to test entire slopes during mitigation work!

So, be sure to play around with ideas you have and follow your hunches. If you regularly assess snow stability, see if you can think of a new way that we can make our evaluations. Is there a test that can still be done in a reasonable time frame, that doesn't require too much digging, and that can give us a better picture of snow stability? If you have ideas, play with them and collect some data and perhaps you can help introduce new ideas that will further the evolution of stability tests in our industry.

Acknowledgments

Thanks to Alec van Herwijnen, Ron Simenhois, and Doug Chabot for quickly reviewing this paper. I owe a huge debt to all the people I've worked with on various tests and techniques, as well as all of those folks with whom I've discussed stability tests over beers or at conferences through the years. There are way more people than I can list, but many of you are in the references and you should all know that I've appreciated all your encouragement, feedback, and data collection efforts! ▲

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Ron Simenhois performing an ECT in the Chugach in 2010. Photo Karl Birkeland

Well, I don't have all that much data. So far I only have 243 tests.

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ALEC VAN HERWIJNEN

Snowmen and the propagation saw test

Mid December 2016, sunny and mild weather in Davos, Switzerland, and hardly any snow in the mountains. It snowed early November, but down in the valley that snow is long gone, except below the snow guns. Up high, the snow has turned to facets and depth hoar, and when the winter will finally start we'll have a very weak base which will likely produce many avalanches during most of the winter. I have somewhat mixed feelings about the winter to come. As a skier I know it will likely be a bad winter and I'll have to stay away from steep slopes and use my rock skis for a long time. However, as a snow scientist I'm excited at the prospect of collecting good data with this weak layer. It will be interesting to see how this layer of depth hoar will react once buried. When will it become active? How long will it stay active? The Propagation Saw Test (PST) will be an essential tool for us to answer these questions.

Mid November 2001, cold and snowy weather in Rogers Pass, British Columbia, Canada. I had just started my PhD on fractures in weak snowpack layers with Bruce Jamieson at the University of Calgary but I knew nothing about snow. For the first time in my life I walked up a mountain in winter with skins glued to my skis. I had no idea what I was doing and fell every second kick turn. When we finally got to the top and dug a snow pit I discovered the Compression test (CT) and wondered what it was for. Tap, tap, tap, and a weak layer fractured. I suddenly forgot the struggle on the way up, forgot that my feet were freezing and I was intrigued to find out that such a simple artisanal test can be used to identify potential avalanche failure planes. I naively wondered if it was really that easy to find out if a slope can avalanche; I had a lot to learn!

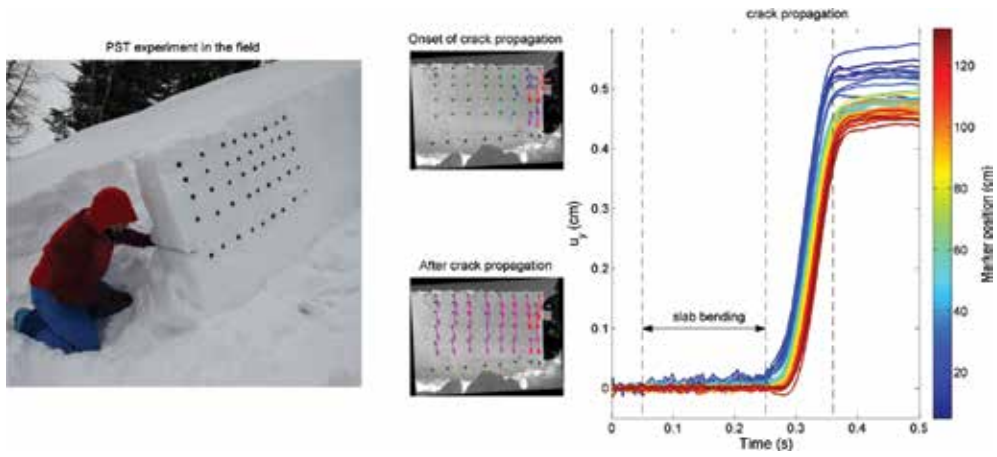
After my first winter in the mountains and some much needed rest, my new toy arrived in the summer of 2002: a shiny new high-speed camera *(Figure 1)*. Finally my PhD research could really begin by looking at fractures in the snow cover with unprecedented detail. With great anticipation we were getting ready for the next field season and familiarized ourselves the camera, in part by running over snowmen *(Figure 2)*. We were ready to take the camera into the field and as usual the deep snowpack at Rogers Pass gave us plenty of surface hoar weak layers to record movies of Rutschblock tests, CTs and drop hammer tests. To our surprise we saw that weak layers collapsed in every experiment we performed. Even though this was in line with the limited number of published observations on weak layer fracture (Johnson et al., 2001; Johnson et al., 2004; Schweizer et al., 1995), it did not coincide with the then deeply rooted view that avalanches start with a shear fracture (e.g. McClung, 1981).

FIGURE 1: The first day in the field with the high-speed camera. In the back, Bruce Jamieson is getting ready to jump on a Rutschblock test with his split board.

We had to make sure our results were reliable. To fracture weak layers in the field we were hitting on our shovel, dropping weights on small columns or jumping on a block of snow. Surely, this external surface loading was in part responsible for the collapse we observed in our videos. When discussing this issue with Bruce, he mentioned the work of Crane Johnson who had performed hundreds of beam tests to investigate the flexural strength of snow slabs by removing the support below the slab with a thick snow saw (Johnson et al., 2000). Bruce mentioned that on some occasions they had performed such beam tests by cutting into weak layers with some very interesting results: the slab did not break and the fracture would 'zip' through the weak layer (I forgot the exact scientific terminology). A few days later we recorded the very first high-speed movie of what later became known as the PST *(Figure 3)*. I couldn't wait to analyze the movie, and sure enough, after a few days of extracting images, improving contrast and tracking black markers, we again saw weak layer collapse during fracture confirming our previous observations *(Figure 4)* and I could publish my first paper (van Herwijnen and Jamieson, 2005).

Since these first experiments at the Fidelity study plot in Rogers Pass, the PST has become a well-established stability test, in particular amongst avalanche researchers. High-speed movies of PSTs can now be used to quantify relevant material properties of the slab and the weak layer (Figure 3; van Herwijnen et al., 2016a; van Herwijnen et al., 2016b) and the PST was the method of choice in various studies investigating the influence of snow cover properties on crack

FIGURE 2: To familiarize ourselves with the high-speed camera, running over a snowman with my car seemed like a good idea.



