

38.4

APRIL 2020

On Saturday, February 15th, a snowbiker triggered a 5–6 foot-deep avalanche that ran 100 feet wide and 500 feet vertical in the Taylor Fork of Montana's Madison Range. It broke near the ground on faceted snow from November. Photo Matt Seifert

THE AVALANCHE REVIEW



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I am lucky to have experience as a skier and snowmobiler prior to getting a snowbike two years ago. I use backcountry skills drawn from each of those disciplines: terrain management, smart travel decisions, and snow assessment are different for all three sports. This experience helps me convey to my students sport-specific points of how to travel safely in avalanche terrain.

—Bill Radecky, *What's that Sound?* page 10



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A3 STATEMENT OF PURPOSE

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Eskimo proverb: "When you come into new country, listen a lot."

First tour day of a hut trip: gathering information about our layering. SLED trip 2019–20. Lynne Wolfe in red, with LaDean McKittrick, Dan Powers, Andi Stoffel. Story page 7. Photo Peter Gauer

FROM THE EDITOR

BY LYNNE WOLFE

Sun's getting higher in the sky but the powder hasn't yet turned to corn. I'm sequestered in my home for the time being, with the distinct privilege of writing to you, my avalanche community. I hope that this packed issue helps sustain your intellectual curiosity this spring. I also hope to see you all in Fernie in October, but who knows what the future will bring. Stay healthy, friends.

Usually the April issue theme revolves around human factors and decision-making. That theme bled backwards into the February issue, so 38.4 presents mini-themes with two notable refrains, psychological first aid and a look at forecasting, specifically under-forecasting and bias.

Regarding the first topic, I'm glad that the avalanche community is continuing to freely discuss the potential psychological impacts of our work. Starr Jamison and Pete Earle lay out some personal stories, starting on page 29, while Drew Hardesty and Laura McGladrey offer professional and empathetic advice.

On our second theme, Drew has also been cogitating on nuances of forecasting. He found an insightful essay from Peter Donner, and asked me to query a few colleagues for their reactions. Independently up in Alaska, Heather Thamm and Nikki Champion use a low probability avalanche case study to drive a similar conversation about "Scary Low" conditions. Starts on page 36.

In another entry under our Forecasting Topics heading you will find an article from Anne St. Clair and her group at Simon Fraser University, looking at bulletin-user typology. I didn't quite understand why this topic matters until Sawtooth Avalanche Center director Scotty Savage laid it out for me. His verbal explanation turned into a short introductory essay on page 33.

Our cover photo comes from the Gallatin National Forest Avalanche Center, where they have been pioneering avalanche education for motorized users for decades. Snowbikes are relatively new on the scene: their agility and power allow access into remote and complex terrain, so we are seeing more avalanche involvement from this demographic. Bill Radecky of 6 Points Avalanche Education shares some insights about snow bikes on page 10.

Other stories to capture your interest and imagination:

- A Sun Valley avalanche from 1952 brings up relevant current issues. Page 17
- Next installment of our women's focus—meet Jenna Malone and Anne St. Clair, page 22
- Jerry Johnson, Andrea Mannberg, and Jordy Hendrickson share some insight into "social positioning" on page 26
- Is climate change affecting the snow and avalanche world? Read McKenzie Skiles' concise and sobering report on page 47.

Deadline for the October/ISSW TAR is July 15. Email me if you have a story or a question, a photo from an avalanche cycle this winter, or a response to our fracture character question on page 45. 

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New Zealand Avalanche Dispatch: NZAD

We are starting a professional avalanche publication for the New Zealand snow and avalanche safety community. We are calling this project *The New Zealand Avalanche Dispatch* (NZAD). There will be two issues per southern hemisphere winter season. The first issue drops in mid-June and the second in early September of 2020.

The intention of *The New Zealand Avalanche Dispatch* is to provide a platform for professional avalanche workers, scientists, and keen amateurs to share ideas, practical techniques, scientific work, case studies, avalanche education, trip reports, photos, and new technologies and equipment for the betterment of the New Zealand snow and avalanche safety community.

Although we are New Zealand specific, we are encouraging anyone interested to submit their ideas, comments, photos and/or other content. We'd also like to invite the North American avalanche community to follow us on Facebook and Instagram [@nzavydispatch](https://www.instagram.com/nzavydispatch). We are also on Twitter [@NZDispatch](https://twitter.com/NZDispatch).

Our website is still under construction but you can contact us via email at: nzavydispatch@gmail.com

Thanks in advance for your support.

—Brad Carpenter

Keep Current with the Avalanche World!

Renew Your Membership

A3 emails reminders about the yearly need to renew memberships. Given the volume of email we all get, coupled with increasingly aggressive spam filters, many members have complained these emails aren't making it to them. We're working on solutions to this problem. In the meantime, if you're not sure if your membership is current, please log in to your profile at: aaa19.wildapricot.org to make sure you're up to date.

Contact dan@avalanche.org if you have any questions, problems, or concerns.



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SLED TALKS

BY LYNNE WOLFE

Our task was to move the whole stack of boxes upstairs and into the truck. “Why do they all say SLED?” I asked Conger. “That’s our trip name,” he replied. “SL for Sorcerer Lodge, and ED, of course, for Ed Adams.”

Seems that Steve Conger and Ed Adams came up with a plan on the keg train on the field trip day for ISSW 2012 in Anchorage. Anyone else remember that day? It poured rain as we peered at slide paths filled with fall colors when you could see them through the fog and drank three kegs on the way back to Girdwood.

Sorcerer Lodge was the obvious choice for this venture (Steve’s partner Tannis Dakin owned the lodge), and 2019–20 marked the 8th year of SLED trips to Sorcerer.

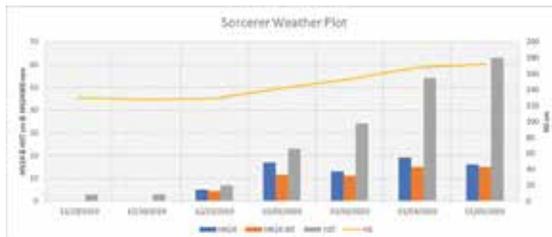
Ed has since retired from MSU and from organizing SLED, but he still gets to come on the trip. When new organizer Chris Borstad had to leave due to a family emergency, we all looked to Ed as the de-facto leader. Conger keep us in line, though, with disciplined morning and afternoon meetings based on our observations and the Info-Ex. Route choices this year were limited by visibility and stability. Wind slab on a Christmas surface hoar layer kept us in the trees.

But what differentiates this hut trip from a thousand like it every winter? Sure, we drank whiskey and played Jenga, but every evening one of the participants gave a talk on their particular area of interest. Most topics are loosely affiliated with snow and avalanches, but the variety kept it interesting. Simple rules: you had to have at least one graph, one formula, and one acronym. Easy.

As you’d expect, I gave a talk about debriefing (I’d been on the SAW circuit with this talk, based on TAR 36.3) on New Year’s Eve, complete with party hat. My husband Dan Powers reprised his master’s work on heat transfer in snow. He was partly thrilled and partly disappointed to know that snow scientists are still debating about pore space, convection, and heat transfer mechanism, 36 years after he did his work at CRREL under Sam Colbeck. He received enthusiastic feedback from avalanche maestros Peter Gauer and Ed Adams.

Other topics this year included Twila Wood’s talk on Greenland ice, Dylan Hedden-Nicely’s discussion of the complexities of BC and Northern Idaho water law (he’s a law school professor at the University of Idaho law school), Chris Moon’s presentation on wilderness medicine, and LaDean McKittrick’s reprise of a previous and popular discussion of avalanche dogs.

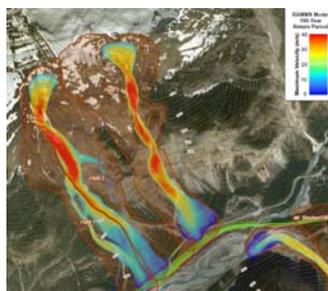
So why am I telling you about this trip? Not just because it’s how I spent my winter vacation, but because a week with new people with different languages, risk tolerances, and skill sets creates a melting pot for snow-related folks across the globe, and pushes us to understand one another’s decision-making. These conversations make room to “talk about things that matter.” Try out this format on your next hut trip, or next potluck with {avalanche} friends: a serious topic does not preclude adult beverages and is expected to evolve into spirited discussion that often goes late into the evening and adds an element of learning to an already memorable experience. ●



Clockwise from Top: 1) Sorcerer Lodge in snow. 2) Ed Adams initiates weak layer collapse. SLED 2020. 3) Now all we need is a formula... Photos Andi Stoffel



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FROM THE EXECUTIVE DIRECTOR

BY DAN KAVENEY

Writing the season's last column for *The Avalanche Review* has begun to feel like another sign of spring, similar to the lengthening days and stronger strike of the sun. The due date for this column corresponds to another transition for me, as I now turn most of my attention from the current winter season to the next. This year the situation is complicated by the COVID-19 emergency, as we hunker down in an effort to preserve humanity's collective health. We don't know what the coming days will bring, or what the situation will be like when you eventually read this column, but I have confidence in A3, our members, and in the burgeoning strength of the organization. As of now, that confidence has me expecting continued growth to our services, scholarships, grants, and membership during the 2020–21 season.

The 2019–20 season has been a good one for A3. Our membership has increased by hundreds of new members, our publishing program is thriving, we've added new sponsors, increased grants to Snow and Avalanche Workshops, expanded our research grant program, continued to support the International Snow Science Workshop (ISSW), witnessed another successful season of Pro Training, enjoyed increased traffic and success with avalanche.org, and further empowered our burgeoning social media programs. We accomplished all this while substantially improving our financial footing.

I love the fact that it was such a team effort! It was terrific to see the member engagement, the generosity of our donors, the thoughtful guidance from the board, the staff's hard work and dedication, the success and devotion of the Pro Training Course Providers, and the sponsors' commitment and generosity. Thanks to you all for doing your part to make this a great season for A3.

Looking ahead, the 2020–21 season is going to be terrific, and I'm thrilled to be able to kick it off by announcing that, thanks to a generous seed grant from **Black Diamond Equipment**, A3 is offering **TEN \$700 scholarships** to defray the costs of attending the International Snow Science Workshop this coming October 4–9 (issw2020.com). These scholarships will be open to all affiliate, affiliate applicant, professional, and professional applicant members. At least one will be reserved for a motorized applicant, at least one for an applicant the A3 board believes will increase diversity in the avalanche field, and at least one for a full time student. Some details:

- Interested parties should submit a 250–500 word essay explaining how they would put the scholarship to good use. If the candidate believes they should be considered as a motorized user, a diversity candidate, or a student they should so indicate in their essay.
- A3 President Halsted Morris will select the winners in consultation with a small board committee he will assemble.
- Scholarship recipients will be required to either write a short article for *The Avalanche Review* or another snow sports industry publication, or make a presentation at an A3 supported Snow and Avalanche Workshop. Recipients will be required to provide at least two social media posts during the conference.

10 scholarships to ISSW 2020 dates and details:

- Interested parties should submit their essays to Dan Kaveney at dan@avalanche.org by **JUNE 1, 2020**.
- Recipients will be notified by **June 15, 2020**.
- Money will be disbursed in **August of 2020**. Proof of registration must be provided prior to disbursement.

Please see aaa19.wildapricot.org/ISSW for full details and frequently asked questions.

We're working on some other exciting initiatives for the 2020–21 season, and I'm looking forward to announcing them when the time comes. In the meantime, I'll remind you that we rely on our major sponsors very heavily for our grants, pro training, and scholarship programs. Please join me in welcoming Black Diamond Equipment to the pantheon of major A3 supporters, and in supporting our existing major supporters—Backcountry Access, TAS, CIL Explosives, and Wyssen Avalanche Control. Together, and along with our members, donors, and other sponsors, these companies make our SAW Grants, research grants, scholarships, and many other things possible. ●

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A3 RESEARCH GRANT UPDATES AND AWARDS

This year changes were made to the grant guidelines and the total award budget was increased from \$3000 to \$5000. Thank Dan Kaveney for scraping that funding together. Changes to the guidelines included: elimination of the practitioner versus graduate student categories, a new scoring system (thank you Jeff Dozier), and elimination of the letter of reference requirement.

We received eight proposals, more than double from last year and the most I've seen as the Research Chair over the past three years. I wish we had greater resources to fund more than two proposals and I thank all the applicants and the reviewers for their efforts. The two selected proposals are summarized [here](#).

We are still in the process of searching for one or more corporate sponsors who want to make a significant gift to show the world how valuable this research is to them. Please contact Dan or myself if you would like to help out with that effort.

—Ned Bair
2/8/2020

A STUDY ON THE EXPOSURE OF AVALANCHE MITIGATION WORKERS TO EXPLOSIVE BLAST OVERPRESSURE

BY MANDY GEISLER, ALLIE FREDBO,
AND KEN THOMPSON

Explosives are widely used across the world to mitigate the threat of avalanches. This practice protects the public within ski resort boundaries, and is also used by highway departments to protect infrastructure from the threat of avalanches. Amongst explosive users safe standoff distances from the detonation zone are not well established or used in practice. Each user and operation tend to develop a safety standard through institutional knowledge and operational experience. Studies have been conducted to measure the effect of explosives and blast waves on the snowpack. However, there has been no focus on how pressure waves produced by these explosives may impact the workers that deploy them. This study will quantify blast pressure exposure levels to understand possible adverse health effects in avalanche workers. Researchers have proposed a link between mild repetitive traumatic brain injury and long term health effects. Various studies have identified exposure to explosive events as a potential source of brain trauma. As research into the long term effects of blast pressure exposure evolves, we will be able to refine our knowledge of the risks within the avalanche industry. This research has implications in evolving safety standards to better protect workers from repeated exposure.

PROPAGATION SAW TEST TILT TABLE

BY SAM VERPLANCK

The Propagation Saw Test (PST) epitomizes ISSW's motto of "merging theory and practice." The test is practical enough to be performed by practitioners and is utilized by scientists in the validation of theoretical avalanche initiation models. Due to the popularity of the test, both experimental and theoretical investigations have attempted to determine the relationship between slope angle and PST results. However, the current data are insufficient, and the results from different studies conflicting. The conflicting results may be due to differences of slab and weak layer properties, which stem from spatial variability.

The primary scientific objective of this proposal is to investigate the relationship between slope angle and PST results. The novelty in this experiment is that spatial variability will be minimized leading to minimal differences in snowpack properties. The method is to develop and utilize a tilt table that can support a PST. We will travel to a snow field with minimal spatial variability and a known weak layer. Then, perform a multitude of PSTs at different tilt angles to find a relationship between slope angle and PST results such as critical cut length, fracture speed, the degree of slab bending, and fracture propagation length.

A secondary objective of this project is to make novel deformation measurements of the slab and weak layer using new instruments. These instruments are field-deployable, stand-alone devices that measure acceleration, the focus of my PhD project at Montana State University. These devices will be embedded within the slab and measure acceleration in 3 dimensions. To calibrate these instruments, we will deploy them in the PSTs along with equipment for Particle Tracking Velocimetry (PTV). PTV is a common method of measuring motion of the slab during a PST. However, it is limited to a visible, 2-dimensional surface. Utilizing these new instruments in a standardized test is an important steppingstone towards deploying them in an actual avalanche. When sub-mm, 3D measurements of slab motion and weak layer failure are made in the field, a critical void in our scientific observation and understanding of avalanches will be filled. Specifically, shear and collapse components of the weak layer failure will be precisely measured. ❖



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What's that SOUND?

STORY AND PHOTO BY BILL RADECKY

On the surface, snowbikes are simple enough. You take the dirt bike you already have, add one of a few different manufacturer's kits and, poof, your summer toy is now a winter toy. That's where the easy part ends and the hard stuff begins.

Snowbikes have some inherent technical problems that we have tried to overcome with adaptations to their temperature and friction systems. Snowbikes also bring new users into the winter recreation scene. An increasing number of dirt bikers who have little to no winter and snow experience are jumping in headfirst to snowbiking.

With all the potential problems and difficulties why would any motorhead build a snowbike instead of just riding a snowmobile like a normal person? That's an easy answer, they are FUN!!! Snowbikes blur the line between human-powered access and snowmobile access. I ride downhill and gain elevation very closely to the ways I manage terrain when I am skiing. Due to the lack of brute horsepower, it's not possible to just point straight uphill to gain elevation, you have to work contour lines and switchback up, or take ridges. Sure it's like skinning, but much faster.

Once you're at the top the real fun begins as you are able to descend lines through tighter trees than fun or possible on a snowmobile. Snowbikes are also much more interactive than snowmobiles. Comparing snowbikes and snowmobiles is like comparing a small manual transmission sports car to an American muscle car with an automatic transmission. One takes a lot of attention and skill to operate at the highest level while the other is very straightforward— just hang on! Neither is right or wrong, they are just different.

I am lucky to have experience as a skier and snowmobiler prior to getting a snowbike two years ago. I use backcountry skills drawn from each of those disciplines: terrain management, smart travel decisions, and snow assessment are different for all three sports. I hope that this experience makes me a better educator and gives me some “street cred” with all the user groups. It also helps me convey to my students sport-specific points of how to travel safely in avalanche terrain.

And isn't that why we work as educators? We all want to enjoy the winter environment, and come home at night safely with great memories of the day and time spent with friends and family. 🍷

Bill Radecky is an avalanche educator and guide based in Rigby, Idaho, where he is the first snowmobile-based guide in the US to obtain the Pro 2 certification. Bill is co-owner of Six Points Avalanche Education with Eric Knoff, guides for High Mountain Adventures, and is a career firefighter/paramedic for the city of Idaho Falls.