Nowadays, the displacement field measured in high-speed video recordings of PSTs can be used to investigate the different stages of the fracture process in snow and derive mechanical properties of the snow cover. (left) Franziska Zahner performing a PST experiment with markers in the slab for particle tracking. (middle) Measured displacement field at the onset and after crack propagation. (right) Slope normal displacement u_y with time showing bending of the slab prior to crack propagation and weak layer collapse during propagation.

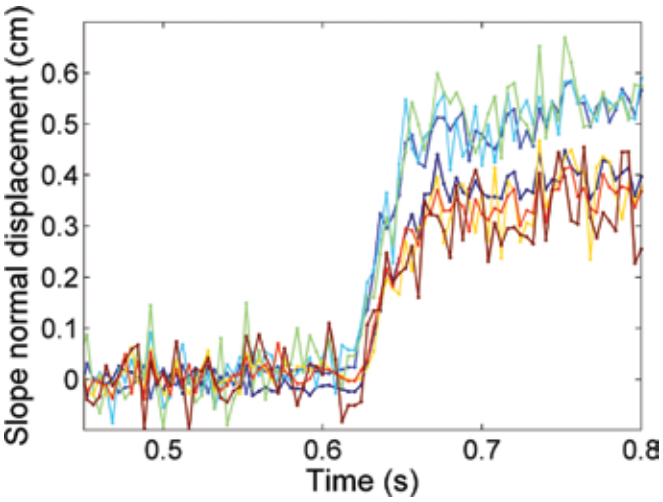


FIGURE 4: Measured slope normal displacement with time clearly showing weak layer collapse during fracture.

propagation, both in the field and through numerical simulations (e.g. Birkeland et al., 2014; Gaume et al., 2015; Reuter et al., 2015; Schweizer et al., 2016). It has provided us with a wealth of knowledge on snow fracture, has triggered the development of new theories for avalanche release (e.g. Gaume et al., 2016; Heierli et al., 2008) and has kept many snow researchers off the streets. Nevertheless, the limitations of this test are well known (Bair et al., 2014a; Bair et al., 2014b) and some of the results have highlighted the need for a more thorough understanding of fracture mechanical processes in snow, including the role of visco-plastic deformation of snow and the dynamic phase of crack propagation. This will require recording many more movies of PSTs to develop and validate the next generation of avalanche release models.

This winter I will whip out a compact digital camera from my pocket to record high-speed movies of PSTs on the layer of depth hoar. The movies will be of much better quality then during my PhD research and when I get back in the office, they will be analyzed in about 15 minutes. If I use the app developed by Ron Simenhois, I can even analyze movies in near real-time on my smart phone (Simenhois et al., 2016). My bulky high-speed camera with its poor resolution, heavy battery and laptop have retired and can stay at home. But the PST still is my favorite test to evaluate and quantify snow stability and will remain a trusty companion to study fracture in snow for years to come. ▲

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FIGURE 3: Cam Campbell putting the finishing touches on one of the first PSTs to feature in a high-speed video in January 2003.

I naively wondered if it was really that easy to find out if a slope can avalanche; I had a lot to learn !

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Alec van Herwijnen did two Master's Degrees before moving to Canada to work on his PhD with Bruce Jamieson. Following this work he landed postdoctoral research positions at SLF and Montana State University before securing a permanent position at SLF as a Research Scientist and the Team Leader for the Avalanche Formation group. Alec is best known for his pioneering work utilizing Particle Tracking Velocimetry (PTV) to analyze snow fracture. He received the AAA's Honorary Membership award at ISSW 2016.

DAVE GAUTHIER

Parking garages and brass hammers

It all started for me when I weighed my backpack after a long day of ski-touring to and from a remote research site. That was 2005, and my pack was over 40 lbs. In it, I had stuffed a contraption made of a 1-foot square impact plate, steel guide rods, and various—yes, seriously—brass 'hammer' weights to drop on isolated columns of snow. We were trying to quantify propagation propensity in cross-slope (just like the ECT) and downslope (just like the PST) isolated columns. It was obvious that this drop-hammer business would never become a 'practical' field test, which was the nominal objective of my research. Bruce had been telling us about the glory days of Crane Johnson's cantilever beam tests and how every so often a crack would shoot across the weak layer in the test beam ahead of the 5-cm thick saw, and how Alec van Herwijnen recorded high-speed videos of the same in beam tests on slopes, with fully isolated columns. There was a lot of energy around ASARC at that time, after the great work of Alec and Crane and others in observing crack propagation, measuring its speed, and demonstrating that there was collapse in weak layers even on steep slopes. Trying to connect the dots, we started batting around ideas like 'parking garage (collapse) theory' and other similar notions. At the end of one particularly frustrating day of drop-hammer testing downslope columns in 2005, I was ranting to Ken Matheson about parking garages and heavy field gear, wondering aloud whether maybe all we had to do was damage the weak layer crystals, without leaving a thick gap from a specially-made saw, to bring down the whole 'parking garage'. Ken, being the wise man that he is, grabbed my 2 mm thick Life-Link saw, and just dove into a 30 cm wide, 3 m long column with surface hoar buried about 85 cm deep. Sure enough, after about 50 cm of cutting the crack zipped to the end of the column, and the slab slid off on to the pit floor. Just like an avalanche! Sort of...

For the next few winters we built on the pioneering work of Crane and Alec and others. We did hundreds of these tests, on slopes from totally flat to over 40-degrees, with slabs from 10 cm thick up to 2 m or more, and column lengths from 15 cm all the way up to 3 m. We cut up, down, and from the middle, in all different weak layers. One amazing day Bruce and I spent about 6 hours digging out a single, 3 m long, 2+ m tall column in the flats at treeline, to get access to a (very) buried surface hoar layer. It had nice propagation to the end of the column, after about 60 cm of cutting. It was…memorable. We did a whole winter of just figuring out the test geometry and another whole winter chasing whumpfs and avalanches to validate (calibrate?) the results to real evidence of propagation propensity. It was great to discover part way through that Christian Sigrist and Juerg Schweizer were developing an identical method for their research. Somewhere in there Karl Birkeland asked what the new test was called. And so the 'Propagation Saw Test' was born ▲.