From the Editor: At press time we are saddened to read of a snowbike double avalanche fatality on February 15, 2020 in Colorado's Vail/Summit County zone: https://avalanche.state.co.us/caic/acc/acc_report.php?acc_id=744&accfm=inv

In the *Colorado Sun*, perennially thoughtful outdoor author Jason Blevins digs deeper into the accident and into snowbikes in general: <https://coloradosun.com/2020/02/25/snowbiker-avalanche-death-vail-prepared/>

METAMORPHISM

Evelyn Lees retires from the Utah Avalanche Center

BY MARK STAPLES

This December, after 28 years, Evelyn Lees retired from the Forest Service Utah Avalanche Center (UAC). Some of her early experiences with avalanches came from climbing big mountains in Nepal, Tibet, Pakistan, Peru, Bolivia, Canada, and Alaska. During the summers, she worked as a senior guide for Exum Mountain Guides in Grand Teton National Park.

Most of us get into avalanche forecasting because we love skiing. There's no doubt Evelyn loves skiing, but one thing that kept Evelyn coming back year after year was the challenge. She routinely said that she was never bored because the snowpack and weather were different every winter. According to Evelyn, "you've got to be on your toes, and you're constantly looking at something new in the snowpack every day." She was ready to finally take a break from remaining vigilant all winter long and let other people worry about forecasting snow and avalanches and simply go skiing for the fun of it.

This fall we continued to make Evelyn offers to keep working and delay her retirement by another year until finally she told us no: she simply had to retire. Evelyn and husband Rick Wyatt already made too many plans for the winter to visit friends and family and go on ski trips around the country.

This winter, we added a new route, "Lees Fork," to the Wasatch Backcountry Skiing Map. The route ascends a gully in Big Cottonwood Canyon between Reynolds Peak and Tom's Hill. Retired forecaster Tom Kimbrough coined the name initially because Evelyn used that route so often for fieldwork. What is unique about this route is that it is not an avalanche path. So often, avalanche paths are named after people who are caught in the path. In this case, Evelyn's route was named after her because, for 28 years, she used that route to help people avoid getting caught in avalanches.

Evelyn has been the foundation for avalanche forecasting in the Salt Lake office since her arrival in 1991 and her impact at the UAC is immeasurable. She has been a mentor to all our staff including our newest forecaster this fall. Evelyn's impact upon the broader backcountry community is also immeasurable. She ran all the women's courses offered by the UAC and has taught countless aspiring backcountry users.

Even this winter, though she was retired, Evelyn continued to check in, offering her support and guidance and keeping us organized and inspired. We survived without her presence but it wasn't the same.



Most of the UAC staff after biking the White Rim trail this fall. Photos courtesy UAC

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ACL - Dan Dobrowski - dan@avconlog.com Cell: 434-960-0558

KPAC: Robby ReChord

After joining the Kachina Peaks Avalanche Center's team in 2018, **Robby ReChord** quickly established himself as a passionate and effective avalanche educator. He brought to KPAC his broad experience gained in the Teton Valley teaching and guiding for NOLS and other avalanche course providers. This winter (2019-20), Robby took the baton from KPAC founder David Lovejoy by assuming the role of Avalanche Education Coordinator.

The season has been very productive with a record breaking 71 students enrolling in recreational Level 1 and 2 courses. These courses provide a mainstay in funding for KPAC's non-profit operational model and in fulfilling the center's educational mission. The San Francisco Peaks contain over 80 active avalanche paths, rising to 12,633', dominating Northern Arizona and the Colorado Plateau. Congratulations to Robby for doing a great job. 🎯



Snow and Avalanche Workshops

NSAW

The 13th annual Northwest Snow and Avalanche Workshop was held in Seattle, WA on Oct 20, 2019, as over 650 attendees, 22 sponsors, 20 NWAC Staff, 15 volunteers, 14 speakers, and nine outdoor industry non-profits came together for an incredible day of learning and community building. We were able to kick NSAW off a tad early, with A3 and 20 Corners Brewery's, co-branded beer, Storm Cycle, release party the evening before. Rich Marriott and Mark Moore gave a "15-minute" talk on *Unstable Beginnings: Early Days of Northwest Avalanche Forecasting*; folks in attendance got a glimpse into forecasting workflow 40 years ago and how far we've come as an industry.

This year at NSAW we had a wide variety of topics from decision-making, understanding behavior, and recent scientific research in snow and avalanches. All of the presentations can be seen on The Northwest Avalanche Center's YouTube Channel.

To kick the day off, Dennis D'Amico, NWAC's new Director of Forecasting, talked about changes that are happening with NWAC, our forecasting product, and some ongoing tech projects with a handful of other avalanche centers.

Evelyn Lees followed with two presentations, *Where's Your Partner?* and *Fatalities During Uphill Travel*. The objective of the first presentation—*Where's Your Partner?*—focused on fatalities statistics and how people travel together in the backcountry. The second



NWAC stalwarts and recent retirees Kenny Kramer and Garth Ferber (left and center) look pretty happy to have handed forecasting duties off to the next generation, represented by current NWAC ED Scott Schell (right). Photo courtesy NWAC

presentation—*Fatalities During Uphill Travel*—did a quick look into comparing uphill and downhill travel fatalities statistics. (TAR 36.4)

Next up, NWAC Avalanche Specialist Dallas Glass and Crystal Mountain Patroller Robin Pendery co-presented *Avalanche Forecasting: A Community Effort*, where the speakers compared the work they do within their profession as forecasters and discussed the importance of community-generated observations. They also outlined the pieces that go into creating an avalanche forecast, and the uncertainty that is inherent to this process.

Liz Riggs Meder lead a thoughtful presentation around meta-cognition and *Building Ex-*

perience in A Wicked Learning Environment. She planted a seed in the audience around meaningful and thoughtful debriefs, and how do you go about debriefing in a wicked learning environment. She included frameworks to drive these feedback loops: Predict—Observe—Compare and Assess—Evaluate—Plan—Apply—Reflect.

Henry Finn shared his collaborative research on *Could the Avalanche Bulletin Be More Effective?* The data presented is from a survey that Simon Fraser University released in Spring 2019. The intention of this survey and research was to better understand how avalanche forecasts are being understood, as over 90% of avalanche fatalities in North America are non-professionals. See story on this topic on page 33 of this TAR.

The last presentation before lunch was *Using Tree Rings to Help Understand Avalanche Frequency* presented by Erich Peitzsch. His presentation talked about using cross sections of trees in Montana to help better understand avalanche frequency—looking at impact scars and reaction wood. Conclusions include finding about a seven-year average interval for avalanche return in the area with subsequent implications for avalanche frequency and climate change.

NWAC hosted a working lunch where the audience could ask a panel of NWAC staff questions regarding changes to the center, tech projects, what the future holds for the center, and any other topic that came up relating to NWAC. Folks on this panel included: Scott Schell (ED NWAC), Dennis D'Amico (Director of Forecasting), and USFS avalanche specialists.

After lunch Jordy Hendrikx kicked things off with his presentation, *Powder Arousal and the White Heat Project*. He started his presentation discussing positional preference and how that may impact one's willingness to accept risk and decision-making process. He then shared a video stemming from his work with White Heat Project on Powder Arousal—how does the excitement and stoke impact our decision making in the backcountry. See story on this topic in this TAR, page 26.

The next two presentations came from research from within the Northwest Avalanche

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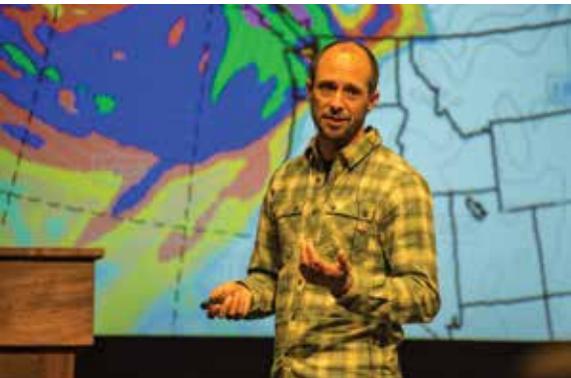
ESAW

BY JONATHAN S. SHEFFTZ

Center. Matt Schonwald, NWAC Professional Observer, led a talk on understanding winter backcountry fatalities in the PNW. He found that location-specific frequency of fatalities and time of year have strong associations with numbers of avalanche fatalities. Cheri Higman, NWAC Education Manager, then presented data on NWAC's Trailhead Outreach Program—read more about this in TAR 38.1.

Following the NWAC talks, Ingrid Backstrom presented on *SAFEAS Clinics: An Approachable Approach to Avalanche Education*. The SAFEAS clinics offer a women-centric approach to avalanche education where the founding principles are to provide practical awareness and training for success, making the scary un-scary, and to get out and have fun.

Next, Lynne Wolfe gave an energetic and engaging presentation on debriefing, *Were We Good or Lucky?—Debriefing Thoughts Via a Close Call in the Tetons*. She dove into the set-up for the day leading to a near miss, talked about the route the group chose, and then the avalanche that occurred. She then posed the question, “Were we good or lucky?” And,



Dallas Glass, NWAC avalanche specialist and NSAW presenter, discusses how weather systems affect the avalanche forecast.

“How do you know?” She provided the audience with a variety of debriefing tools including the AAI Checklist, AIARE's Debrief Questions, After Action Reviews, and Hypothesis testing, to name a few. This author appreciated Lynne's conclusion of her presentation, “1) Be a lifelong learner, 2) Your lessons and messages will change over time, 3) Have a sense of humor 4) Own your shit.”

And to close-up the evening, Nick Bond, Principal Research Scientist for JISAO, for his fifth year in a row gave the attendees a seasonal outlook and what to expect for the season. He predicted that the PNW will end the season with a higher snowpack than the 2018/19 season, and significantly better than the 2014/15 season—a dismal snow year for us in the PNW.

The line up for this year's NSAW was diverse, the support from our community was the strongest we've seen, and we like to think that this was one of the better NSAW's we've put together, and we're looking forward to next year's NSAW at Seattle Town Hall on October 18th.

Cheri Higman has been with the Northwest Avalanche Center since 2018 as their Education and Outreach Manager. She currently works and plays in the mountains near Seattle, Washington.



The ninth annual Eastern Snow & Avalanche Workshop (ESAW) on October 19 attracted approximately 155 attendees at Fryeburg Academy in Maine, just across the state border from New Hampshire's Mount Washington in the White Mountains' Presidential Range.

This year's ESAW was, as always, a collaborative effort. The organizing partners included the USFS Mount Washington Avalanche Center (MWAC) and the White Mountain Avalanche Education Foundation (WMAEF), with support from the Mount Washington Volunteer Ski Patrol (MWVSP), Friends of Tuckerman Ravine, and other volunteers. ESAW once again relied on a grant from our lead sponsor the American Avalanche Association (A3), with your faithful correspondent as A3 Member Representative and the sole East Coast A3 board member. Additional support came from our title sponsor, Patagonia. Registration fee proceeds over and above hosting costs benefitted the WMAEF, which provides avalanche education to youth of the Northeast and avalanche awareness events for all ages.

Frank Carus, the WMAC Director, repeated his performance from last year as our MC for the day. In anticipation of the 2019-20 season, we started off with a look back at the 2018-19 season and earlier:

- Liz Jurkowski, a meteorologist with the Watershed Sensing Lab at Plymouth State University, explained the design, installation, and results of the multiple weather stations now installed on the eastern slopes of Mount Washington

for snowpack depth, spatial variability, and snow melt.

- Rebecca Scholand, Summit Operations Manager for the Mount Washington Observatory, summarized the past season's weather and snowpack summary, yet also snuck in an early-morning summit report of nearly four inches of new snow, which had already created four-foot drifts.
- Organizational updates were provided from the Friends of Tuckerman Ravine by Jake Risch, the White Mountain Avalanche Education Foundation by Bethann Swartz, and A3 by your faithful correspondent.
- Frank described the April 2019 avalanche fatality on Mount Washington's Raymond Cataract, including the harrowing rescue effort he had personally led. The official incident report is posted at: <https://www.mountwashingtonavalanchecenter.org/4112019-avalanche-fatality-raymond-cataract/> ... and Frank also displayed numerous previously unpublished photos of the victim (with the permission of the father) after he was extricated while still alive following a two-hour burial.
- Major Nathan Fry and Staff Sergeant Tim McLaughlin, the Training Division Chief and an instructor (respectively) for the U.S. Army Mountain Warfare School, comprehensively described the preparations, conditions, rescue, and aftermath of a March 2018 avalanche incident in Vermont's Smugglers Notch that hospitalized five members of the Vermont Army



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National Guard while on a training exercise. A detailed account is available at: [https://vtdigger.org/2018/09/18/avalanche-report-reveals-lack-of-vermont-national-guard-response-despite-obvious-danger/...](https://vtdigger.org/2018/09/18/avalanche-report-reveals-lack-of-vermont-national-guard-response-despite-obvious-danger/) but the personal elements and concluding thoughts of “Slow Down, Make Time, Be Present” led to a standing ovation.

Rescue was also the focus for two of the other presenters. First, Dr. Nathalia Dolan, MD, an emergency medicine resident at Dartmouth-Hitchcock Hospital, with a specialty in psychiatric stress injuries, described her peer-reviewed study, “A Qualitative Study of Psychological Outcomes in Avalanche First Responders,” published by the *High Altitude Medicine & Biology* journal. The excerpts from her interviews were especially affecting as she read the accounts of first responders whose own lives had fallen apart after their heroic efforts to save strangers’ lives. She concluded with the reminder that mental health problems are an occupational hazard of first response work, to the same extent as physical hazards.

Second, Graham Kane, a Clinical Specialist for Eagle County Paramedic Service, and also with Vail Mountain Rescue and Vail Ski Patrol, presented a rescue case study, and then explained small team response to avalanche rescue. Graham mixed in avalanche fatality statistics with highly valuable first-aid advice. He observed that asphyxia deaths vastly outnumber trauma in part simply because asphyxia sets in first. Hypothermia is another distinct cause of avalanche death, yet is seldom

discussed since it accounts for only about two to five percent of fatalities. Graham’s hypothermia death timeline graphic (one of many such grim graphics) essentially starts up where the asphyxia one leaves off: if you want to die from hypothermia in an avalanche (his deadpanned phrasing!), then you need both an intact airway and a large air pocket, combined with cooling rapid enough to die from hypothermia before asphyxia. Graham also cautioned that, “As a bonus, hypothermia can still kill your patient after you rescue your patient.” Graham also introduced us to the term “iCPR”—no, not a new Apple product, but rather intermittent CPR delivery, typically via on-off cycles of five minutes each, up to even several hours.

In the previously referenced April 2019 Mount Washington avalanche, all of the foregoing hypothermia-related factors were tragically present. During the transportation down the mountain to the trailhead, Frank implemented the very same treatment protocols that Graham presented to us. Frank also knew that the only hope after that point was rapid transport to a medical center for cardiopulmonary bypass and extracorporeal membrane oxygenation. Upon transferring the victim to the transporting EMS agencies, whose staff administered cardiac-pacing drugs, epinephrine, and multiple AED shocks, the victim was pronounced dead at the trailhead.

On other topics, Eammon Lynch brought his perspective as a Senior Instructor at the Faculty of Business Administration of the University of New Brunswick to bear on the topic of risk mitigation among passive versus active backcountry users. Eammon highlight-

ed the challenging factors of the non-linear environment and an ambiguous feedback system for staying safe in avalanche terrain. And Frank hosted a panel discussion then an Ask Me Anything session on the Mount Washington Avalanche Center.

Dale Atkins, whom all TAR readers should already know (as among many other positions he was previously our A3 President) presented on a global comparison of avalanche safety and rescue outcomes, and then on the illusion of control and perils of positive outcomes in avalanche incidents. Dale listed ten common missteps of avalanche professionals, and explained that risk is best considered not in terms of potentially being acceptable but rather as justifiable. He explained that the unknown is not necessarily the uncertain, as the future is always unknown, yet not always uncertain. His take-home message was to manage your uncertainty: process matters!

Dale started his second presentation with a compare/contrast: data is objective; data assessment is subjective. He then asked us who would want to fly with a pilot whose assessment of a flight was, “We took off in some really sketchy weather conditions, but we made it through fine.” But how many of us would want to tour with a skier whose assessment of a tour was, “We skied in some really sketchy avalanche conditions, but we made it through fine.” Or how many of us have even said that? He had us all chant together, “Safety should be born in the belief that everything I do can lead to a potential disaster.” He also introduced us to—and advised us how to stop—the phenomenon of Dysfunctional Momentum: the unchallenged concept that events are unfolding as expected.

We concluded with our annual expo, including rep displays for Arc’teryx, Acadia Mountain Guides, Backcountry Access, Backcountry Babes, Black Diamond/Pieps, BRASS Foundation, Marmot/Barryvox, MWVSP, Mount Washington Weather Observatory, Ortovox, Patagonia, Ragged Mountain Equipment, Ski the Whites, and Sterling Rope. Throughout the day we had raffled off and auctioned donations from these sponsors plus MSR and Skimo Co. The day concluded with a party at Tuckerman Brewing Company, sponsored by Protect Our Winters.

Jonathan Shefftz patrols at Northfield Mountain and Mount Greylock in Western Massachusetts, where he lives with his wife and daughter. He is an AIARE-qualified instructor, NSP avalanche instructor, and A3 board member. When he is not searching out elusive freshies in Southern New England or explaining to his daughter that to go sledding instead of skiing we have to ski to the sledding hill first, he works as a financial economics consultant. He can be reached at JShefftz@post.harvard.edu.



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At Least You Tried

(Sort of)



The descending skier is Jonathan's touring partner **Pete**, just below the diamond-shaped boulder formation. The ascending figure (looker's right of Pete) is an **unknown hiker**. **Nick** is in the center left of the boulders, transitioning from skinning to climbing.

STORY AND PHOTO BY JONATHAN S. SHEFFTZ

“**Jesus. Total mind f*ck on that one.** At least you tried.” The common phrase is “Out of the mouths of babes [...]” but the same can often be said of somewhat foul-mouthed social media posters, as that quoted excerpt from an online forum in response to my experience succinctly sums up all of the following.

But had I really tried? Almost exactly half a year has now passed, and I still occasionally ask myself that question. On one level, sure, yes, I definitely tried. But had I tried enough? Judging by the outcome, obviously not. Okay, so how about, given the information known to me at the time, did I try sufficiently?

The two-day trip started off according to plan: my friend Pete and I carpooled to meet T at a western trailhead for New Hampshire's Mount Washington in the Presidential Range. T had recently moved to literally across the highway from a northern trailhead of the Presidentials. A talented multi-sport endurance athlete, including ski-mo racing, T did not have any experience with above-treeline ski mountaineering. So I was “selling” the outing as a nice, easy, safe introduction to such endeavors.

The **Moderate** avalanche bulletin for the day and its snowpack discussion excerpted below would have been utterly generic, were the date not April 10 (a Wednesday):

Wednesday April 10 2019, Mount Washington Avalanche Center (MWAC)

The roughly 3.5 inches of mixed precip types that fell on upper elevations on Monday were ultimately wetted to the bed surface at ravine levels by several hours of freezing rain in the late afternoon & evening.

Warm air Tuesday morning melting an ice crust may also have played a part in adding water to Monday's snow. Due to southern wind direction with limited fetch, moderate wind speeds, dense, sticky snow and possibly an ice crust, drifting snow was limited, resulting in an evenly distributed covering of snow.

By Tuesday, this moist snow covering was found at all levels in the ravines. Overnight, temperatures dropped well below freezing at mid and upper elevations; this will eventually freeze the existing snowpack solid, if it hasn't done so already. Any instabilities in the snowpack today will be limited to new windslab formed from the 1.9" of snow recorded on the summit overnight.

By mid-April, such a typical winter cycle has usually given way to a corn cycle that is perfect for both skiing conditions and avalanche stability, allowing even the steepest terrain to be skied with no avalanche danger concerns. Fortunately, the atypical mid-April avalanche problem was coupled with an equally atypical snowpack, but in a good way: more moderately angled terrain that usually lacks skiable snow cover during any portion of the season was in excellent condition. Therefore, instead of nibbling around the edges leading to mere crumbs, a full-course meal was available.

Unfortunately, as we skinned up, the visibility deteriorated. We continued to near the summit since we were following the Cog railway line, a reliable navigational handrail. We then crossed the summit road to try a few turns on a snowfield, but the vertigo was absurd.

After my attempt at a skins-off contouring to return to the other side of the summit road, we slowly skied down along the Cog railway line. An ascending snowboarder was so astounded by our appearance that he insisted upon a picture: upon receipt of the picture a few days later, I understood his astonishment, all three of us and our ski poles were entirely white, encrusted with rime. I detoured for a quick lap in the adjacent Burt Ravine, which somewhat salvaged the outing for me, while Pete and T decided to cut their losses and head back to T's place ASAP.

The weather for April 11, looked perfect, but not the stability conditions:

April 11 2019, (MWAC)

Temperatures have continued to fall since yesterday, resulting in a sketchy mix of wind scoured, bulletproof ice crust, and fresh wind slabs.

Areas that contain these wind slabs have MODERATE avalanche danger due to the possibility of a human triggered avalanche.

Steep terrain without well-bonded new snow will have a significant sliding fall hazard. Don't count on arresting a fall on the icy surface beneath this new snow. Even a small avalanche can cause a significant problem today.

A brief window of sunshine and warm temperatures may bring some softening this afternoon but consider your options if it does not. And bear in mind that the new wind slabs will weaken if and when they warm today.

First up was Huntington Ravine's base area, known as the Fan. Hardly a destination in itself, but combined with the Fire Road that makes for a passable ski trail, it was a good warm-up on my planned three-ravine tour. I started out ahead of Pete to get in a quick lap, on which I immediately encountered all of the snow conditions described in the avalanche bulletin. He had made a new friend on the skin up.

“Nick here has flexible objectives for the day,” Pete announced. “Oh, I know all about meeting objectives,” I replied. “Yesterday we met both our primary objectives, plus our bonus objective. First, nobody was killed or seriously injured. Second, no major gear items were lost or broken. And bonus points for how all party members are still on speaking terms with one another!”

I said it in a jesting manner, as I have repeated it many times before. But it was also a serious reminder not to bemoan a backcountry skiing outing for its weather conditions, snow conditions, vertical (or lack thereof), etc. You were able to recreate in the backcountry and everyone (plus their gear) returned safe and sound? Success!

Nick said he planned to ski Raymond Cataract. I said that in various ways that struck me as a **Bad Idea**. I have skied the “Raymond” part numerous times: exactly the kind of moderate terrain we generally lack in the Presidentials. And just as many times, I have reskinned on a perfectly positioned, nearly flat platform beyond which Thar Be Dragons. More specifically, a steep avalanche-prone rollover, complete with an icefall (i.e., the cataract), shwacky trees, and other terrain trap poster child hallmarks.

Nick said that before that goal, he planned to ski Central Gully. That also struck me as a **Bad Idea**, and not even a tempting one at that. The gullies in Huntington Ravine tend to be the province of ice climbers. Even though Central is considered a walk by them, the crux of Central looked tight at best through the ice that day. I suggested South Gully instead, which although shiny in places on the approach, at least looked tempting, with the caveat of the avalanche danger.

Nick had good ski gear, which is hardly the norm in the Presidentials. He even had a beacon, which is even more of an exception in the Presidentials, especially for a solo skier. Plus he had to be fit to have kept up with Pete on the ascent. And I could tell by his skintrack setting that he was both skilled and experienced. So I said less than I would have otherwise. Plus, even having just met him, Nick was so much fun to talk with about other topics.

But on with the tour plan, which I was absolutely sure had absolutely no avalanche hazard. On the approach to Tuckerman Ravine, I stopped to chat with Frank Carus, the Director of the Mount Washington Avalanche Center. I recall that we bemoaned the sorry state of avalanche rescue gear frequency among ski tourers on Mount Washington. I do not remember though if I had noted the admirable presence of a beacon on our solo ski tourer Nick.

Finishing up the tour in the Gulf of Slides, I cut over from the moderately angled bowl I had been skiing to join the very bottom runoff of a steep gully, where I had noticed three skiers repeatedly climbing up then skiing down the optimally angled terrain for avalanches. I switched my avalanche beacon to search. Silence.

“You guys must be pretty confident in the snow stability.” “Huh?” “You don't have avalanche rescue beacons.” Some half-joking/half-defensive/all-nonsensical reply followed about how they had been doing this for years yet were still okay so it must be all good, etc.

Back on the highway, Pete mentioned he had to move my car when the helicopter was landing. I asked Pete why the helicopter was here.

“Avalanche victim in Raymond Cataract.”

“But Pete, that's ... where ... Nick ... said ... he ... planned ... to ... ski.” Pete slowed down and pulled over slightly to the side of the highway to make room for multiple emergency vehicles. I checked my phone to see if anyone had posted anything knowledgeable. The solo skier in a Raymond Cataract avalanche was confirmed. A helicopter meant the victim still had some hope. Then, nearly in real time, the final post with any relevant timeliness, before the entire incident became past tense.

During the drive home, and over the next day or so, before the victim's name was released, Pete and I encouraged each other in an absurd—and increasingly unconvincing—round of self-denial that the confirmed beacon-equipped solo skier from northern New Hampshire who died in an avalanche in the seldom-skied Raymond Cataract might be someone other than the beacon-equipped solo skier from northern New Hampshire planning to ski Raymond Cataract whose company we had so briefly enjoyed. The official incident report:

<https://www.mountwashingtonavalanchecenter.org/4112019-avalanche-fatality-raymond-ataract/>

... contained many harrowing details, including Frank Carus's just-in-case beacon search of a debris pile after receiving a visual report of an apparently fresh crown line in Raymond Cataract, which led to a probe strike, and then moaning from the still entirely buried body, like something out of a summer campfire horror story, but all the more horrible for being real.

Whenever I read such incident reports, I am always left wondering why the party chose to ski the slope that ultimately slid. Even more so in the case of a deceased solo skier. But not for this incident: I did not have to wonder at all about that, because I had already known Nick's plans at the time.

Whenever I read such incident reports, I also am always left wondering whether I could have dissuaded the party from choosing to ski the slope that ultimately slid. But not for this incident: I did not have to wonder at all about that, because I had already tried to do so with Nick at the time.

Upon my return home the evening of Nick's death, my wife criticized my lackluster attempts at outreach, in the process amusingly garbling my alphabet-soup collection of avalanche-related affiliations: “You do all that for all those different organizations, yet you say so little to skiers in the field when you should be educating them?” I tried to explain that I did not want to be all preachy and judgmental to my fellow skiers: they had the right to make their own risk decisions, no matter how much and how often they deviated from what I personally deemed prudent.

Then the following day I received a message from a person whose name I did not recognize. He was one of the three beacon-less skiers in the Gulf of Slides whom I had implicitly chastised. One of them had been friends with Nick. Upon hearing the news that evening, all three of them had ordered avalanche rescue gear and planned to take an avalanche safety course. ●

The Great

Sun Valley

Avalanche



BY DAVID BUTTERFIELD

In 1952 Sun Valley was the model U.S. destination resort, but safety procedures and technology that we take for granted today were still in the formative stages. When a chain of natural and human-influenced events culminated in January of that year, it would cost four people their lives.

Among Europeans on the ski school, there was no shortage of common snow sense, but avalanche safety fell to the mostly American lads of the Sun Valley Ski Patrol. Their leader was Nelson Bennett, an innovative and energetic 10th Mountain Division veteran who ran the patrol with near-military discipline. As December 1951 and early January 1952 brought unusually heavy snows, the orders were to keep the public out of known slide areas and wait for the snow to settle and bond.

Nelson Bennett: *The snow depths had been building and building and building...the snow depth on Baldy was in excess of seven feet of free-fall snow. It was cold, dry. There is always a breeze, of course, on the top of the mountain, and slab conditions did prevail. Winds came up and that slab condition was formed over some rather soft snow. I had checked it pretty carefully along with some of the patrol.*

Twenty-year-old Bob Albrecht had the choice job of pinsetter in the Sun Valley Lodge bowling alley, which opened in the late afternoon. This enabled him to ski Baldy almost every day.

Bob Albrecht: *The bowls were not open due to avalanche danger all through Christmas and January. (All of) Baldy was closed at least one day in January due to heavy snow.*

The Ski Patrol was a tough crew. Grooming now done overnight by machinery was a constant manual effort of shoveling, raking and ski packing. Along with being in good shape, many of the patrol were excellent skiers and wanted to move up to more lucrative positions as instructors.

In 1950 and 1951, the ski school had been led by another former 10th Mountain soldier, John Litchfield. Sometime in late 1951, he committed to further military service and the ski school was turned over to veteran instructor Siegfried "Sigi" Engl, who had also served in the 10th. An Austrian and German presence goes back to the beginning in Sun Valley, however, some patrollers felt the Europeans were arrogant and there was some friction. Animosity sometimes surfaced in brutally competitive broomball games (hockey with no pads, brooms and a softball) on the Sun Valley ice rink.

As more snow fell in January, not only the top cornice but the ridges between the bowls continued to load with wind-blown snow. The entire area remained closed. In the middle of January, per previous plans, Nelson Bennett left town for a meeting of the Pacific Northwest Ski Association in Everett, Washington.



Nelson Bennett was the head of the ski patrol and responsible for all grooming and safety considerations. Bennett was out of town when the avalanche hit; he had left orders with his second-in-command to keep skiers out of the bowls.

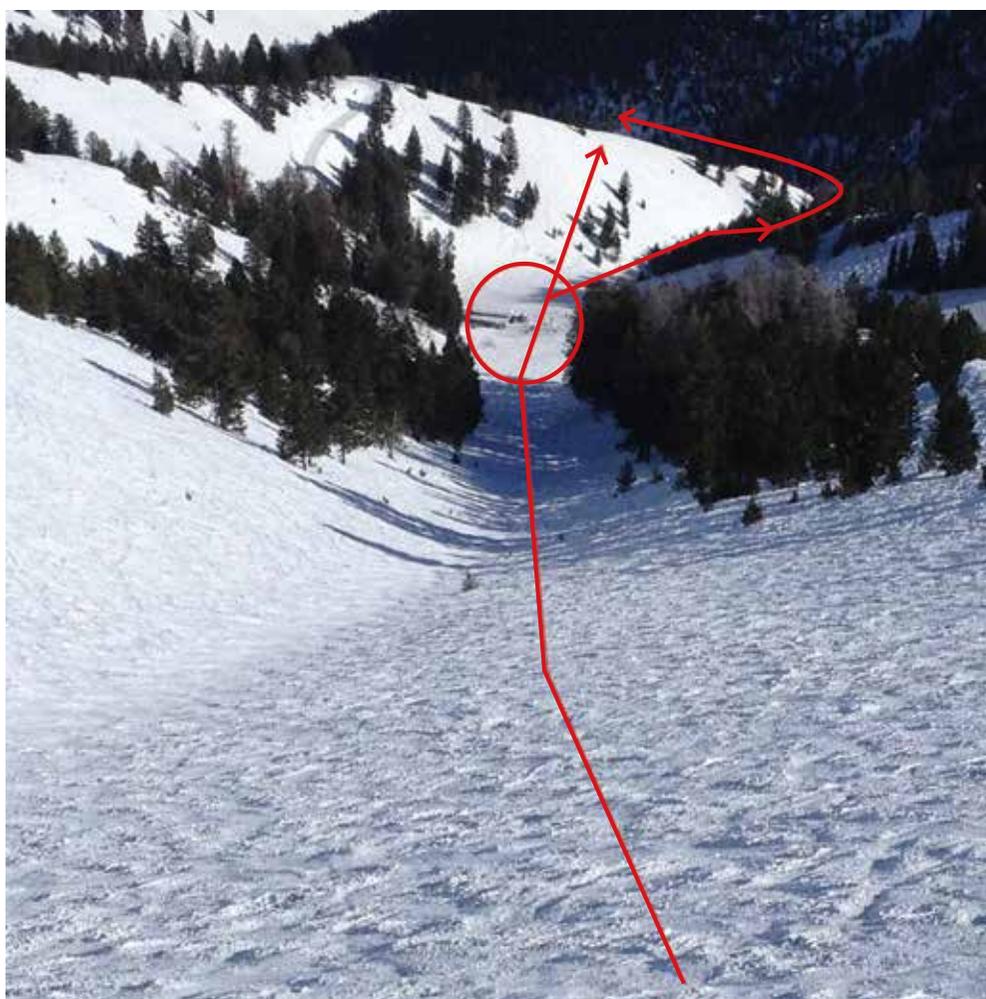


Sigi Engl was the new ski school director, one of many Europeans who worked in Sun Valley. He ordered the bowls to be opened to the public for skiing.

This article first appeared in the December 2016 issue of *Skiing History Magazine*.



Word spread quickly that skiers had been buried, and Sun Valley employees all over the mountain were mobilized. Staff and guests searched for survivors well into the evening.



The view down Lookout Bowl. Victims were recovered in the circled areas. The tragedy sparked improved safety procedures and communications at the resort.

Bob Albrecht: *I was told that he gave orders to his second in command, Lou Whitcher (10th Mountain veteran), that he didn't want to see any tracks in the bowls when he returned.*

The allure of powder snow is strong and Sun Valley had a reputation for delivering an extraordinary skiing experience. Guests and instructors had been pressuring management to allow them into the untracked closure area. Meanwhile, with the patrol and ski school not on the best of terms, communication channels may not have been fully open. On the morning of January 19, Nelson Bennett's closure was countermanded, and on Sigi Engl's authority, the bowls were opened to the public.

Instructor Victor Gottschalk had several guests in his class. According to historian Wendolyn Holland, Stuart Fraser was visiting from his home in Mexico and Arthur Gardner was on vacation from New York City. There were two or three others in the class. Rudolph Mandl was an Austrian visiting from Washington State and hopeful of soon being hired on to the ski school. It is not clear if he was part of the class or just in proximity to the other skiers as they followed Broadway along the lower bowl meadows. At this fateful mid-morning moment, high in Lookout Bowl, with multiple layers of snow under tons of pressure, a large section of snowpack collapsed, cracked, and released.

It was a tremendous spectacle. The main slab rumbled off the upper northeastern aspect of the ridge, on the skier's right. Gaining speed and mass by the second, it roared into the gully, on down the bowl, through the meadows and down into the narrows. Some say a good portion skipped the bend in the narrows, blew up and over the facing hill, gathered more snow on the backside, then rejoined the main slide below. The deluge then ran the remaining quarter mile to the Cold Springs lift, where the shack and a few chairs were partially buried. The cable popped off the first roller and the lift stalled. Finally, the beast came to a halt. There was a complete whiteout as a fine mist of snow hung over the mile-long slide path, and one has to imagine, a few minutes of dreadful silence.

Those who didn't witness the event found out quickly and the word was that skiers had been caught. Sun Valley employees all over the mountain were mobilized. Bob Albrecht was near the Roundhouse.