BRUCE JAMIESON

The early days of the propagation saw test

When does a cantilever beam test become a propagation saw test?

One of ASARC's first graduate students, Crane Johnson, undercut slabs with a 2 cm thick saw to assess the bending strength of the slab (Johnson et al., 2000). The columns (cantilever beams) were parallel to the slope and many were on almost level terrain *(Fig. 1)*. One day, Crane cut along a thick surface hoar layer and the crack shot from the saw cut to the end of the column *(Fig. 2)*. The next test did the same. We were gobsmacked! Although the test was intended to assess the bending strength of the slab, it was telling us something about how a crack propagated in a weak layer. Serendipity had struck. For his MSc thesis, Crane studied remote triggering and crack propagation – noting the importance of weak layer collapse. He also measured the speed of a propagating crack with geophones, and derived an equation for crack propagation along a collapsing weak layer in low-angle terrain.

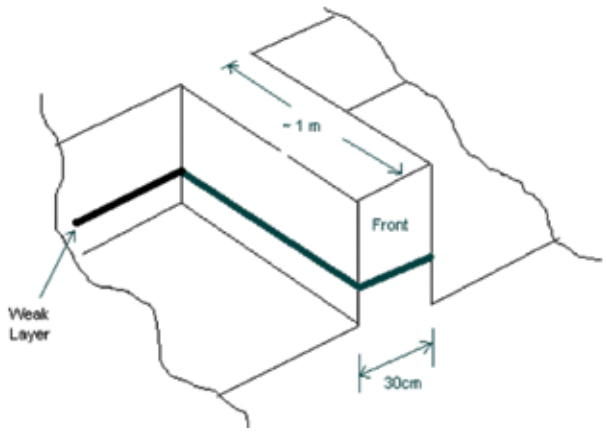

FIGURE 1: Crane Johnson's version of the cantilever beam test. The length of the beam is parallel to the slope, and the saw cut is along the weak layer (thick black line). Taken from Johnson et al. (2000).

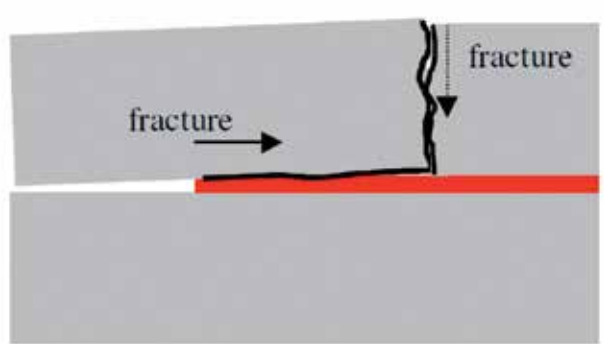

FIGURE 2: Crane observed bending in the slab, and propagation along persistent weak layers. Because the beam was not isolated from the snowpack (Fig. 1), most tests resulted in a crack (fracture) through the slab. He argued that the crack through the slab ran down from the surface. Taken from Johnson (2000, p. 65).

In the winter of 2004, Alec van Herwijnen (the camera wizard) was studying fracture speed by videoing black markers stuck in the side of columns, including two cantilever beams undercut with Crane's thick saw. He presented his results at the 2004 European Geophysical Union conference in Nice, France (van Herwijnen and Jamieson, 2005).

The big dig with Bruce, c. 2006. Photo Dave Gauthier

A deep PST on the flats, this time in depth hoar. Hot chocolate powder made for a better video, c. 2006. Photo Dave Gauthier

In the winter of 2005, Dave Gauthier and research technician, Ken Matheson, dragged a regular snow saw – not nearly as thick as Crane's custom saw – along a persistent weak layer in a column parallel to the slope. The fracture shot to the upslope to end of the column. Gob-smacked again! Even the cut from a 2 mm thick saw could transition to a propagating crack!

The PST: Is it for research or forecasting?

Until around 2004, the ASARC team and likely others were thinking of these beam tests as a promising research tool. Probably because we were getting short saw cuts on persistent weak layers that were releasing slab avalanches on the same day, Dave Gauthier began to study the potential of the propagation saw tests (PST) for avalanche forecasting (Gauthier and Jamieson, 2006). This led to a calibration of the forecasting version of the PST (e.g. Gauthier and Jamieson, 2008; Greene et al., 2010; CAA, 2016). At the same time as Dave Gauthier was developing the forecasting version of the test, Christian Sigrist did the first comprehensive study on fractures in snow in Switzerland (Sigrist, 2006). He took his fracture mechanical experiments to the field and independently developed the PST method and provided the first quantitative analysis of the PST, highlighting the importance of the slab and weak layer interaction (Sigrist and Schweizer, 2007).

Research versions of the PST abound. They are closer to the crack propagation that releases slab avalanches than the forecasting version. Most are longer than the forecasting version. Some involve not cutting the upslope end of the column (Fig. 1). Others cut the upper and lower end of the column perpendicular to the slope. However, none of the research versions have, to my knowledge, been calibrated with a large dataset of slopes that did, and did not, propagate cracks in weak snowpack layers.

Is the PST in my quiver?

Before answering that question, I want to emphasize the quick field observations that do not involve digging. I worry that our fascination with instability and propagation tests compromises the attention – especially by advanced recreationists – appropriate for quick field observations like recent avalanches, snowfall, wind transport, solar radiation, whumpfs, shooting cracks, etc. These quick observations all operate on the scale of avalanches whereas instability and propagation tests only operate on a small piece of the snowpack.

When I dig these days as a ski tourer and educator, I do mostly extended column tests (ECT), compression tests (CT) and deep tap tests (DT). When I am curious about a deep persistent weak layer that is producing sudden fractures in deep tap tests but not avalanches in nearby mountains, I often do a propagation saw test. I get a rush every time the crack shoots to the end of the column after dragging a saw under less than about half of the column. ▲

Although the test was intended to assess the bending strength of the slab, it was telling us something about how a crack propagated in a weak layer.