Bob Albrecht: *I was told to go with Ken Beck (10th Mountain veteran) to the ski patrol cabin at the top of the Ridge lift, pick up the avalanche probes, and ski down to the lower part of Lookout Bowl where the victims of the avalanche were last seen.*

There was no chairlift to the top of the bowls at this time; the only way over was to traverse. The pair made their way across Little Easter, Easter, and then to the ridge northeast of Lookout Bowl.

Bob Albrecht: *Judging from the fracture headwall in Lookout Bowl, there was about ten feet of snow in the starting zone, and there was a definite fracture line in Easter Bowl that had not slid. Along the*

sides of Lookout Bowl were blocks of snow as big as cars that had dislodged then stopped.

They continued down the ridge to the area where the class members not caught in the slide last saw the victims, approximately where the base of the Seattle Ridge lift is now. There were about 40 people on the scene. Albrecht and Beck delivered the probes to Lou Witcher, but Sigi Engl was there and in charge.

Bob Albrecht: *I reported to the ski school director about the fracture line in Easter Bowl and that the snow in that bowl appeared to be fairly unstable and likely to avalanche at any time. He neither made acknowledgment of this information nor asked any questions, but only stared off into space seeming to be in some kind of trance.*

Who knows what Sigi was thinking? He may have already seen or been told of the fracture line in Easter Bowl. There were victims, possibly alive, under the snow. More and more people were traversing or skiing Easter Bowl by the minute and arriving at the bottleneck of this upper deposition zone. Did the traffic constitute a de facto safe-skiing of the terrain or was it still unstable? Any new slides in any of the bowls would also track to this spot, but still, there was urgent lifesaving work to be done. Meanwhile, first year instructor Ben Walker, was teaching on Dollar Mountain.

Ben Walker: *Someone (got our attention) and he said, "All right, all the guys over to Baldy!" You could look over into Lookout Bowl and there was just a line of demarcation at the top, and then nothing but sage, rocks, and grass. It just took everything. And we had to go over there and they gave us these long bamboo poles to look for bodies.*

Soon over 150 employees and guests were searching. The snow depth in this part of the slide was about 30 feet. As the assembled bamboo probes were only 20 feet long, some searchers were set to work digging parallel trenches 10 to 15 feet deep so the probes could reach the ground.

Bob Albrecht: *The only victim found that day was the instructor Victor Gottschalk. He was found about one and a half hours after the avalanche occurred. He was not breathing and could not be revived.*

Digging and probing continued well into the evening with the aid of Coleman-type lanterns. During this time, the lift crew was able to excavate the Cold Springs chair, make repairs and get it going again. At about 8 p.m., approximately nine hours after the slide, Sigi Engl called off the search. No more bodies were located and there were no more slides. People rode up the Cold Springs chair in the dark and down-loaded on the Exhibition lift holding their skis and poles in their laps. For reasons not clear, each of the single chairs was loaded instead of the usual skipping strategy. The fixed attachment lift accelerated to almost runaway speed.

Bob Albrecht: *It felt as if we were literally flying down through the dark. The only light was a big splash of light at the bottom where I found that they*



The ski patrol was a hardworking outfit. Second in command, Lou Witcher is third from left in the middle row.



Bob Albrecht, pictured here, participated in the rescue effort. The crown and southern edge of the slide is visible in the background; the fracture line was eight feet high.

It was a tremendous spectacle... Gaining speed and mass by the second, it roared into the gully, on down the bowl, through the meadows and down into the narrows. Some say a good portion skipped the bend in the narrows, blew up and over the facing hill, gathered more snow on the backside, then rejoined the main slide below.



It snowed after the avalanche, covering exposed dirt and sagebrush. Still visible are the parallel trenches dug in the deposition zone.

had three men doing the unloading. One to grab the skis and poles, one to hold the chair back, and one to grab the occupant and fling him away from the line of the lift. It worked.

The search continued by daylight and two more bodies were recovered. Then, via Union Pacific train, Nelson Bennett returned from Washington and resumed command of the ski patrol.

Nelson Bennett: *One of the bodies wasn't found and we had a patroller in (the area) each day from that point forward.*

Ben Walker: *I remember that during the spring when we skied it was really eerie because we didn't know if we might run across a body, maybe an arm sticking up or something like that.*

Eventually the last body was found and there were, of course, repercussions and problems to fix. It had been a tragic combination of unusual weather, good intentions gone awry, inefficient operations, and happenstance. The top mountain manager was out of town. The new ski-school director was perhaps too easily swayed to try to maximize the ski experience for his clients. Communication and relations among departments were strained or failed. In *Sun Valley: An Extraordinary History* (1998), author Wendolyn Holland reports a lawsuit by one of the families and a settlement reached just before trial.

The patrol and ski school developed better relations and eventually Sigi Engl looked at the patrol as his farm team. Even younger skiers from down-valley Hailey made it onto the prestigious ski school. And of course today, snow science, high technology, equipment advances, and checks and balances in decision-making have become a regular part of mountain resort protocol.

Few long-time skiers are untouched by avalanche danger. Most of us have a friend that has had a close call—or worse. And it's not necessarily knowledge or experience that can make the difference between a memorable day and a life-changing tragedy. All the variables of weather, human judgment, equipment, and situational awareness are in play, and the time frame for nature to display her awesome natural power includes right now. ●



High in Lookout Bowl, a large section of snowpack cracked away and released. It roared down the bowl to the Cold Springs lift, where the shacks and a few chairs were partially buried.

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Lookout Perspectives

Simon Trautman, National Avalanche Center and former Director, Sawtooth Avalanche Center



I remember seeing a photo of this avalanche in the Sun Valley Ski Patrol shack. There were also photos of the debris and destruction floating around the Avalanche Center office in Ketchum. It's striking that 60 years later this event continues to impact the thoughts and perspectives of avalanche workers in the area. From my perspective, the article is especially compelling because of its focus on the workers involved. The event undoubtedly cemented friendships, ended others, and ultimately changed the way Sun Valley managed its people and terrain.

Contemporary avalanche operations may have a different approach than those of yesteryear, but the endemic social traps remain. Gaps in leadership, friction between departments, loss of communication, breaking the scope of practice—all of the pitfalls described in the story can play out today in one way or another.

This story offers a close and personal view into why policy, procedures, and professions evolve, and why they are so important in keeping both the public and workers safe. After all, it is the people involved in events like these who have contributed so much to our current approach to snow safety and who will likely contribute more in days to come.

Rich Bingham, Sun Valley Ski Patrol for 62 years, now retired.



That's a great story. Butterfield wrote it up and did a good job; Bob Albrecht always told the same story. We had a photo of the 1952 crown up in the patrol shack for as long as I was there. That avalanche changed the way they did things on Baldy. I started on the patrol in 1967 and spent 52 years there; for the bowl we had used a 75mm then a 105mm recoilless rifle, which is still in play, plus all kinds of hand shots, and up to 60# in a sled. Now there's all kinds of new ski and snowboard technology that lets skiers and snowboarders get in there, disrupt the weak layers. Hard to do with skis that were 65mm at the waist, haha. We never did much bootpacking, it was always too little too late to reach the depth hoar at the bottom.

Lookout Bowl was always one of my favorite routes to run over time. Now we have easier access due to a lift that goes to the top, so no more bootpacking to get there, plus snow fences across the back to change wind and deposition patterns. Mitigation has changed through technology so much since 1967; it's not even the same game. Everything has evolved.

Sun Valley is at the mouth of the high desert plateau. When we get SW to S to SE flow at 9–10,000', the moisture is still intact and wrings out right over us. The storm in 1952 was probably southern flow on top of basal facets, with some sun crust mixed in. I've seen that whole bowl go with one shot, or only a little piece of it go, then I'm scratching my head, saying "what's going on?" NW flow pulls the moisture out before it gets to us, you guys get in Jackson Hole, I've seen it for years.

Nelson Bennett (ski patrol director in 1952) used to come visit after he retired. He was out of town that week, but had left strict instructions not to put a single track into the bowl. Sigi Engl was young and aggressive, countermanded the order. Nowadays it would be way harder for something like this to happen, there's enough checks and balances, advanced systems in place. We like to think that we learned from the mistakes that were made in that one. ●

Another avalanche in Lookout Bowl: Wind slab (top photo) in Lookout Bowl ran past Mayday lift (center photo), all the way to the Seattle Ridge lift (bottom photo) December 4, 2012. Photos Rich Bingham



Women's Inclusion Project

PART 2

BY EMMA WALKER

A3 has been working hard to answer a big question: How can we diversify our membership? This is part of a larger conversation within the outdoor industry. In the avalanche world, we're lucky to have a huge number of female role models, and in TAR 38.3, we posed questions to some of the best and brightest: Janet Kellam, Melis Coady, Wendy Wagner, and Eeva Latosuo.

This series of profiles on the women of A3 has been a long time coming. A3 Board President Halsted Morris initiated the conversation last fall when he told A3 board members he wanted to see more women joining (and feeling welcomed in the ranks of) the organization.

Lynne Wolfe and I made a list of the questions we'd always wanted to ask our mentors—and then we asked them of our mentors. We also gathered the names of other people's role models, and our list of women to pose these questions to keeps growing. Each set of answers we've received has taught us something new and unexpected.

This issue includes Part 2 of our women's inclusion project series. We hope there will be many more.

Anne St. Clair

Forecaster, Avalanche Canada • Revelstoke, British Columbia

Anne has spent over a decade in the backcountry working in avalanche education, guiding, and snow safety. As a social science researcher, she is most interested in the effectiveness of operational risk management practices, education curriculum, and public risk communication products. Anne recently completed a master's degree working with Simon Fraser University's Avalanche Research Program (SARP) in Vancouver. This winter, she is excited to be working at Avalanche Canada as a public forecaster in Revelstoke, B.C. and traveling across the border as a member of the AIARE instructor trainer team.



TAR: What was your first job in the avalanche industry? How did you get your start?

ASC: My first job was working as a tail guide for a cat-ski operation. There was a late-season opening due to an employee injury, and I met the requirements with avalanche and wilderness medical training, a resume of personal backcountry skiing experience, and five years of professional guiding as a multi-day mountain bike guide in Moab.

Who were your mentors? How did they challenge you?

John MacKinnon taught my first avalanche course and I distinctly remember thinking, "I love all of the elements of this process and I wonder if I could make a career in this classroom." I've since had the privilege of teaching with John and collaborating on the AIARE instructor trainer team. I am continually inspired by his example as an educator, and I attribute my connection to the industry to his classroom.

Early in my career, I was approached by Kirstin Nelson who was working with the Backcountry Babes. She encouraged me to actively pursue professional development, as there were few women in the local community qualified to work in leadership roles in avalanche education. I think it can be difficult to navigate the avalanche industry in early career stages and to find your place. Having Kirstin outline a purposeful direction and an explicit role for me to fill was instrumental in helping me overcome the bottom rungs of the ladder and in making me feel that my contribution to the industry would be valued if I made the investment.

What's the most useful feedback you've ever gotten?

I was fortunate to work with Tim Brown

on a guide team. I distinctly remember Tim prompting me to consider what I wanted in terms of mentorship and how I could take steps to make it happen. It was an empowering prompt that encouraged me to self-direct rather than passively accept my professional development experience.

How can newcomers to the field build sustainable avalanche careers? Have you done that?

I don't feel qualified to offer advice on a sustainable avalanche career. However, from my experience in the research realm, I think there could be exciting opportunities to better connect the avalanche industry to applied research in fields such as GIS, weather and snowpack modeling, data visualization, risk communication, policy, and decision-making. I think it's important to give voice to these alternative approaches as guiding/patrolling careers seem to dominate the industry lore. I am optimistic that technological and methodological advances could continue to open doors to creatively navigate theory and practice in an avalanche career, but that's a biased hope and hypothesis.

How do you fuel yourself when you're not thinking about snow?

I enjoy bikepacking on the skinniest trails I can link together.

Jenna Malone

Jill Of All Trades • Salt Lake City, Utah

Jenna's avalanche education began when she moved to Jackson, Wyoming, where she patrolled at JHMR and taught for NOLS. In 2004, she moved south to attend the University of Utah's Physician Assistant program, and now works in Neurosurgery and Trauma at Intermountain Medical Center. When not working as a PA, Jenna works as a ski patroller at Alta, a guide with Powderbird, an instructor with the American Avalanche Institute, a medical provider on Denali's West Buttress Route, and a newly-elected Councilperson for the Town of Brighton, Utah.



TAR: What advice would you give your 20-year-old self?

JM: Keep doing what you love. Spend more time in Alaska and British Columbia. Actually, just go to Alaska now.

What was your first job in the avalanche industry? How did you get your start?

My first job in the industry was as a professional ski patroller at Jackson Hole Mountain Resort. I interviewed for “any resort job” as a 24-year-old east coast transplant. The resort HR director looked at his list and said, sarcastically: “Well, there’s an opening on the ski patrol,” then laughed (loudly). I did get a job with the race crew that year and skied around with bundles of gates on my shoulder. That’s how I learned the mountain. We had a powder clause on the race crew; if it snowed more than six inches, the NASTAR course was closed and we could free ski. Four years later, there was an opening as a patrol dispatcher. That was my chance, and I jumped on it. I was hired as a patroller a year later.

How have you seen the industry change since then?

Back then, a friend told me that as a woman in a mostly male industry, I should never let it show when something bothered me. Instead, I

should use humor as a shield—“fake it ‘til you make it.” I think I’ve changed with the industry. I’m more comfortable saying “I don’t know,” and I think we’ve all gotten better at acknowledging and even embracing uncertainty. The industry talks more now about the important role humility plays in surviving a lifetime in the mountains (though I know the wise older folks have long known this).

Who were your mentors? How did they challenge you?

My oldest sister, Cat, who went west first, is a mentor, as is my dad, who drove to Jackson with her, and was a volunteer ski patroller when we were growing up, just like his dad. All the women on the Jackson Hole Ski Patrol (JHSP), including Jen Calder, Shannon Brown, Carrie Elkins, Kathryn Hess, AJ Cargill, Suzanne, Pam Wright, and certainly all the women I saw working in snow—Lynne Wolfe, Margaret Brady, Rebecca Clough, Evelyn Lees—inspired me.

The JHSP crew taught me to laugh off the small stuff, and also that the people willing to dig you out will quickly become your family (even though I left). They helped me learn more in that job than any other. I’m sure I’m one of countless people to list Don Sharaf, and I’ve learned something from every American Avalanche Institute instructor with whom I’ve worked.

What’s the most useful feedback you’ve ever gotten?

This was advice regarding human nature, rather than feedback: No one thinks about you as much as you think they do. Don’t waste time wondering if someone has misinterpreted what you said or if they were offended by a comment; they likely didn’t give it a second thought and have already forgotten it.

Describe a time you made a bad decision and got away with it—a time you got lucky. What did you learn?

I was skiing the Alta sidecountry with my favorite ski partner. It was my birthday. We were storm skiing—and it was good. We were hiking up for one last run, late in the afternoon,

with it snowing a little less than an inch an hour, when conditions changed. The winds ramped up into the forties and fifties, and snowfall increased to four inches an hour. We tried to manage our terrain by skiing a line we both knew well, but cracks started spidering out from my skis halfway down the run.

“Shit, we should NOT be here,” I thought. “We are definitely getting away with this.” But seconds later we were clear, and high fiving as we laughed at how epic the skiing was (pretty epic). We got to the locker room at dark, just as a crew of our coworkers was loading into the cat to respond to a reported avalanche that had tumbled a skier and buried her gear. That avalanche was on the same slope we’d skied, but about a quarter mile to the north, and maybe (maybe) a touch steeper. Our friends responding were glad it wasn’t us. I was glad it wasn’t us. Familiar terrain and the late day “get to the barn” feeling let my powder pig take over on that one.

Have your leadership and communication styles changed over time?

Yes. I’ve gotten more comfortable admitting uncertainty, and I’ve learned to listen more.

How can newcomers to the field build sustainable avalanche careers? Have you done that?

Find a mix of jobs, or one job, that provides a blend of physical and intellectual challenge, with great people and as much powder skiing as possible. I am incredibly fortunate to have a great balance of fun, challenge (physical and cerebral), and skiing, though my new political role has cut into my ski days a bit! It’s important to build in some days of skiing that are just for yourself, with your favorite people.

How do you fuel yourself when you’re not thinking about snow?

I love yoga, reading, mountain biking, and spending time with my husband and our giant dog, Moses. 🐾

The aftermath of a 15# airblast before initial opening of some of the more alpine terrain of the Irwin cat ski tenure near Crested Butte, CO. 1 finger hard slab failing on 4mm depth hoar near the ground. *Photo Irwin Havlick*

It happens every hundred years or so. A combination of weather factors over the course of winter create a prolonged period of dangerous avalanche conditions that challenge human perspective and reconfigure the landscape. The winter of 2018-19 was just such a winter in the La Sal Mountains of southeastern Utah.

A particularly persistent weak layer and snowfall of more than 200% of average created a season of sketchy, hair-trigger avalanche conditions that resulted in a fatality, numerous natural cycles, and a historic event in mid-March that wiped out mature aspen stands and 75-100-year-old Douglas firs in the process.