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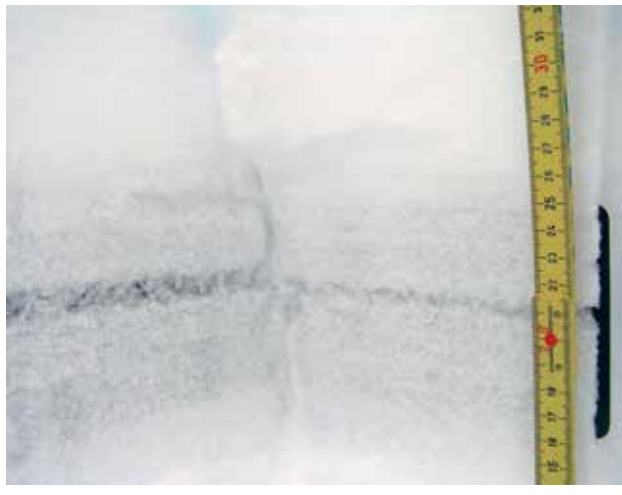
Bruce Jamieson is enjoying work as a consultant, trainer and half-time academic. Bruce is rather fond of ski touring when the surface hoar is on the surface.

Photo of Bruce at CSAW by Bill Cotton

The big dig PST weak layer on the right after propagation, on the left undisturbed, c. 2006. Photo Dave Gauthier



When the fracture propagates to the end of the column and the block of snow slides towards you, it is a reminder of the power of moving snow and the reality of being in avalanche terrain.

MICHAEL CONLAN

Propagation saw test results for deeply buried weak layers

When I was first introduced to the Propagation Saw Test (PST) during a training week many years ago, I wondered if I would ever use it. That winter, a prominent surface hoar layer was buried across western Canada on February 12 (the Feb 12 layer), followed by substantial snowfall for the remainder of February and March. For the first few weeks after burial, the snowpack tests we have in our toolbox were producing unnerving results (sudden fracture characters, whole block releases, high propagation potential results). After a few weeks, the Feb 12 layer was buried between 1 and 2 m down in the snowpack. The compression test has a maximum recommended depth of 120 cm. The Extended Column test is meant to be applied for column depths between 80 and 100 cm, which is similar for the Rutschblock test. For the remainder of the winter, we were left with two snowpack tests that targeted the Feb 12 layer, the Deep Tap test (DT) and the PST.

I used the PST extensively during my research with the Applied Snow and Avalanche Research group at the University of Calgary (ASARC), both for my own research of studying persistent deep slab avalanches as well as for my colleagues' research of persistent weak layer evolution. For my research, the weak layer depths were generally between 100 and 300 cm in depth, which required us to use these targeted snowpack tests. The DT test provides modest information on propagation potential when analyzing the fracture character, but for determining high-quality information on the propagation potential in these deep weak layers, the PST is the test of choice.

For 63 persistent deep slab avalanches mostly in the Columbia Mountains of western Canada, we performed 111 PSTs during fracture line and representative snow profiles *(Figure 1)*. The distribution of the PST results is shown in Figure 2. Combining all test results, the PST propagated to the end of the column (End result) 93% of the time; four of the PSTs arrested before reaching the end of the column (Arr result) and four produced slab fractures (SF result). The majority, 72%, of the PSTs had cut lengths less than 50% of the column. Applying the standard of the test requiring an End result and the cut length being less than 50% for a high propagation potential result, 68% of the failures were classified as having high propagation potential.

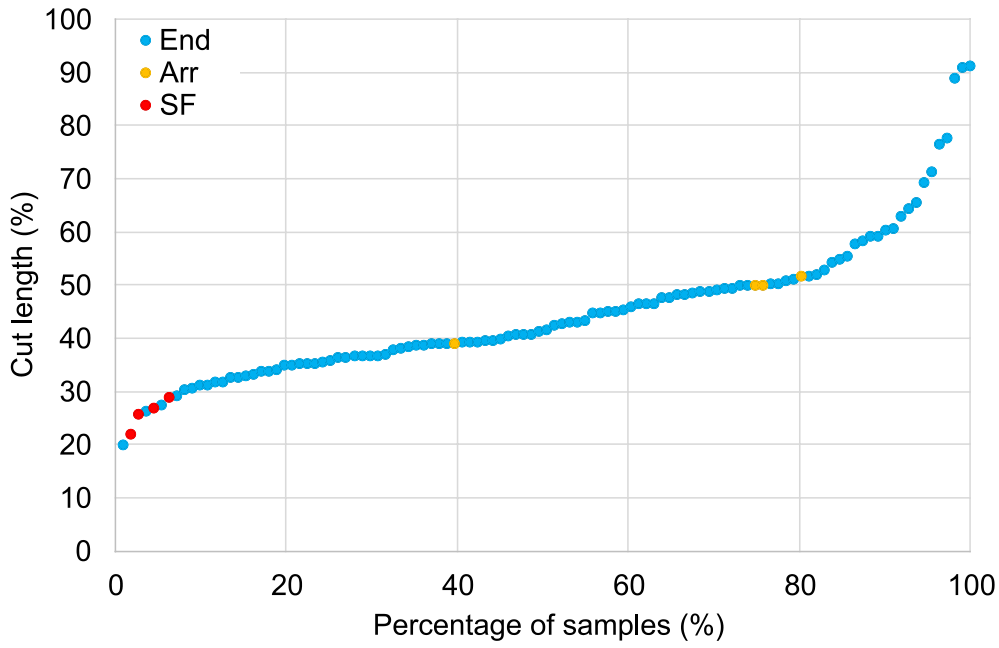


FIGURE 1: Distribution of the PST results in profiles near persistent deep slab avalanches.

We predicted that the majority of the PST results should have indicated high propagation potential due to the proximity of the tests to released slab avalanches, where propagation of the weak layer occurred. All of the tests were conducted within a few days of the release and in areas of the snowpack deemed representative and not influenced by the avalanche. Assuming the tests were representative of the conditions that released the avalanches, we would expect all of the PST results to indicate high propagation potential. Since only 68% of the PST's indicated high propagation potential, we propose that a threshold cut length of 60% along with an End result may be a better predictor of propagation potential for deeply buried weak layers. If this were the case, 82% of the PST results in our dataset would indicate high propagation potential. We recognize that bonding in the days after the avalanche may have increased the cut lengths.

A primary limitation of the PST to study deeply buried weak layers is the amount of time it can take to prepare each test. Recall that the slab length is to be equal to the depth to the weak layer; i.e. a weak layer buried 200 cm requires a column that is 200 cm long in the upslope direction. Digging out such a test can take an hour or more, which may be impractical for certain situations. That being said, there are limited other approaches in our toolbox to assess for fracture propagation potential, particularly for deeply buried weak layers, so we might just have to bite our lip and do what it takes to get the data required.