This photo is Exxon's Folley, N 11,200' 1500' wide 1200' long 4' deep R3 D3. Part of a widespread cycle that occurred on March 13, 2019 after 32" of snow/ 3" of SWE fell in 36 hours. *Photo Eric Trenbeath*





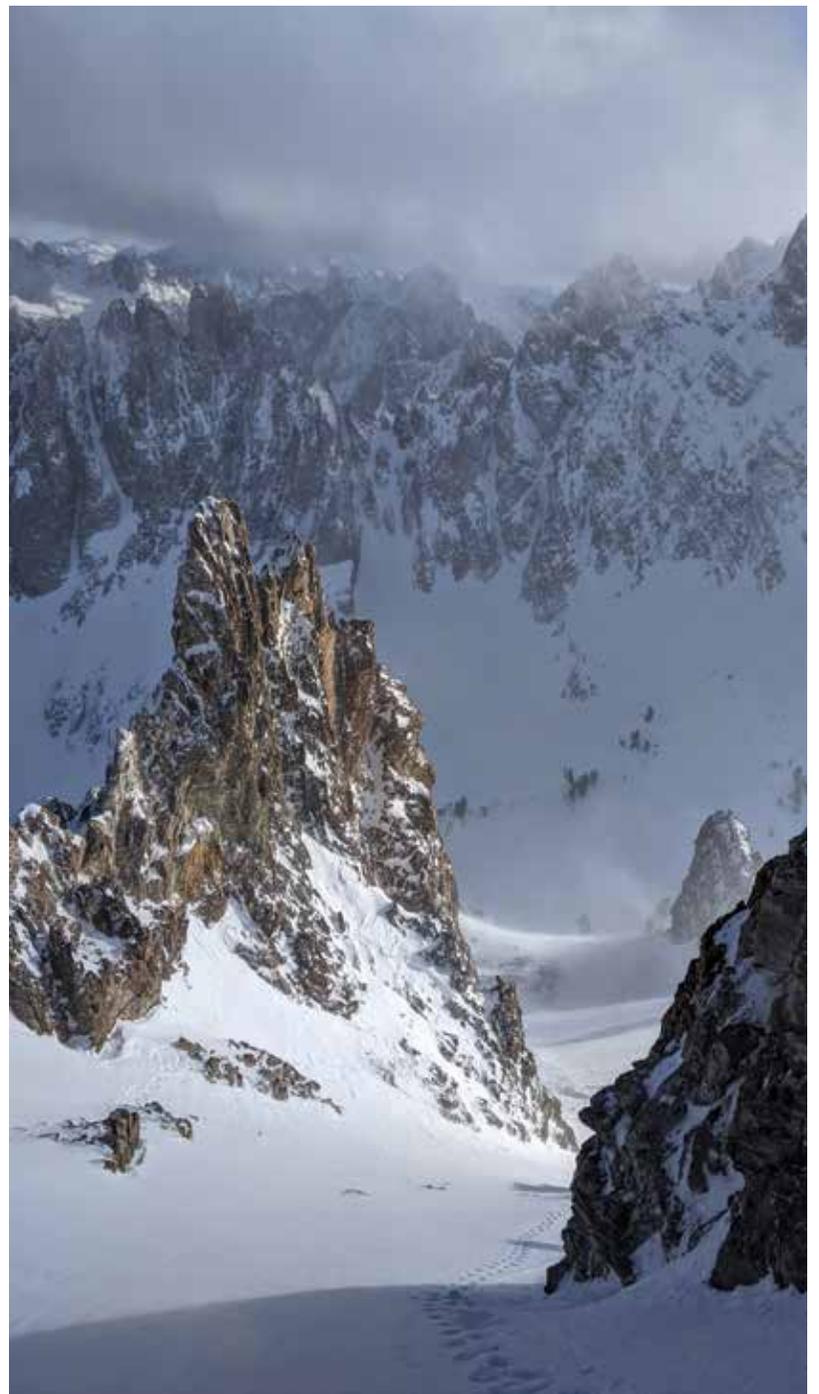
✓ Mt. Shuksan (9,131') on a clear day as seen from Mt. Baker Ski Area. *Photo John Stimberis*



✓ Sunrise in the mountains can be reward for getting going in the dark. *Photo Ethan Greaves*

✓ A D3 hard slab failed on an October facet/crust combo on Heavens Peak in Glacier National Park. The slide was triggered by ~2.5" SWE during a warm, wet loading event that culminated on November 17. We observed several similar crowns like this scattered across the higher elevations in Glacier National Park during a period of clear weather. This is terrain we can't usually access mid-winter because of road access. For better or worse, most of our forecast area saw half of that storm fall as rain, which capped the October facets with a thick rain crust. *Photo Zach Guy*

✓ Sawtooths: As I closed in on the summit I had a cool snow/weather experience: strong to extreme winds were pulling off chunks of the 15-20cm of water-ice rime that accumulated during the storm (mostly on 2/6 I think) and throwing them hundreds of feet up in the air. As I climbed, I was frequently pelted by these golf ball sized chunks of aerated water-ice as they came falling back to earth. Radical. *Photo Ben VandenBos*



When we, via social media posts or direct communication, signal that we value knowledge and wise decisions, we affect the social norms that determine the direction of positional behavior.

We can probably all remember a time we skied a line or hiked a couloir we thought was sketchy. We followed along so our friends didn't think we weren't hard core. That's the country music moment. You know, the one where George Jones sings of that feeling of regret for cheating on the wife, gambling away the paycheck, or drinking the night away and wrecking the truck. In the morning we look ourselves in the mirror and ask "why, why on earth did I let those guys talk me into that?" The old joke in country music was that if you played it backward you would get your wife back and reverse all your mistakes. In avalanche terrain we need to make the right decision the first time since we can't play them backwards in the backcountry. We don't want to ask why or how we got away with it or why we let our friends talk us into skiing terrain we had no business skiing. Usually we just take a deep breath and put aside the regret.

Social Signaling

Avalanche educators, forecasters, and virtually everyone else in the backcountry ski/riding world worry (rightly) about accidents and the behaviors that lead up to them. There is no shortage of theories of why some of us place ourselves at risk even when dialing back is clearly warranted. Read reports of avalanche accidents. While some accidents are due to ignorance of the hazard or a lack of knowledge about the snowpack, it seems today that most accidents are due to a choice to ski risky terrain during risky conditions. Sometimes we get caught up in the heat of the moment, sometimes we make that choice because we want acceptance from our social peers.

As part of the White Heat Project we have been steadily expanding our thinking by placing greater emphasis on how riders' personality characteristics interact with social factors and then affect decisions in the backcountry. Specifically, we investigate how some individuals express their risk preferences based on how they think about themselves in a broader social context.

In this article we will discuss personality-driven behavior called *positionality* or *positional preference*. In behavioral economics, if an individual has positional preferences, this means that she or he not only cares about her absolute level of consumption of various goods and activities, but also cares about how this level compares to that of others. In other words, someone with positional preferences cares about her social position in the group and consumes accordingly. No surprise here. We do this all the time with clothing, cars, and homes. But do we do this with our recreational activities?

Let's take an example to illustrate: Let's say I head up to Bridger Bowl and ski the Z-Chute with a friend. It's good snow and I have a great time but it isn't exactly the toughest line on the mountain or the deepest snow. Later that day I talk with friends who claimed to have skied epic powder on Saddle Peak—so good in fact that they are still going on about it an hour later. How do I feel about their experience compared to mine? I can stay happy knowing I had a good time, I can feel happy for my friends that they had a good time, or I can feel like I missed out and so feel left out. (FOMO is REAL!!!) One thing I could do is run over and ski an even better line off Saddle and regain my self-esteem. Many of us

have probably had similar experiences. We are perfectly happy with our car, homes, and skiing experiences until we see that a neighbor or friend has something better. Or skis something better.

Background

In comparison to other species, humans are highly social animals, and our self-esteem is closely linked to the approval toward us held by others in our social groups. We continually compare ourselves to others as we aspire to higher levels of respect and approval. These behaviors move us up in the pecking order. Those of us who care a lot about what others think of us are said to be *positional*. You know the type—we drive the "right" cars, have the "right" gear, and we try really hard to be in the right place at the right time. We (at least in part) base our consumption and investment choices on how we think that others will react—"that's enough about me, what do you think about me?"

These aspirational behaviors are, in many cases, healthy and productive. They can be how we climb the corporate ladder or rise to positions of leadership; such behaviors lead to how some measure success. Accomplished people read the social cues around them and chose to respond accordingly. There is a downside however. This sort of behavior is a never-ending chase because there is always someone richer, smarter, faster, more successful. At the end of the day we may find we have wasted valuable time and resources chasing a goal that can never be reached. We think of this in terms of mis-invested or inefficient use of resources.

The consumption of status goods such as cars or homes is clearly understood in the research literature, less understood is the role of social cues and resulting personal actions in risk-based recreation. Why, for example, are there so many wealthy people willing to spend large amounts of money to climb Everest? It could be they care about the status of the accomplishment as much or even more than the mountaineering experience. No surprise—It is highly likely that some Everest climbers are positional. Having an Everest climb on your resume or your Instagram= winning.

Climbing Everest or paddling the Grand Canyon clearly holds some cultural value. To what extent does backcountry skiing hold

similar value and what might it have to do with risk? Do people respond to social cueing in the backcountry?

Most of us enjoy a day of social skiing with friends. Many of us also like occasionally testing ourselves in challenging terrain. Now suppose that we run with a social group whose norms valorize risky behaviors—does it make sense that in order to stay a member of good standing with this group we too will react to those norms and so increase our risky behavior? We will if we are positional personalities.

Approach

During the winter of 2018 we collected data through an online survey aimed at backcountry riders. We reached out to potential respondents through the American Avalanche Association, avalanche education providers, via the avalanche forecasting centers, and Powder Magazine. We also presented at several regional SAWs. Of the 1494 completed surveys, 647 were usable for our analysis. We asked questions aimed at understanding demographics, backcountry skills, their risk-taking preferences, their skiing satisfaction and related social media use, and asked them to engage in a decision-based exercise.

On average, our sample consists of highly educated men in their thirties with substantial backcountry experience. Twenty-four percent of sample participants are female. Median age in the sample is 34, and 81% have a university degree. About half of the participants have skied in the backcountry for more than five years. On average, riders in our sample ski the backcountry 21 days per season. A majority (66%) of our participants have participated in some form of formal avalanche training and 20% have professional training; 15% had no formal avalanche training. We also asked participants to assess their backcountry travel skills on a scale from 1 (beginner) to 5 (extreme). Forty-three percent rate themselves as expert or extreme backcountry travelers. Finally, we asked our respondents about their experience with avalanches. Forty-one percent have been involved in a situation where an avalanche was triggered. Of these, 11% have been involved in an avalanche accident in which someone in their group was injured. Our sample mirrors most other survey results but keep in mind, given the nature of the sampling, it is likely skewed towards motivated riders with an interest in avalanche safety and so should not be generalized to the backcountry riding population.

There are many ways to measure risk-taking behavior. We presented two hypothetical terrain choices in a computer-based survey. Respondents were shown photos and read about a hypothetical backcountry ski tour and provided information on weather, snow conditions, the overall avalanche danger level, and avalanche problem, all of which were identical for both runs and provided in detail.

Terrain hazards varied by slope and terrain features affecting the consequences of a fall or an avalanche: **The Field** represented low angle terrain with low probability of an avalanche occurring and no dangerous terrain features (i.e., simple terrain according to the Avalanche Terrain Exposure scale, ATES).

The Bowl is a steep terrain trap in which avalanches from multiple zones are possible (complex terrain according to ATES). The difference in perceived risk between the two options was intentionally large so there was no confusion over relative risk of the two options.

We then asked two questions:

1. which of two alternative routes down the mountain would you *prefer* to ski?
2. which would you *accept* to ski if someone in your group wanted to ski it, and no one else objected?

The intent here is to see if our respondent could be persuaded to move beyond their personal risk tolerance. If risk tolerance is fluid, we want to know why.

The next phase of the survey asked about their level of satisfaction in a ski day compared to other members of their social group. This is the *positional* part. We asked the following question:

“Imagine a weekend where you have been out riding. You rode terrain that you judged to be safe and responsible given current avalanche conditions and your riding and terrain management skills. Snow conditions were good. Now imagine that you learned afterwards about what others in your social group that weekend rode or skied (either by talking with them or on social media).

How would your experienced level of satisfaction with your weekend be affected by the following situations? Presume that no accidents occurred.

1. **You** rode much **more** challenging terrain than others did
1. **Others** rode much **more** challenging terrain than you did.”

We measured responses on a scale ranging from -3 (much less satisfied) to +3 (much more satisfied) for both questions. Zero was explicitly defined as “no effect.” **We define a rider as positional for terrain if the rider states that she would feel less satisfied if others rode more challenging terrain than they did, and more satisfied if they learned that they had ridden more challenging terrain than others.** Both conditions had to be present in order to be considered positional with respect to terrain. The first measure reflects the perceived threat to self-esteem for not living up to social standards. The second is the aspirational feeling of conspicuous consumption.

To validate our measure of positionality, we collected information on behavior that can be presumed to signal both positionality for, and a social value of, risky terrain. We first asked the participants how likely it would be that they talk to friends about, and/or post pictures on social media of, each of the hypothetical runs. Respondents answered on a scale from 1 (extremely unlikely) to 7 (extremely likely). We compared the answers to these questions for each activity (posting pictures and talking to friends) and created two new variables that measure the relative likelihood to boast about skiing a steep line and less steep line to friends and on social media.

Finally, we asked the participants about their personal values and social feedback. Respondents were asked to rate their level of agreement (scale: 1-7) with four statements: “I admire riders who ride bold terrain/lines,” “I admire riders who have a strong focus while out riding,” “If I ride bold terrain/lines, I get respect from my friends,” and “If I have a strong focus on safety while out riding, I get respect from my friends.” The first two statements were aimed to capture personal norms, while the latter two aimed to capture social norms of their peer group.

Key Findings

One third of our sample was identified as “Positional.” They were moved to ski a more risky line in the run choice scenario. These are people who reported that they think riding bold lines will result

The more formal avalanche training you have, the more you are likely to curb your positionality behavior.

Mmmm, yes, you did ski a bolder line than I did.
Photo
Heather Thamm





Positionality is a reaction to our personal feelings of self-esteem and the desire for social acceptance among our peer group.

Gotta go over the Ridge on the way to both the Field and the Bowl.
Photo Heather Thamm

in respect from their peers, admire those who ride bold lines, and are likely to boast either in person or on social media about riding bold lines. Non-positional riders think a focus on safety commands respect and likewise, they respect those who focus on safety. This is not to say that positional riders are, by definition, not safe. It is just that they feel they gain respect and great satisfaction by riding and boasting about the terrain they ride. They care about the terrain they ride and how that compares to others.

When it comes to making a decision about skiing the Field or the Bowl (the relatively riskier line), almost everyone stated that they preferred to ski the Field (92%), and very few said that they wanted to ski the Bowl (8%). A significantly larger share (25%) said that they would *accept* to ride down the Bowl and those we identified as positional were much more likely to do so. Those with advanced avalanche training moderated that behavior by nearly 50% that is; the more formal avalanche training you have, the more you are likely to curb your positionality behavior. Riders with formal avalanche training were less likely to say that they would accept to ski the Bowl, but avalanche training did not moderate the effect of positional preferences. In other words, we find that positional riders are more likely to ride the Bowl regardless of avalanche training. Here is why our findings are important.

Positionality is a reaction to our personal feelings of self-esteem and the desire for social acceptance among our peer group. If all backcountry riders were rational and non-positional, they would choose a level of risk exposure that match their risk preferences, and their preferences for terrain. Positionality for ski terrain implies that individuals' wellbeing is not only affected by their own riding accomplishments in isolation, but also by how those accomplishments compare to other riders' accomplishments. If we take on risk in order to satisfy those feelings, we may discount red flags and potential terrain features that place us at risk. This may result in an accident or near miss we would have otherwise avoided. We avoid the regret of "getting away with it." These actions may be exacerbated by our use of social media.

The share of positional individuals in our sample is relatively low (about 30%). This may be an underestimation. Hypothetical

scenarios talk to our cold and analytical self (system 2 thinking) but it is quite plausible that some of our participants are unaware that they have positional preferences and would react to social cues in a real-life situation.

For the rest of us who consider ourselves as non-positional, it is important to remember that our behavior affects the behavior of others who are positional. Many of us send out social cues via films, Instagram posts, or at the bar. We are all, at least to some extent, influencers. If we post more frequently when we have done something "rad", we (perhaps unconsciously) bias the social ecosystem for the group. We articulate values to the group that positional individuals respond to. Social cues that we send out can and do provoke the behavior of others.

There is good news. The first is that many of the major influencers of our sport have stepped up. Today, it is rare to see a ski film that does not show skiers doing a beacon check and some mention of avalanche hazard. Several companies have produced high quality videos that reframe the social cues of the sport—one that stands out is BCA's Safe Shredding series where the frame of risk is shifted to a frame of judgment. The videos are exciting, the footage sometimes spectacular but the message is on safety and fun rather than risk and reward.

The second is that we, ourselves, have the power to affect our social environment. **When we, via social media posts or direct communication, signal that we value knowledge and wise decisions, we affect the social norms that determines the direction of positional behavior.**

Obviously, one of the goals of avalanche education is to teach, specifically to encourage us towards safe riding practices. Maybe it is time to include a discussion about (perhaps in combination with simple tests of) positionality and social norms in avalanche courses?

By including these insights as part of future avalanche education we may increase the awareness of the role of positionality in decision-making in avalanche terrain, and through this awareness avoid the regret of bad decisions. Let's avoid the country music moment. 🎱

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Being Human

Creating a Personal Season History

Each winter is different. As avalanche professionals, we track season history to tease out trends and help us recognize patterns to predict snow behavior. Some winters drop early snow and go high and dry, leaving us with foundational problems for much of the winter. Other years we get lucky and it starts snowing late and never stops, with bi-weekly resets that freshen the skiing but don't upset stability. Each autumn we're cautiously optimistic that the upcoming winter will bring plenty of snow, good stability, and bluebird powder days.