One of my favorite aspects of the test is how real the results seem. When the fracture propagates to the end of the column and the block of snow slides towards you on your knees, it acts as a reminder of the power of moving snow and the reality of being in avalanche terrain. A typical 'Woah…' generally runs through the crowd of observers. Years and hundreds of PSTs later, it is probably my favorite snowpack test to perform for some of these reasons. ▲

Michael Conlan completed his PhD in snow mechanics, focusing on improved forecasting for persistent deep slab avalanches. Since graduating, he has been working as an engineer on a variety of avalanche-related projects.

A 2.2 m long PST adjacent to a persistent deep slab avalanche. The persistent weak layer is highlighted by the dashed line. The saw is located at the location where the propagation became self-propagating within the persistent weak layer. The result was PST 91/223 End.

RON SIMENHOIS

A few words on how the ECT came about

In mid-November, I received an email from Lynne. She reminded me that it has been 10 years since we first presented the Extended Column Test (ECT) and asked me to write a few words on how it came about. The ECT is a byproduct of a horrible snow season. 2004 was a notably bad ski season in the Mt. Hutt Range in New Zealand. We had hardly any control work and the ski surface consisted mostly of rocks and occasionally some clear ice. In fact, on most days, the steel rails at the terrain park were the softest ski surface you could find. Those long days in the patrol shack gave me ample time to read Bruce Jamieson's (2003) and Karl Birkeland's (2002 and 2004) papers on avalanche release, the importance of crack propagation and what shear quality has to do with it. Armed with my newly acquired knowledge, I went to look at the snow and realized to my dismay that assigning shear quality appears to be somewhat of a subjective process and I couldn't figure out how to fit different fractures into one category. I needed a different method to test if a slab/weak layer combination could carry a fracture away from point of initiation, and over distance. Using a column that extends beyond where the crack is initiated appeared to be a set-up worth investigating.

Why a cross slope 90 cm column?

We initially tried the ECT with column sizes of 60, 90, 120 and 150 cm. We also tried different column orientations—cross slope and slope parallel. We tried center ECT which rarely propagated. We eventually honed in on a cross slope, 90cm long column as it appeared to have the best combination of test's accuracy with minimal digging effort.

How did we test the ECT?

We tested the ECT using typical ski patrolling tools. We used explosives to tests and reduce the avalanche hazard and we opened the slope for the masses to ski. We than compared our stability testing with explosives and skiing to our ECT results. Our relatively heavy loading method to determine slope stability may explain the relatively high false unstable results of the SnowPilot dataset (18%) (Birkeland and Simenhois 2008) in comparison to our initial results of 2%.

Why we don't use the number of taps as stability indicator?

We didn't find a strong correlation between the number of taps and slope stability when we compared the ECT results to our slope stability assessment. This may be due to the relatively heavy loading methods we used to test slopes stability. Regardless, we decided to omit the number of taps from the stability assessment when using the ECT. We also had several instances where we could not initiate cracks at all (ECTX) on both stable and unstable slopes. In other words, ECTX is not an indication of either slope stability or instability.

Other work we did with the ECT:

In addition to using the ECT as a stability test, we also used an ECT-like setup for several field based studies. In 2008, we showed that cracks are more likely to propagate from areas where the slab is relatively thin to areas where the slab is thicker than the other way around. We also showed that crack propagation is more likely when slab's temperature warms to and close to freezing temperatures. In 2010 and 2012 we demonstrated that ECT results are independent of slope angle. In other words, we can conduct our stability tests on flatter, safer terrain if we have a good reason to believe that the snowpack we test is similar to the snowpack we ski.

Karl Birkeland and Alec van Herwijnen also used an ECT-like test to study crack propagation (2012). Ned Bair and others used the ECT to investigate storm snow slab avalanches (2012) and the influence of edge effects on crack propagation in snow stability tests (2014)

What next:

My hope is that newer and better stability tests will be developed as we improve our understanding of avalanche release. In the meantime, we should recognize that the ECT is not perfect. We should try to map conditions where the ECT performs well and when it does not. The ECT is a useful tool, but the tool is only as good as the observer. Both how the test is performed and where it is performed are critical to the utility of the results. We should do more work on the effect of site selection on stability tests and how to identify an appropriate site.

On a personal note:

The last 10 years left me both surprised and humbled by the acceptance of the avalanche community. I have been shown appreciation and was credited, sometimes more than I deserve. I would like to acknowledge my wife Jenny and Karl Birkeland. Without them I would not have presented the ECT to the larger community. I would also like to thank the many others that worked or talked with me on these projects. Finally, if you think you have a good idea, we want to hear about it! We don't care if you are ski patroller, mountain guide, a forecaster, or a researcher. Test your idea and send it to Karl Birkeland (he's just not busy enough these days). ▲

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Acknowledgments:

The list of people that have helped me over the years is too long to list in this issue. Several of these people are mentioned in this article and the references. I would also like to thank Ethan Greene and Brian Lazar for reviewing this article.

Ron Simenhois has worked as a ski patroller and avalanche forecaster in Colorado, New Zealand, and Alaska. In addition to his forecasting jobs, he has also collaborated with scientists from the US and Europe on applied research projects. Ron's work includes the development of the Extended Column Test with Dr. Karl Birkeland as well as other avalanche forecasting tools. Ron enjoys spending time outside with his wife and two kids.

If I am worried about a deep weak layer, how likely am I to get a useful test result from the ECT?

IAN HOYER

How low can you go?
Changes in ECT results with varying depths

Ten years ago, Simenhois and Birkeland (2006) introduced the Extended Column Test (ECT) and since then, it has been widely adopted across the avalanche community. Over these years, avalanche professional discussed how it performed on weak layers at different depths. Ross and Jamieson (2008) suggested that it performed best on weak layers buried between 30 and 70 cm, but no one has specifically set out to look at where the test's performance degrades. This study examines the limitations of the ECT, and can hopefully help inform use of this test by both professionals and recreationalists (Hoyer et. al, 2016).