What we rarely do each autumn is take stock of where we're at personally as we head into winter and then monitor ourselves through the remainder of our season. Did summer work run late and you're coming into the winter season overworked and tired? Perhaps your shoulder season was a little too long this year and you're maxed out on credit cards, stressing how rent will get paid next month. Life tends to get in the way and can put us on our heels heading into the winter season.

As we move through the season, we need to continue to self-analyze. Maybe it's a nagging injury that's impacting your ability to work without discomfort. Perhaps you recovered an avalanche victim during a SAR mission. It might be day six of an avalanche cycle and you're worn out from a long run of early mornings.

Because of these very real hypotheticals, I propose that we need to track our personal season history. Reflect back on a past season when you had a "tough" year on a personal or professional level. Perhaps it was when you lost a parent. Maybe you went through a divorce. You may have had extra work pressure from switching jobs or a new assignment. It might be as simple as having a living arrangement that didn't work for you.

How did that season go? Were you firing on all cylinders or were you treading water and counting the days until May? Did you lack the mental bandwidth to balance your personal life and professional decision-making? Were you exhausted from making decisions? Did you have a near miss or any incidents that winter?

I had one of "those years" last year. Snow-wise, Utah experienced a phenomenal winter. I, however, was off the back. I was balancing two ski guiding/forecasting jobs and teaching a complement of pro avalanche courses. My wife and I were not sure we wanted to stay "my wife and I." Two days before Christmas, my truck was stolen. While dealing with police, insurance agents, tow truck drivers, and a struggling relationship, I tried to celebrate the holidays.

One week after New Years, in the midst of these personal challenges, I had a near miss at work that included an 800' crown line, a deployed airbag, and a fortunate outcome. Did I simply make a bad decision in the field, or were other factors at play? After the incident I took time to reflect on the events of that day, and why I ended up in a compromised position in a large avalanche path.

In the wake of this event, I found it very beneficial and would encourage you to look at your personal and professional experiences through the following lenses:

Reflect on the confidence/experience graph in Bruce Tremper's *Staying Alive in Avalanche Terrain*. (see graphic). Bruce will tell you this is a conceptual visual he adapted from a similar graph by Canadian Clair Israelson, and is not based on scientific study. That said, I encourage you to think about past accidents, involvements, or losses and plot yourself on the graph. If you find yourself at a precipice of confidence, beware and be thoughtful, and extra vigilant when in avalanche terrain.

Revisit Ron Simenhois and Scotty Savage's paper from 2009 detailing Professional Avalanche Near Misses in TAR 28.1—page 16.

BY
PETER
EARLE

In it they discuss four main contributory factors that led to near misses. These were identified as distractions, motivated reasoning, repeat incidents, and communication failure (see graphic). They found that distractions played a role in nearly 80% of the near misses they studied. Analyze your individual factors and see if you can find a theme or pattern, then work to see how you can reduce the factors present in your daily work life. **If distractions are one of your factors, develop a system to be fully present whenever you're entering avalanche terrain.**

We live in an age of information overload. We have a device in our pockets that unlocks bottomless information while simultaneously acting as a GPS, compass, altimeter, slope meter, camera, and a potpourri of other apps. While a useful tool, smart phones can be a distraction and allow our brains to drift from the task at hand in avalanche terrain.

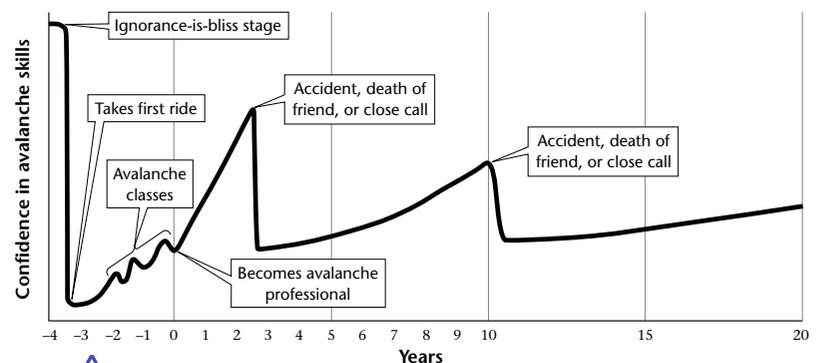
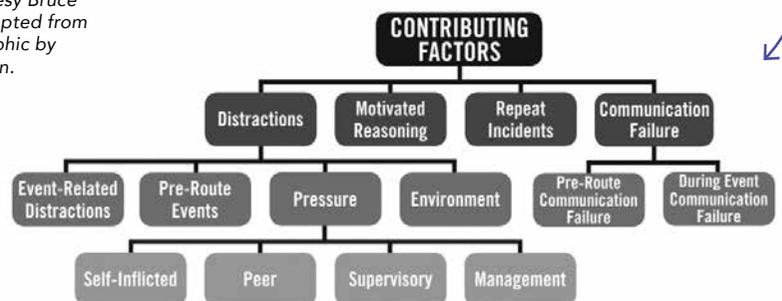


Figure courtesy Bruce Tremper, adapted from a similar graphic by Clair Israelson.



How many factors do you experience on a regular basis? Figure courtesy Savage/Simenhois, TAR 28.1.

Soon after my near miss, I was involved in two additional avalanche incidents; another (smaller) avalanche in the Uinta Range, and a double fatality avalanche in which I ended up helping excavate two victims. This all happened in a 10-day stretch. To say that I was shell-shocked for the rest of the winter is an understatement. My confidence was shattered and my risk tolerance plummeted. I was fortunate to have family, coworkers, friends, and mentors who checked in on me and made sure I was doing okay. By talking through the events in my personal and professional life, I was able to safely and thoughtfully do my job for the remainder of the winter.

Be there for your coworkers and friends. If they're going through a tough time at home, or stressed from work, reach out to them. Our industry has a long and strong history of stiff upper lips and drinking a beer (or 10) after a hard day. These coping mechanisms may help temporarily, but we all need to look out for one another in the long run. Be that person for one another. It can be uncomfortable, awkward, and hard to initiate these conversations, but as the recipient, I can assure you that it will make a world of difference to someone having a hard time. Ultimately, it will make the team you're working with stronger and more cohesive.

In the end, we do this work for any number of reasons; from skiing powder in the backcountry, to helping others, throwing hand charges, or for the mental challenge of avalanche forecasting. We all want to go out and do it again tomorrow, but we need to take stock of ourselves and our peers and make sure we make it through today first. ●

Pre-Traumatic Stress Management

The Next Step

Breaking trail—the challenge of every step, anticipation of what’s around the corner and most importantly creating the path that makes it easier for those that follow.

BY STARR JAMISON, WITH INTERVIEWS WITH LAURA MCGLADREY AND DREW HARDESTY

In the last few years, momentum has exponentially grown to promote conversations about mental health, stress injuries, grief, and trauma in the outdoor industry. Many avalanche professionals have stepped forward to share their stories, which helps create and maintain healthy communities, with the byproduct of longevity in our careers,

Without a doubt, 2013 was my breaking point. I had been experiencing years of difficult professional and personal life traumatic events and thought I had worked through my grief and PTSD, but started having nightmares, was anxious and detached from relationships. It started with fear in my job; anticipating catastrophic events, watching over my shoulder for anti-government folks, witnessing death and disaster in the place where I once searched for solitude. My escape, pleasure and paradise of backcountry skiing also brought pain and PTSD. I lost two friends within two months in avalanches. I didn’t stop running from my fear and pain. Six months later I was on a bike tour and became a victim of a hit and run. Almost losing my arm, it was severely broken and permanent nerve damage left me unable to open my hand for over a year. Each recovery process was interrupted by the next and I couldn’t catch up until the physical trauma took me down and left me to face it all.

I had time to think about how all of these events had stacked up. As a park ranger, silence was prevalent; no one wanted to talk about traumatic events. I was told that, in the unfortunate case I needed to talk to someone, there was a chaplain, who sounded like someone distant, foreign, and disconnected from my community. We trained six months before we could travel on our own as rangers, but had no medical or pre-stress management training to manage events we may see out there. For my personal traumatic events, which were now compounding with professional trauma, I watched myself changing but didn’t understand what was happening. At the time there wasn’t a name for it and I was curious to understand more about how traumatic events affect us.

I found multiple Websites for veterans or basic information from therapy or counseling websites. To my surprise, with much research I found no support for the outdoor industry around bereavement and backcountry accidents, no one who spoke the language of skiing or climbing. During my search for peer support, I heard stories of suicide, attempted suicide, alcoholism, divorce, and escapism. I talked through events with friends, gave them resources I had found or participated in. It was a learning process taking information from others about their events, creating our own peer support group.

This led to the creation of SOAR—Survivors of Outdoor Adventures and Recovery. In 2014 I launched the Website SOAR4life.org with the vision of offering support for accident survivors to lead healthy lives through self-care, staying connected to their communities, and continuing to adventure. This organization developed from not only my own experiences but also by compiling information and questions from other survivors and their friends and family members. SOAR embodies efficacy, connection, and hope, all of which are part of Physiological First Aid.

When I heard Laura McGladrey on the Sharp End Podcast *Episode 34- Psychological First Aid*, her message resonated with me. She was speaking about mental health in the outdoor industry, the topic I had been searching for. Through the Responder Alliance, Laura has become a powerful force in

pioneering stress injury training and awareness. A veteran NOLS wilderness medicine instructor, emergency department nurse practitioner, and humanitarian aid worker, McGladrey works at the University of Colorado as a nurse practitioner with fire, EMS and law enforcement officers and systems who have been impacted by traumatic stress. She has piloted programs with Eldora and Monarch Ski Patrols and now works with rescue teams, ski patrols, snow scientists, guides, and national parks teams to identify and mitigate stress injuries on teams. This year you’ll find her hard at work in Yosemite, Denali, Rocky Mountains and the Tetons.

With curiosity I dug a bit deeper into the Responder Alliance’s Website and learned that it has a mission to advance national conversation on stress injuries in rescue and outdoor culture. Laura is training Ambassadors in avalanche, ski patrol, search and rescue, and guiding communities to recognize and talk about stress impact. I was inspired and wanted to be part of this forward movement, combining their mission with my experience and passion. I found myself in Leadville, Colorado, in the fall of 2019, with other guides, rangers, patrollers, firefighters, law enforcement rangers, and avalanche folks, training to become a Responder Alliance Ambassador. Laura packed two weeks of information into three days of training. The energy, ideas, and collaboration were innovative and inspiring.

I was asked to speak about my experiences and SOAR at the 4 Corners SAW in Silverton, CO. Inspired and now an Ambassador I jumped right in, discussing trauma formation and how it plays a role in our careers. I highlighted others who have come forward to share their stories about traumatic stress injuries, then discussed how stress injuries are formed and mitigated while also discussing the momentum of mental wellness in the avalanche/ ski patrol community. I was inundated with follow-up questions from attendees and discussions on preparedness for the inevitable in our careers. Do you continue with the old ways of “debriefing” and how do we prepare for these events that inevitably affect us?

In my presentation at 4SAW, I included excerpts from a podcast from the Utah Avalanche Center, hosted by Drew Hardesty. Drew mentions the idea of Pre-Traumatic Stress Management. He says,

“Rather than waiting for teams to be surprised by overwhelming events and scramble to find someone to ‘debrief them,’ why not start the season with a pre-traumatic stress plan and practice for it? We train for rescue, beacon searches, etc. therefore we need to be talking about stress injuries and anticipate these events.”

Pre-Traumatic Stress Management is a term that McGladrey and Hardesty often kick around. In a collaboration of thoughtfulness and years of experience, together they are determined to move this from a *post* to a *pre* movement.

Follow up emails and conversations from 4SAW and my own inquisitiveness led me to query Laura and Drew for their insights:

SJ Pre-Traumatic Stress Management, where do we start with our teams?

LMG We've never seen the term stress injuries used for the avalanche community, and I don't think we've named these exposure patterns for forecasters. It seems very pertinent to the conversation. We've identified that awareness, common language, and early recognition, as well as operational use of Psychological First Aid are the components of pre-traumatic stress management,

SJ So, what do you call it?

LMG **Awareness**, there's something important about naming it. Once you can name it, you can recognize it, you can start to heal. If you can't name it, it feels like it's just something wrong with you. Naming the impact of the exposure and loss actually allows you to connect and make different choices. It's unrealistic to watch people you've skied with, that you're responsible for, that you've partnered with, injured and killed doing exactly what you love to do and not be affected by it. Gravity doesn't work that way.

SJ Stress injuries, how do they play a role in trauma formation?

LMG This is the language that the military introduced in combat and operational stress first aid. We use it now in structural fire, law enforcement, and EMS. NOLS Wilderness Medicine, thanks to Tod Schimelphenig's leadership, now has a section on Stress Injuries that fits squarely between head injuries and chest injuries. We saw Stress Injury introduced in Accidents in North American Mountaineering this year as climbing injury type. It's fair to call this an exposure injury, but it's more than that. It also happens with the wear and tear of decision-making, responding and depletion. If you're a highway forecaster in the midst of the March 2019 avalanche cycle, closing roads, responding to one avalanche after another and the whole state is looking to you, you could sustain this injury without ever seeing a traumatic event. But add that kind of depletion to a bad call, or overwhelming trauma and you have the recipe for significant injury formation.

These injuries occur on a continuum. They aren't one size fits all. One of our great challenges in supporting this injury type currently is that we only have one name for it; Post Traumatic Stress Injury or PTSD, and the reactions associated with PTSD are very real, but represent a serious injury type. We haven't had a language to recognize and identify early changes in this injury type. The stress continuum is designed to be a common language that responders could use to first recognize stress impact before it ever becomes an injury.

Creating teams that folks want to come home to when hard things hit might be the single most important thing we can do to mitigate traumatic stress. Sometimes it's the hardest.

SJ How do stress injuries develop?

LMG There's a formula, actually. Folks think if you do critical incident support you have a magical ability to determine when folks will get hurt. It's not like that. Like so many things in avalanche, it's pattern recognition and once you start looking for it you'll see it everywhere.

Stress injuries are formed when a stressor or series of stressors overwhelms the person experiencing its capacity to integrate it or make sense of it. This means stress injuries occur in a state of stress. That means look for the folks when something tough happens who are stressed, depleted and don't feel like they can handle what's in front of them. That's whom traumatic exposure usually hurts.

The human machine is actually made to respond to stressful situations, such as one's car sliding off the road or a taking a small ride in an avalanche, and then skiing out of it. Each time that happens we mount a physical response, overcome, then send out a chemical 'all clear' signal and forget all about it.

It's not until moments when our brains register that 'this could be really bad,' or when we are isolated and can't respond (think swept in the avalanche without a witness) that our brain register threat to life. At that moment, there's a failure of the all-clear signal and we tend to mount a survival response. In those moments, even if we watch someone else caught in a slide, we will store the memory of it happening to us. At that moment, we flip a switch from living the lives we were living to survival. The brain and body's primary goal becomes survival, which means rather than spending our lives enjoying skiing, falling in love and creating we are hyper vigilant, isolated, exhausted with less and less joy for the things we used to love.

SJ Why the mission to change the way we talk about traumatic stress?

LMG An adage that we work with often in my clinical work is "awareness, then choice."

If you don't know that your life's on fire, you won't do anything about it.

If you're a patroller who has a short fuse, is feeling burned out on forecasting, dreads coming to work, but can't do anything else and thinks it's just how everybody feels at a certain point in their career, then you won't try and change it. So often what we see as stress impact gets assigned to personality. We think, "that guy or gal is just toxic. Let's get him out of here because it sucks to work with him." We don't say, "Man, that guy is really affected by losing half of the friends he started with, and weighed down with the responsibility of making these calls day after day. Let's support him."

Until we name it, we won't recognize it and we can't do anything about it. There's something important about naming it. Once you can name it, you can recognize it, you can start to heal.

It's like recognizing that chest pain, shortness of breath, and radiating pain have a name. Ah, heart attack. Right. I know what to do.

SJ We are starting to see the stress continuum in ski patrol locker rooms, Ski Patrol Magazine and at SAW events. Tell us more about the continuum and have you created one for avalanche forecasters and guides?

LMG The continuum was originally based on one used by the marines in Combat and Operational Stress First Aid. We have been calibrating it for Patrol, Rescue, and NPS climbing rangers and now avalanche. It has four stages Ready (Green), Reacting (Yellow), Injured (Orange) and Critical (Red). Eldora Ski Patrol is the first patrol I worked with who crafted this continuum for the Ski Patrol and Avalanche community. It was pretty simple. We put up four colored pages in PHQ (Patrol Headquarters) and let folks fill them out for patrol. At morning meeting, when patrollers do personal risk assessment, they take note of what color they are on the continuum. If folks are creeping up into the orange, they notice it and can take steps like taking some time off, connecting with each other or letting the patrol director know in order to take action. We also set a goal of finishing in the green as much as we can. Having a language and a goal to be healthy seems to be changing culture.

No we haven't created a forecaster or guide-specific continuum yet, but we're working on it. I'm hoping someone reading this thinks, "This is what I want to do," and reaches out to do it.