Methods/ Results

I analyzed data submitted to SnowPilot between 2007 and 2016. SnowPilot is a free software program that allows users to record and graph snow profiles (Chabot et al., 2004). Users can also submit their data for research purposes. In the nine years studied, a total of 386 users submitted 5013 ECT results and associated snow pits to the SnowPilot database. While these users are diverse in geography and experience, most identify themselves as avalanche professionals (Birkeland and Chabot, 2012).

To look for general trends in this dataset, I plotted a scatterplot of number of taps in ECTs vs weak layer depth *(Figure 1)*. For both ECTP and ECTN results, there is a trend of increasing ECT scores (p-value < .01) with increasing depth. There is also an increasing proportion of ECTP (propagating ECT) to ECTN (non-propagating ECT) results with increasing depth. Around 25% of ECTP results have weak layer depths less than 30cm, 45% have depths between 30 and 70 cm, and 30% are on weak layers deeper than 70 cm. Deeper than ~35 cm, the frequency of both ECTP and ECTN results decreases with increasing depth. However, this is a gradual trend, with 245 ECTs initiating a fracture on a weak layer deeper than 100 cm. A total of 137 (55%) of these were ECTP results, which is 9% of all ECTP results in the database.

I also wanted to know: *"if I am worried about a deep weak layer, how likely am I to get a useful test result from the ECT?"* To answer this question, I looked at the distribution of ECTX results at increasing weak layer depths. ECTX results do not have a depth associated with them, as they indicate that no fracture initiated on any layer in the column. To allow for comparison, I assigned ECTX results the depth of the "layer of greatest concern", a value selected by the observer. I then compared ECTX results to

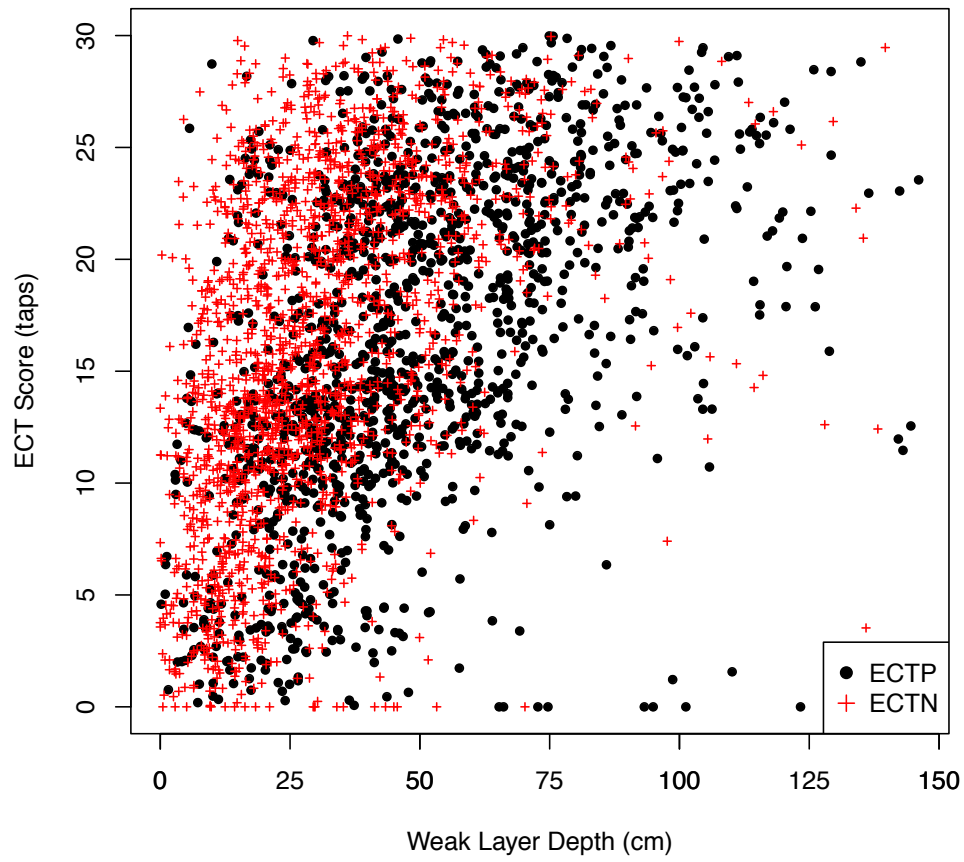

FIGURE 1: Scatterplot of ECT score and weak layer depth, showing ECTP and ECTN results spread over a wide range of depths.

ECTN and ECTP data from ECTs performed on the "layer of greatest concern" in the profile. A normalized stacked bar plot shows the changing proportion of ECTP, ECTN, and ECTX results *(Figure 2)*. The proportion of ECTX results generally increases and proportion of ECTN results generally decrease as depth increases. The proportion of ECTP results increases until ~80 cm and then decreases slightly as ECTX results increase. At depths around 100 cm, ~2/3rds of ECTs initiate a fracture. Even at depths of 120 cm, about 40% of ECTs initiate a fracture on the layer of greatest concern, with a high proportion of those tests propagating.

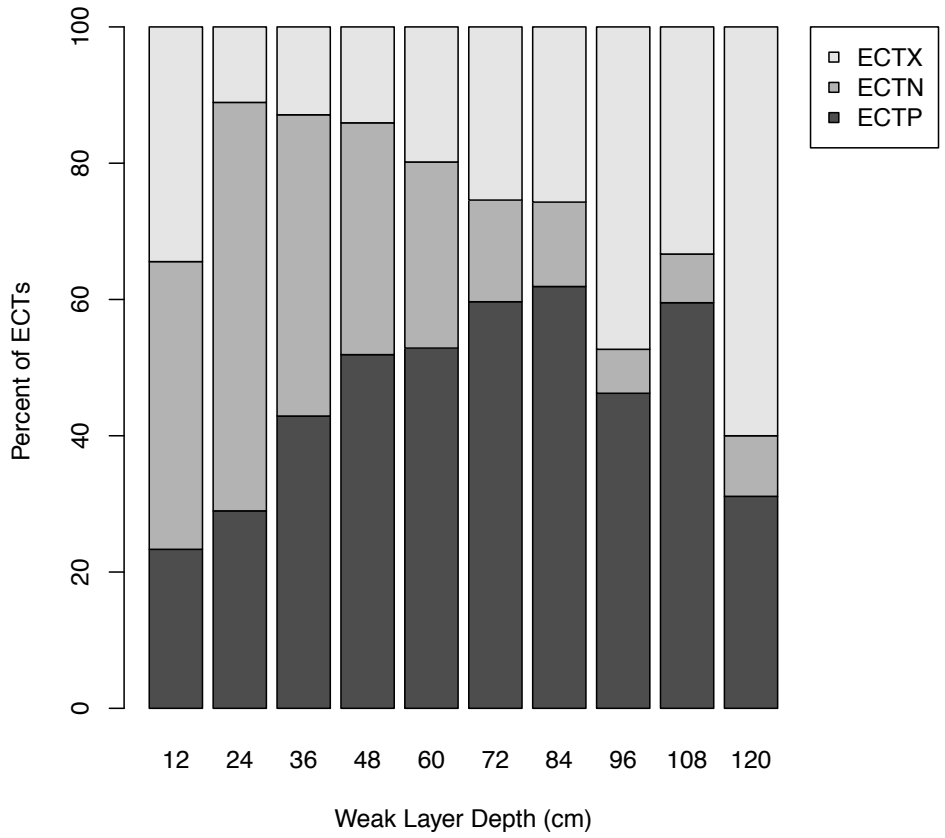

FIGURE 2: A normalized stacked barplot showing the weak layer depth distribution of ECTX, ECTN, and ECTP results. This plot shows that fractures continue to be initiated in ECTs at significant rates even at depths greater than 1 m.

Discussion

These results show that cracks routinely initiate and propagate in ECTs on weak layers shallower than 30 cm and deeper than 70 cm. More than half of the ECTPs in the SnowPilot dataset were on layers outside that range, and there is nothing in the results to suggest that the ECT is less reliable at shallower or deeper weak layer depths. With 30% of ECTP results breaking on weak layers deeper than 70 cm, the ECT appears to be effectively capturing propagation for slab thicknesses significantly greater than the 70 cm maximum proposed by Ross and Jamieson (2008). Although the number of tests in the SnowPilot dataset decreases at greater depths, there is no indication of a clear cutoff depth where ECTP results are no longer possible. A large proportion of ECTP results (25%) were also on weak layers less than 30 cm deep. This suggests that the ECT can effectively capture propagation at shallow depths.

Conclusions

This study suggests that the ECT can provide information on weak layers buried at a variety of depths. Limiting use of the ECT to a prescribed band of slab thicknesses means missing potentially valuable data. The high proportion of initiating ECT results on weak layers buried over a meter deep suggests that the ECT can be a useful tool for testing weak layers at those depths.

The take home message is simple: regardless of weak layer depth, there is a good chance of quickly getting useful data when performing an ECT.

Acknowledgements

I'd like to thank the co-authors of my 2016 ISSW article that explored the same topic in more depth: Ethan Greene, Doug Chabot, and Karl Birkeland. I appreciate the insights and refinements each of you contributed to this research. ▲

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MARK STAPLES

Forecaster perspective

Beam tests give the ability to measure propagation directly instead of using indicators like shear quality or fracture character. The ability to measure and quantify propagation eliminates the need for subjective descriptors to estimate propagation because we get this information directly in beam tests. Another advantage is beam tests are much less subjective than other tests. With the Extended Column Test (ECT), did it propagate or not? With the Propagation Saw Test (PST), did it propagate to the end? If so, what were the cut length and beam length? Whether or not a column propagates is an easy question to answer. At avalanche centers we receive observations from a wide range of people. Having objective tests is a huge advantage in comparing results between different observers.

How do forecasters use these tests? Before using beam tests, we start with bull's eye information like recent avalanche activity, cracking, collapsing, snowfall, and wind which are the foundation of every forecast. Bull's eye information is like the ABC's of medicine,information we return to when stability and snowpack conditions are confusing because it's information we know with certainty.

After evaluating bull's eye information, we turn to beam test results which help us forecast both rising and decreasing danger. Forecasting a rising danger is easy in many cases. Forecasting a dropping danger is often more difficult. Using the medical analogy, beam test results are like vital signs. A single set doesn't have much meaning when forecasting for an entire mountain range. Instead, we analyze the results of many tests through both space and time. With the ECT specifically, tracking ECTP and ECTN/X results can be very helpful. We often see many ECTP results during a time of instability. As conditions stabilize, we see a mix of ECTP and ECTN results until finally the majority of results are ECTN/X.

While the PST is interesting and potentially very useful, there is a much smaller data set relating it to stability and avalanche danger. The PST commonly answers research specific questions which can be very different from a forecaster's questions. Additionally, one early data set showed high rate of false stable results with the PST, which makes it a dangerous test to evaluate stability. In personal experience assisting with research, I have witnessed stability go up and down and not correlate with PST results which varied along a much more linear curve. As we learn more about avalanches and more about the PST, it may become a very useful tool but for now it seems like it should be used with caution.

Unfortunately there is a lot we still don't know about avalanches. Beam test have helped us inch forward and are now an integral part of the forecasting process. ▲

NED BAIR

Isolation in beam tests

One thing that all of the stability tests discussed here have in common is that they are isolated from the surrounding snowpack, almost always on four sides. Why do we isolate these tests? Simply put, to weaken the snowpack. Technically, since isolated edges cannot transmit stress, they act as stress concentrators (Bair et al., 2014). Thus, cracks in tests with isolated sides are subjected to much higher stress than those without. This statement is intuitive and can be easily verified. The next time you are performing a stability test, try only isolating one side (i.e. the front). I'll bet you cannot get the test to fail.

Given this need for isolation, the dimensions of the beam or column become important with regard to edge effects that cause differences in stress intensification. My review of the literature shows that the dimensions of the two most popular tests, the Extended Column Test (ECT) and the Compression Test (CT), have little in the way of rigorous testing, although the 30 x 90 cm dimensions of the ECT may be close to optimal given its high unweighted accuracy (84%, Moner et al., 2008; Simenhois and Birkeland, 2009; Winkler and Schweizer, 2009; Bair et al., 2015; Techel et al., 2016). We've experimented with a 2 m-wide ECT (Bair et al., 2015) and found that it does reduce false unstables (an unstable test result in a stable snowpack), but at the expense of an unacceptably high false stable rate (a stable test result in an unstable snowpack). Longer ECTs also show some interesting results rarely seen in the 0.90 m standard ECTs, such as a slab fractures ~70 cm past the shovel edge (*Figure*).