Stress Continuum

Ready	Reacting	Injured	Critically Injured
<ul style="list-style-type: none"> • Let's Shred, • I love this job. • Let's get some good observations to CAIC. • I do uphill laps before work. • Stoked to pick up shifts. • Light-hearted. • I'm coming back next year. • I love working lower mountain. • People are nice. 	<ul style="list-style-type: none"> • Sundance coverage sucks, • Dreading the cold. • Cutting corners, • Something hurts, I'm working anyway. • My weekend wasn't long enough. • Others aren't pulling their weight. • I'm not working extra. 	<ul style="list-style-type: none"> • Lack motivation for off-work skiing. • Lack of snow nerd interest. • Drinking to forget or to feel numb. • Dealing with early uphill. • Call dodging. • Eating too much. • Showing up late or not at all. • Stressed out watching people ski from the lift. • Too tired to play. 	<ul style="list-style-type: none"> • I don't want to ski. • Doing nothing outside work. • Drinking when it's dangerous. • Insomnia or dreams about last call. • Work projects to avoid patient care. • Going through the motions. • No emotion. • Scared to ski.

COSFA, created by Eldora Ski Patrol and adapted by Laura McGladrey

SJ Drew, as a long-time forecaster can you give us an example of what stress injuries you've seen or experienced in your career?

DH What's interesting is that we have different kinds of forecasters and responders and the stress injury plays out differently.

Each niche of avalanche forecasting—backcountry, highway, and ski area avalanche forecasting has its own type of stress, but they can all involve sleep deprivation, uncertainty, continuous attention to detail, perhaps even some close calls or accidents. There can be cumulative stress and a lifetime of exposure that can lead one toward traumatic stress without proper attention and support. Each of us assumes a great weight of responsibility to protect the public, commerce, and one another.

A good example is the recent early February storm in the Wasatch Range. Upper Little Cottonwood Canyon received nearly 7" of SWE in 50 hours with sustained strong west winds. Nearly every avalanche path ran naturally or with artillery. The backcountry forecaster issues the High to Extreme danger rating and tells people to hide under the bed. The highway forecaster gets very little sleep because the town of Alta is interlodged and the road is closed for 42 hours. The plow drivers then work to clean up the debris while underneath all of the avalanche paths that have run...but there is always some uncertainty here.

What does seem to be common for all is the weight of the decisions that forecasters of all types have to make. If you're a backcountry forecaster and you blow a forecast, someone might get hurt or killed. The same is true on a highway if a natural avalanche knocks cars off the road. No different for the patroller who keeps terrain open resulting in an inbound avalanche or the guide who takes folks out only to have them swept and killed. It's weighty, and the weight accumulates.

I often joke that I get paid to pay attention but the truth of the matter is that paying attention is a lot of f---ing work. Paying attention all the time is hyper vigilance. Paying attention during continuous weather causes tremendous strain. It can wear on you. Heuristics are shortcuts that we use because we have to make decisions all the time and paying attention to everything all the time is exhausting. Some call it "lazy," others "efficient." These shortcuts work most of the time but that's not good enough. Regardless, one must pay a high level of attention to the snow and the weather because avalanche conditions can turn on a dime...and because we know what's at stake.

There is this idea of message fatigue and inadequate patience. "You and the public get tired of saying the same things over, Depth hoar, facets at bottom...blah blah blah and nothing happens. You stop paying attention or let desire cloud judgment and then you blow it."

SJ Laura, you mention Psychological First Aid as a component of Pre-Traumatic Stress Management. What is it?

LMG Psychological First Aid is basically a toolkit for folks responding to others who have been overwhelmed by what's in front of them. They are tangible steps, stuff you might do anyway if you knew why it matters, to help folks fire off the all-clear signal we just talked about. In 2015 we formally added this injury type to our curriculum at NOLS Wilderness Medicine. We've been teaching folks for decades what to do to support and stabilize physical injuries. Now it's time to have something up our sleeves for early intervention in psychological injury, like when you come on scene at an avalanche and see a partner with the thousand-mile stare. We should consider them injured too, stress injured. Dale Atkins wrote about this a few years ago in TAR 36.2, where he outlined the steps of PFA (psychological first aid). It's really worth going back to review. I'd like to see us teaching this in avalanche education in the next few years.

SJ At the end of my 4 SAW presentation, I was asked in a panel discussion "what advice in one word would you give someone dealing with traumatic stress" and my answer was, "connection." Can you tell us your thoughts on connection and how it is a tool for pre-traumatic stress management?

Rather than waiting for teams to be surprised by overwhelming events and scramble to find someone to 'debrief them,' why not start the season with a Pre-Traumatic Stress Plan and practice for it?

LMG We know that in the traumatic stress literature, the single most important factor in how injured you will be after you experience a traumatic exposure is your level of social connectedness. This means that it matters if other people know you and have a sense of how you're doing.

One of the most impactful stories I've heard occurred after an inbound avalanche in Colorado where a patroller was killed. The local clinician showed up to the locker room and said, "You're a family and families have what it takes to get through this. This is grief and you know what to do. I'll be back tomorrow to check on you." It brings us back to the basics. Creating teams that folks want to come home to when hard things hit might be the single most important thing we can do to mitigate traumatic stress. Sometimes it's the hardest.

What I candidly believe is it's crucial to have your own peer support team, not necessarily from professionals. [We need] people to ground things with because that is our only real technology for integration of grief and trauma, the weightiness. This is our job, to do that for each other. I think that's where we are moving in debriefing, instead of bringing people back into a hot topic that may trigger them. The old model is "we will wait till something bad happens, then come in with an eraser, and make it not bad."

SJ How do we prepare for the worst? Tell us your ideas on pre-traumatic stress management training?

LMG This is where we need to break new trail. In all rescue teams that I work with, there is still near-universal agreement that we should only wait until after an event to support the traumatic stress, usually by an outside 'expert' that nobody knows. Nothing could be further from the truth.

We can plan on traumatic things happening as backcountry, patrol, and highway forecasters, even as guides. We don't want them to happen, but it's not possible to eliminate all risk. If we know that stress injuries occur in a place of stress, then the innovation should be to reduce stress, both occupational stress and life stress, and build capacity to respond to hard things. If you see yourself or your team getting depleted by early open or a continuous storm cycle, pay attention to the sleeplessness, the strain, the lack of connection, and the feeling of overwhelm. See what you can do about it.

We know traumatic events are going to occur on the teams and areas where we work and play. It is rare for any of the teams I work with to get through the season without at least one fatality. Rather than waiting for teams to be surprised by overwhelming events and scramble to find someone to 'debrief them,' why not start the season with a Pre-Traumatic Stress Plan and practice for it?

If you could predict next week that you were going to have one of the hardest most difficult moments of your life, could you look around and know who your people are and the level and connection you have with these people? If you don't have one or two people this makes you so vulnerable to shame, regret, moral injury. The people you come home to are the predictors of how well you integrate trauma. Not the people who come in and spend two hours in your critical incident debrief.

I think in decision-making and avalanche, the more you engage in those resources to get folks to a point where they feel like they have enough [resources] for the situation ahead, have something to offer, they are connected to the people and can stay present throughout the whole scene, the better the decisions they will make in real time. That's actually an operational outcome. If we could pair how important these resiliency factors are to pre-resourcing we would have it.

As this movement gains traction, start by taking a look at your team and yourself and determine where you are in the continuum. Do you have appropriate tools in your box when the inevitable happens?

If you want to learn more about these tools and topics check out responderalliance.com, SOAR4life.org and americanalpineclub.org/grieffund ●

Getting to know the recreational audience can improve the effectiveness of the avalanche bulletin

Why does bulletin-user typology matter?

BY SCOTT SAVAGE, ETHAN GREENE, AND SIMON TRAUTMAN

Backcountry avalanche forecasts have come a long way. Research has advanced our understanding of snow and avalanche phenomena, and numerical and conceptual modeling has improved the precision and accuracy of the forecast. The different ways we communicate the forecast have evolved from faxes and phone recordings to engaging, informative, multi-media web pages and social media posts. These advances have, for the most part, been driven and engineered by avalanche center staff. The problem; as a community, our technical snow and avalanche knowledge far exceeds our communication and education expertise.

Currently, avalanche center products are about as good as avalanche forecasters moonlighting as web designers, risk communication systems designers, and education theorists can make them. Limited avalanche center budgets hinder the hiring of non-avalanche specialists to study, test, and improve our messaging. Avalanche forecasters need outside help to further improve these important public safety products, and the working group at Simon Fraser University is making some interesting progress.

Anne's (and her group at Simon Fraser University) work provides actionable insight into "who understands what" and lays the foundation for further study and exploration. In essence, she has demonstrated that users can be grouped in terms of comprehension and how they apply knowledge, an insight that allows forecasters to critique products through the lens of each user type.

To take the next step(s), we need people like Pascal, Anne, Henry, Robin, and others to continue studying how people absorb and interpret public avalanche forecasts. And, we need them to work with forecasters to develop new tools and techniques to maximize people's understanding of avalanche conditions.

The timing of this work couldn't be better. Many US avalanche centers are working together to create a common avalanche forecast platform. In addition to creating an economy of scale through shared technology, we can more quickly and effectively implement expected improvements in the coming months and years. We're excited about the potential for communication and comprehension-related research to drive the next major leap in public forecast effectiveness.

Forecast Audience

BY ANNE ST. CLAIR, HENRY FINN, PASCAL HAEGELI, KARL KLASSEN, AND ROBIN GREGORY

Self-directed winter backcountry recreation in avalanche terrain presents a particularly challenging public safety issue given that recreationists are voluntarily going into the mountains, where there are few mandated closures and where they are responsible for their own risk management.

The fact that 90% of avalanche fatalities in both the U.S. and Canada involve self-directed recreationists clearly highlights this challenge. To help them plan safely, avalanche warning services publish avalanche bulletins with detailed information about avalanche conditions. To be most effective, the bulletin must excel in two capacities: it needs to provide consistent, unbiased, and accurate information; and it needs to deliver that information in a way that can be understood by the audience.

However, recreationists vary widely when it comes to their knowledge, skills, and experience managing avalanche risk. With the rapid growth in backcountry recreation, this range in comprehension continues to expand and leads recreationists to interpret the bulletin information in different ways. To make the bulletin most effective for the broadest audience, it's important we understand and address these differences.

While our industry has made significant advances to improve the accuracy and consistency of forecasts, including developments such as the North American Public Avalanche Danger Scale and the Conceptual Model of Avalanche Hazard, we have yet to explicitly examine how recreationists use bulletins. Because best practice in risk communication emphasizes the importance of knowing our audience (Fischhoff, 1995), our objective was to get to know the recreational audience in a way that goes beyond demographics or activity type and that allows us to see them in terms of how they use the products. We explicitly examined how recreationists find, interpret, and incorporate bulletin information into their avalanche risk management practices to identify patterns in bulletin use behavior that can be classified into a bulletin user typology.

We conducted 46 individual, qualitative interviews with a full range of backcountry recreationists in Vancouver, Squamish, and Whistler. We made a concerted effort to include entry-level backcountry users, with 14 participants with no formal avalanche training and participants reporting never or rarely using the bulletin. To identify patterns and to establish a classification system, we conducted an applied thematic analysis supported by a series of quantitative analyses.

AVALANCHE BULLETIN USER TYPOLOGY

The resulting Avalanche Bulletin User Typology reveals a five-class hierarchy with a clear progression in the depth of bulletin use, the degree of comprehension, and the extent of information application (Figure 1). The classes are labeled Type A, B, C, D, and E and are detailed as follows.

Type A stands for "Absent" as these recreationists do not consult the bulletin. They may intercept information from other channels, such as news media, trailhead signage, or social networks. They had different reasons for not using the bulletin. They may lack awareness the product

exists, or they may not consider it relevant to where they travel or to their activity type.

Type B stands for “**Based on the Danger Rating**” as these recreationists make a go or no-go decision dictated by the rating. They expressed difficulty making decisions with the ratings in the middle of the scale, especially for considerable danger. Additionally, they found the forecast beyond the danger rating difficult to understand. Because they pre-determine their safety, these users are not making observations related to their terrain exposure or to avalanche hazard while traveling. Instead, they rely primarily on marked trails, peer recommendations, and online resources to guide their risk management decisions.

Type C stands for “**Considers Terrain.**” These users primarily use the danger rating, but they combine it with a consideration of avalanche terrain severity to decide where to travel. Using the danger rating as a threshold, they determine whether exposure to avalanche terrain is appropriate, and they describe their field assessments as focused on terrain identification. Like Type B users, they too find incorporating avalanche problem information a challenge, so they simply avoid situations that require its application, or they commonly defer to more experienced partners to make risk management decisions for them.

Type D stands for “**Distinguishes Avalanche Problems.**” These recreationists integrate the avalanche problems into a complete risk management strategy that accounts for hazard and exposure by applying the information to open and close terrain appropriate for travel. They generally understand the implications of the avalanche problems for risk mitigation strategies; however, they may not accurately recognize or assess the hazard conditions in the field. Therefore, they place greater weight on their pre-determined terrain closures than on their field assessments. In general, they express a lack of confidence in their interpretations.

incorporated into travel decisions; and the latter two stages require a qualitative, conceptual restructuring to deepen understanding of the information.

The resulting Avalanche Bulletin User Typology establishes an evidence-based framework that defines the stages of bulletin information use, details the product challenges for users in different stages, outlines the explicit barriers to progression, and organizes the recreational audience in terms of how to reach them with risk communication products. From this, we can consider improving the bulletin’s effectiveness in two ways.

First, we can consider how well our products resonate with recreationists at specific stages. For example, given that Type B and C users are most dependent on the effectiveness of danger rating, we can now evaluate and improve the product in the context of their decision processes. Secondly, we can consider the bulletin’s capacity to explicitly improve users’ ability to conceptualize and incorporate the information into decisions by targeting stage transitions to help recreationists advance to higher-level information outcomes.

Interestingly, in their suggestions for improvement, participants made requests that align with their corresponding transition criteria. For example, those making a transition requiring a deepened conceptual understanding (Type C, D, and E users) requested interactive exercises offering feedback as to whether they are interpreting the information correctly. This is important to reflect upon given the backcountry’s “wicked learning environment,” where recreationists have few corrective feedback opportunities from which to learn (Hogarth, 2001).

The results of this study suggest for the bulletin to reach its full potential, we need to re-envision it as an educational tool instead of just a conditions report. Thinking in this way requires engaging a systems thinking perspective to best integrate and optimize the complete landscape of public avalanche safety initiatives (i.e. awareness programs, social media outreach, formal ed-

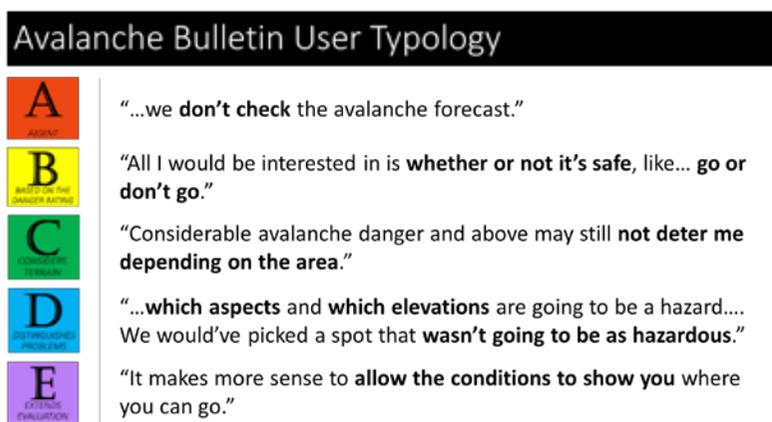


Figure 1 Avalanche Bulletin User Typology

Type E stands for “**Extends Evaluation.**” These recreationists use the bulletin as a starting point to inform their continuous assessment of avalanche hazard where they are traveling, which is how it is intended to be used. Type E recreationists review all of the bulletin information with a focus on the details so that they can confirm or disconfirm the regional hazard information with a localized assessment. They are capable of recognizing conditions different from the forecast.

The resulting Avalanche Bulletin User Typology consists of defined, ordered stages that build on each other and meet the criteria to operate as a stage theory. Stage theorists suggest developing explanations for each stage transition to address specific barriers to advancement (McCammom, Haegeli, & Gunn, 2010).

Interestingly, we discovered an interdisciplinary link to the field of education in Biggs and Collis’ (1982) Structure of Observed Learning Outcomes taxonomy (SOLO) that offers an explanatory framework for the stage transition criteria. The SOLO taxonomy is a well-established hierarchy of learning quality that parallels the Avalanche Bulletin User Typology, whereby learners may miss the point (Type A), identify one relevant aspect (Type B), combine several relevant aspects (Type C), recognize a system and its integrated parts (Type D), or extend the subject into a new dimension (Type E) (Figure 2).

Most importantly, the SOLO taxonomy defines the two main changes that mark stage transitions to address the barriers to advancement: the first three stages require a quantitative increase in the amount of bulletin information

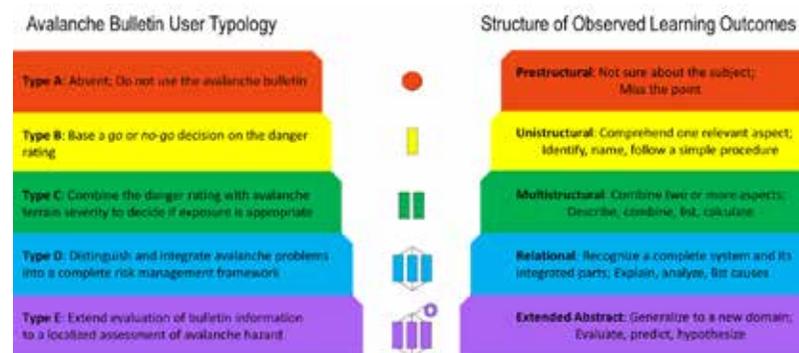


Figure 2 The link between the Avalanche Bulletin User Typology and the SOLO Taxonomy (Biggs & Collis, 1982).

education curricula) to most effectively reach recreationists at particular stages or advance them to more proficient avalanche bulletin users. Due to its central role as a provider of up-to-date avalanche information, the bulletin is uniquely positioned within this system to reach and engage a wide-ranging audience on a routine basis.