Personally, I find the CT to be too small, as there is almost always some kind of failure regardless of the strength of the snowpack. This finding is supported by the high false alarm rate for the CT (Schweizer and Jamieson, 2010) even when fracture character is included (van Herwijnen and Jamieson, 2007). In terms of dimensions, the Propagation Saw Test (PST) has undergone far more rigorous testing in its development (Gauthier, 2007) than the ECT or the CT, although recent work shows that a 1.5 – 2.0 m beam is preferable for studying crack propagation (Bair et al., 2014; Gaume et al., 2015). Despite having a higher unweighted average accuracy than the CT with fracture character (80% for the PST vs. 68% for the CT w/ fracture character, Ross, 2010; Schweizer and Jamieson, 2010), the PST has been slow to catch on, being used in fewer than 1 in 6 pits recorded in SnowPilot (Birkeland and Chabot, 2012; Bair et al., 2013), possibly because of its unacceptably high false stable rate (37% vs. 13% for the ECT, Schweizer and Jamieson, 2010).

Test geometry may also play a role in the flat trend of test scores versus slope angle documented in the ECT, CT, and PST (Heierli et al., 2011; Bair et al., 2012; Birkeland et al., 2014), particularly for the ECT and CT, with their vertical walls, as slope normal walls have been used for research with the PST. An excellent discussion on this topic is provided by Gaume et al. (2016). Note that the seminal finding that stability tests can be performed on safer and lower angled-slopes (Birkeland et al., 2010) remains valid regardless of these geometric effects.

The rarely seen ECT slab fracture ~ 70 cm from the left edge of the shovel on a 3 m ECT. Contrast has been enhanced in this image.

In summary, these small tests are attempts to simulate little avalanches and we isolate the columns or beams in them from the rest of the snowpack so that the test will fail with much less force than is required for the entire snowpack to fail. If the snowpack is touchy enough that it fails on approaching a pit, then you really don't need a stability test! Column/beam isolation comes at the expense of edge effects that we do not fully understand, but with more research we will gain better insight into how these tests results can be extrapolated to full-sized avalanches, thereby improving our ability to assess slope stability. ▲

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CRAIG STERBENZ

The "bridgeblock" cantilever beam test

It was 20 years ago, after attending ISSW 1996 in Banff, that I decided to develop a new "snow stability" test that would give me more information than I was getting from the "stability tests" that were currently in vogue. Standard "snow stability" tests 20 years ago were all, in reality, snow "instability tests." The shovel shear test, the compression tests and the Rutschblock were all focused on instability, trying to locate and quantify the weak layers in the snowpack.

I was working as a snow safety technician in the San Juan Mountains in Southern Colorado where the snowpack is often comprised of nothing but faceted snow. I've been quoted as saying, "Depth hoar lives in the San Juans, but only visits other mountains." I didn't need a test to help me find or quantify the weak layer, it was always there and it was always weak. I needed a test that would tell me why it wasn't avalanching when all the ingredients were there.

As I wrote in my ISSW 1998 paper, "…the relationship between stress and strength in the snowpack remains complex and important. Stress must equal or exceed strength for failure and avalanche release. The shear fracture or collapse within the weak layer must also precipitate **tensile failure** of the overlying slab for avalanche release to occur. Because the weak layers are so important for avalanche formation, little has been done to evaluate the strength of the slab layer. The "**Bridgeblock**" or cantilever beam test is a simple field test designed to evaluate the **tensile strength** of the slab material overlying the bed surface weakness."[1]

In the late 1960s Ron Perla had done some work with the cantilever beam test but no-one had revisited it for nearly 30 years. In fact, the general consensus amongst practitioners was one of un-acceptance of the concept of a strong slab acting as a "bridge" over weak layers. The "Bridgeblock" test was developed to look at 'bridging' and the role played by slab strength in avalanche release. It does not involve the weak layer and as such is not a stability test (instability test). In fact, the underlying weak layer is removed entirely as the first step of the test. A 1m. x 1m. section of the undercut slab is then sequentially cantilevered by cutting back the flanks until it fails in tension and fractures. The Bridgeblock differs from traditional, or standard, cantilever beam tests in that it does not use a uniform slab thickness, rather it uses the in-situ slab thickness. For a description of the test procedure see the latest edition of SWAG.[2]

At the time I was developing the Bridgeblock test Art Mears was conducting another study using the cantilever beam test to look at changes in the strength of new snow layers over time. We presented our concurrent but independent studies at ISSW 1998 in Sun River, Oregon. Apparently our presentations sparked some interest and another cantilever beam test study was presented at ISSW 2000, in Big Sky, Montana by Ben Johnson, et. al., from the University of Calgary.[3] There haven't been any published studies specifically using the cantilever beam or Bridgeblock tests since 2000 and It's doubtful that anybody is currently using the Bridgeblock test on a regular basis. In fact, it's doubtful that its use was ever widespread, in part because of some difficulty in interpreting or quantifying the results and in part due to a small target audience. The Bridgeblock test still needs some further development and fine tuning if there are any inquisitive, energetic, interested souls out there.

Slab strength, or stiffness continues play a role in most, if not all, of the current fracture propagation tests. As noted by Ben Johnson in 2000, fracture propagation through a weak layer is driven by a "flexural wave in the overlying slab. Energy is transferred through the overlying slab to progressively collapse the weak layer… with the stiffness of the slab controlling the speed of propagation."[3] Recent PST studies presented by Birkeland, et.al., at ISSW 2016 in Breckenridge, Colorado[4] seem to be taking a closer look at the overlying slab, and how increasing the load on the slab effects fracture propagation. Incorporating cantilever beam tests in with the PST data might help shed some light on future fracture propagation studies. **How might fracture propagation in a weak layer change over time as new snow sitting on the overlying slab gains strength?** ▲

Preparing to conduct—and high-speed film—a modified PST for research in 2013. Photo Packy Cronin

If Yoda studied snow his take would be "It's propagation or propagation NOT, there is NO Q."

— Bill Anderson
AAI, Exum, and JHMR

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After spending several years with his head stuck in the snow, **Sterbie** is now a recently retired and hopefully recovering snowaholic who's still trying to figure out what he wants to be if he ever grows up.

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