The Avalanche Bulletin User Typology provides a critical stepping stone for improved bulletin information transfer and for identifying which public safety programs and products are best to provide recreationists with the information they need for decision-making at their particular stage and to advance them to more proficient avalanche bulletin users most effectively.

Interested readers can access the thesis publication via the following link: http://www.avalancheresearch.ca/pubs/2019_stclair_bulletinusertypology/

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Bias, Variance, and Loss in Avalanche Forecasting

Forecaster Bias

BY
PETER
DONNER

Statistical theory is relevant to avalanche forecasting through the concepts of bias, variance, and loss. Bias is the systematic difference between the forecast and actual conditions. Variance is the random difference and captures the notion that because conditions cannot be anticipated with certainty, forecast and actual can be different. Loss is the cost, however defined, of an inaccurate forecast. The best forecast is the one that minimizes loss.

PURE STATISTICAL THEORY

In pure statistical theory, which is completely abstract and ignores human well-being, loss is usually defined as a function of bias and variance. Bias, in particular, is generally undesirable because the objective of the forecast is to predict actual conditions, not to make a prediction that is expected to be different from actual. When the forecast is expected to be the same as actual, except for unknown random effects, or variance, it is unbiased. In complex problems, forecast and actual are never or rarely the same, but the process is designed so the forecast is high as often as it is low and over time the difference averages out to zero. If the forecast is unbiased, then the loss is simply the variance and the objective is to design a technique that minimizes variance.

AVALANCHES HURT PEOPLE

Avalanche forecasts are not abstract, and a forecast that understates the actual hazard can result in injury or death. In this situation, an unbiased technique, one that understates the hazard as often as it overstates, may be undesirable in the sense people can be injured or killed when the actual hazard is greater than forecast. In contrast to pure theory, then, an upward or positive bias in avalanche forecasts may be desirable.

DANGER SCALE AND ROSE

While experienced backcountry users typically look at the weather forecast before the avalanche forecast, even the most experienced focus on the “current danger rating,” the one-word summary of the overall hazard, based on the North American Public Avalanche Danger Scale. On this scale, an experienced user may say:

1. **Low green** go—human triggered avalanche unlikely
2. **Moderate yellow** go carefully— human triggered avalanche possible
3. **Considerable orange** think about where to go— human triggered avalanche likely
4. **High red** light keep it low angle— human triggered avalanche very likely
5. **Extreme black** keep it very low angle— human triggered avalanche certain

After the one-word summary, the danger rose is highlighted in official forecasts produced by the UAC. Comprised of eight aspects and three elevations, it has 24 petals, each of which gets a danger rating. When the rose is all green petals, users think of visiting terrain they would never go to when the danger is considerable.

Objective analysis of summary conditions and of snow and weather and recent avalanches adds nuance to the forecast. This analysis is difficult to quantify in terms of bias and variance, so the discussion will be limited to the numeric danger scale, 1=low, etc.

AVALANCHE MECHANICS

Avalanches result from the interaction of four elements: 1) a slab of snow is 2) triggered 3) to fail on a weak layer and 4) slides downhill on a bed surface. The problem in the human context is that people make excellent avalanche triggers. In terms of developing a forecast danger rating, uncertainty exists about slab formation and to a lesser extent weak layers and bed surfaces.

SNOWPACK UNCERTAINTY IS KNOWN

Snowpack is relatively well understood by UAC forecasters, though some uncertainty exists about the nature and location of slabs, weak layers and bed surfaces. Combining its staff and its observer network, UAC receives information from hundreds if not thousands of snowpits during the season.

Beginning with first snow in fall and continuing through winter into spring, UAC monitors weak layers on the ground and throughout the pack, noting which are dormant and which are actively producing avalanches.

THE REAL UNCERTAINTY IS WEATHER

The real uncertainty in the daily forecast is weather, what precipitation intensity (PI) and wind will be over the course of the coming day. Though it is true during warm spells and as spring commences, air temperature and direct sun can turn dry snow wet, for the present discussion the focus will be on cold winter conditions where PI and wind are the main weather variables. Given enough loose snow on the ground, sustained and gusting wind on its own can increase the hazard from low to considerable in a few hours, sometimes in a few minutes. Likewise, high PI combined with any wind can spike the danger 1 or 2 levels. Because the UAC is located at the Salt Lake office of the National Weather Service, it has the best available information on likely weather as the daily avalanche forecast is published. This serves to minimize forecast variance.

LOSS FROM FORECAST ERROR IS ASYMMETRIC

If loss, the cost of an inaccurate forecast, is defined in terms of damage to backcountry users, rather than variance from actual, then it is

asymmetric. Although 1 and 5 are both a distance of 2 from 3, that is, low is two steps below considerable, and considerable is two steps below extreme, the expected loss from forecasting 1=low when conditions are actually 3=considerable is greater than the loss from forecasting 5=extreme.

The reason for the asymmetry is that people are more likely to travel in hazardous terrain when the forecast is low than when it is extreme. If actual conditions are considerable but the forecast is low, then more people will travel in hazardous terrain, making accidents and harm are more likely. In contrast, if the forecast is extreme, few, perhaps no, people will travel in hazardous terrain. While no, or less, physical harm occurs when the forecast overstates danger, those with exceptional hazard management skills will have missed the opportunity for more challenging and rewarding recreation.

Over time this unnecessary loss of opportunity will cause users, especially advanced users, to lose respect for the forecast. Nonetheless, by any reasonable measure, the loss of life is more costly than the loss of respect.

Asymmetric loss, then, suggests the forecasting procedure should be designed to minimize situations where actual conditions are more hazardous than forecast. In particular, the procedure should only generate low hazard when the actual danger during the coming day is low. A low forecast causes people to visit hazardous terrain. If it is possible winds or PI higher than forecast would lead to a higher hazard, then the forecast should not be low.

A BIAS TO OVERSTATE DANGER IS GOOD

None of this discussion is unknown to UAC, but framing the issue in terms of bias, variance and loss may enable better communication of how the forecast relates to actual hazard. To some extent, UAC already incorporates positive bias into its forecasts, so when the forecast is different from actual, forecast hazard is higher than actual much more often than lower. This practice has lead users, particularly advanced users, to view the UAC as too conservative and to discount the forecast hazard. Comments like “considerable is the new moderate” are sometimes heard. And yet serious injuries occurred with all members of the touring party caught and carried in an avalanche on two occasions during 2019 when actual conditions were considerable or high and the forecast was low or moderate.

OBJECTIVES AND CONSTRAINTS IN AVALANCHE FORECASTING

The situation can be framed in the terms of classic optimization, where an objective is optimized subject to constraints. The constraints must be first satisfied and then the best possible is done with the objective. If the focus is providing accurate information, the problem is to minimize forecast related accidents subject to the constraint the forecast informs backcountry user decision making. Here the constraint is to inform decision making, and some forecast-related accidents are expected to occur. If, in contrast, the focus is preventing forecast-related accidents, the problem is to maximize information subject to the constraint no forecast-related accidents occur, or expected accidents are zero. This is a sketch of the logic with the understanding the application is ill-posed because the objective and constraints cannot be specified as a mathematical function of data UAC possesses.

It is worth considering how the constraint expected forecast-related accidents are zero could be made operational. The main point is when the forecast is accurate, it does not cause accidents. If the forecast is considerable, for example, and this verifies during the day, then if accidents occur it is because users traveled in terrain that was forecast as likely to avalanche. In this case the accident was caused by user error, not forecast error. Likewise, if the forecast overstates hazard, then accidents that occur are, by definition, the result of user error. It is only when the forecast hazard is lower than actual that the error in the forecast may cause accidents.

ENHANCED WEATHER AS A SAFETY FACTOR

If, as suggested above, the main source of forecast error is weather, then one way to eliminate expected forecast-related accidents is to incorporate cases when wind or PI were higher than forecast. I'm not suggesting UAC do this, just continuing to sketch the logic necessary to consider the problem. One approach would be to establish a window around the forecast date and analyze how often wind or PI was higher than forecast. If the window is two weeks and the forecast date is January 10, then data for January 3 to January 17 for some period of

years would be analyzed. The National Weather Service uses 30 years to establish weather norms. The result is what is known in engineering as a safety factor that is added to the previous standard forecast wind and PI. This could be called the enhanced weather forecast in contrast to the standard forecast the UAC has previously used.

Enhanced weather is most useful in eliminating forecast related accidents when standard weather suggests the forecast danger will be low, and to a lesser but still significant extent with moderate danger. When avalanches are forecast to be unlikely, or danger is low, reasonable people will consider visiting hazardous terrain. When avalanches are possible, or danger is moderate, it is still reasonable to consider visiting hazardous terrain, but fewer people will and those that do will be more mindful of mitigation strategies. When standard weather leads to a forecast of considerable or higher danger, since avalanches are likely or certain, there is no need for a safety factor because reasonable people will develop strategies to mitigate the hazard.

CONCLUSION; HERE BE WOLVES

Again, UAC forecasters are well acquainted with the concept of enhanced weather as a safety factor though they may not use the phrase and there may not be a shared understanding among the staff on how to incorporate the logic into the forecast. In the two accidents in 2019 where the entire party was caught and carried, the suggestion that wind and PI higher than forecast could spike the danger 1 or 2 levels might have caused the parties to develop mitigation strategies that would have prevented the avalanches. The downside to this approach is that it is a bit like crying wolf. Both forecasters and users will grow tired of a warning that is never needed. But even the boy who always cried wolf ultimately did come across a wolf.

Peter Donner grew up in Utah, where he began skiing at age 3 in 1965. He received a Master of Statistics from the University of Utah in 1988, then worked as an economist in the Utah Governor's Office of Management and Budget (GOMB) until his retirement in January 2019. He served on the board of directors of the Friends of the Utah Avalanche Center from 1993 to 2000 and continues as a regular UAC observer.



Peter Donner's article raises good points regarding the importance of high loading rates and their effect on avalanche danger, especially in regards to a couple of avalanches that caught very experienced skiers off guard. I have two points I'd like to mention in response to the article,

1. For us at the Gallatin National Forest Avalanche Center, **uncertainty with the snowpack is a far greater concern than uncertainty with a weather forecast.** The weather forecast is easily verified while the snowpack is not. Its layers remain hidden until we dig or they roar to life in an avalanche. Uncertainty with the snowpack has almost killed me more than once and it's my top worry.
2. A high PI and wind (aka, snowstorm) is certainly when we see most avalanche activity. As a rule of thumb, most avalanches happen during or immediately after a storm. In Peter's last paragraph he hypothesizes that an enhanced PI and wind forecast might have changed the skier's intentions. I have my doubts. No matter the weather forecast or avalanche danger rating, **if it's snowing and blowing then you have plenty of information to notch your plans back,** no matter if the weather service had a bright sunny icon that morning or the avalanche forecast was colored Low.

We are always interested in better forecasting tools, for both weather and snowpack, Peter's goal of improved prediction of loading rates would be a welcome step in creating more accurate avalanche forecasts. And Lord knows, I need help with that on some days!

—Doug Chabot



That is a dense essay. I had to put on glasses, read it again, take some notes, and have a beer to confirm that I disagree with its fundamental assertion.

If I understand correctly, Mr. Donner tries to create a logical path arguing forecasting should have a positive bias because negative variance results in intolerable loss. He then suggests we may accomplish this by applying a margin to weather forecasts and incorporating that into danger forecasts.

His argument pointed towards a contextual challenge with public forecasting, specifically, the user context. In my experience, the one-word summary is the last thing experienced users focus on. I argue a primary goal of avalanche education is reducing users reliance on the danger rating, in favor of an examination of how that danger rating came to be.

A five-level danger rating across a 12-36 hour temporal scale; a range or region spatial scale; and a novice to professional user scale, by its very nature encompasses colossal context and may - or should - lack the precision associated with a go or no-go decision.

A positive danger bias can work well for user groups focused on risk avoidance, and that's a fair priority. After all, public avalanche forecasting is public safety messaging.

A positive bias is a dangerous disservice to those most likely to accept reasoned exposure to avalanche hazard - those trying to calibrate their tolerance, maybe even those that die because Considerable was the new Moderate - the accepters. We are legion.

I've encountered a positive danger bias in four of the zones I worked in over the last five years. In many places, the author's proposed systemic bias already exists.

Explaining avalanche problem assessment to students can be hard. Justifying purposeful forecasting bias devalues the forecast product. Forecasts are estimates - supported by evidence and qualified with uncertainty. We can do that. We do it well. I would prefer not to dumb it down.

—Doug Krause

Doug Krause is a skier, forecaster, mitigator, and educator. He likes rocking chairs and tracking lions.



It is only when the forecast hazard is lower than actual that the error in the forecast may cause accidents.

It's hard not to have the ego activate when the word "respect" is used. Loss of "respect" can immediately feel like a personal attack. Our feelings can be hurt if what we say isn't valued. We may become angry and defensive or maybe even cry. But we as forecasters are all secure big boys and girls (right!?), and we know we are still good people doing the best job we can in a realm where perfection just is not possible. Sometimes we make a bad call. Part of a forecaster's job is to keep perspective and handle their emotions, and not let a fear of disrespect influence our evaluation of hazard. So the potential feelings of "loss of respect" that a forecaster may feel shouldn't be a big deal, and definitely shouldn't be the driving force behind any kind of assignments of danger rating. However, "respect" isn't just about ego. Take the ego out of "respect" and we are left with **people not believing what we say**. Now that is a big deal, and can lead people to expose themselves to dangerous avalanche hazards when we say they shouldn't. The good news as forecasters is that we are allowed to use sentences and words to describe our uncertainty. We can say that danger may be higher than expected if certain less-likely weather conditions happen. The bad news is lots of people don't like to read too many words, let alone sentences. Glancing at a color for some is the limit of their attention span, but it doesn't have to be.

We are a growing avalanche center out here in the Eastern Sierra, and at times in the past when we haven't issued daily advisories we have not assigned a danger rating. Issuing daily advisories with danger ratings is something we are very proud of accomplishing. But when we don't, people are forced to read a few more words and think a little bit more on their own in order to formulate their own "danger rating", and may actually be safer as a result.

When danger ratings are accurate, which is much of the time, they offer a great service. When there is uncertainty or conditions fall in-between, how about we evolve our danger ratings color scheme to have an outline in a different color? Say, green with a yellow border. Or yellow with an orange border. Low "plus", Moderate "plus". The point being that something is going on that makes the danger not as clear cut, signaling to the user it behooves them to read a few more words than they normally would like. I'm sure discussions like this have gone on way before my time since the dawn of danger ratings, and that there are good reasons for the way that danger ratings are the way they are today. Simplicity is very powerful ... except when things aren't simple.

Josh Feinberg moved to the Eastern Sierra for a winter in 2002 and hasn't left the mountains since. He's had the privilege of being part of the Mammoth Mountain Ski Patrol team for over a dozen years, and it is now his sixth year as part of the Eastern Sierra Avalanche Center's forecasting team.



BY
DREW
HARDESTY

A Bad Map is Worse than No Map at All

The Crossing

In his novel, *The Crossing*, Cormac McCarthy describes a scene where the two boys, having just crossed the border into Mexico, come into the company of an old man and ask him directions to the ranch which they seek.

The old man proceeded to sketch in the dust streams and promontories and pueblos and mountain ranges. He commenced to draw trees and houses. Clouds. A bird. He penciled in the horsemen themselves doubled upon their mount. Billy leaned forward from time to time to question the measure of some part of their route whereupon the old man would turn to squint at the horse standing in the street and give an answer in hours.

All the while there sat watching on a bench a few feet away four men dressed in ancient and sunfaded suits. When the old man had gone, the men on the bench began to laugh.

Es un fantasma, they said.

One of the men threw up his hands. He said that what they beheld was but a decoration. He said that anyway it was not so much a question of a correct map but of any map at all. He said that in that country were fires and earthquakes and floods and that one needed to know the country itself and not simply the landmarks therein.

He went on to say that the boys could hardly be expected to apportion credence in the matter of the map. He said that in any case a bad map was worse than no map at all for it engendered in the traveler a false confidence and might easily cause him to set aside those instincts which would otherwise guide him if he would but place himself in their care. He said that to follow a false map was to invite disaster. He gestured at the sketching in the dirt. As if to invite them to behold its futility.

Another man on the bench nodded his agreement in this and said that the map in question was a folly and that the dogs in the street would piss upon it. But another man only smiled and said that for that matter the dogs would piss upon their graves as well and how was this an argument?"

And yet.

The last man gestured. He said that plans were one thing and journeys another. He said it was a mistake to discount the good will inherent in the old man's desire to guide them for it too must be taken into account and would in itself lend strength and resolution to them in their journey.

Forecast Map

On Saturday, January 5th 2019, I issued what turned out to be the most blown avalanche forecast of my 20-year career. And not by a little. I stated that the avalanche danger in the backcountry was LOW. By the end of the day, we heard about nine skier-triggered avalanches with seven people caught and carried in separate events, with one visit to the emergency room. One might imagine the unspoken conversations of the slid skiers that day prior to the incident while noting the significant transport of wind drifted snow (on top of weak diurnal facets no less)—“Are you gonna believe Hardesty’s LOW...or your own lying eyes?” They followed the bad map.

And this brought about great introspection:

- Who are we as forecasters?
- What are the goals of a forecast?
- Why do we get it wrong?

[Why do forecasters blow a forecast and what does it mean to be wrong?](#)

First, let’s tackle the second question—What does it mean to be wrong? This is best understood by looking at what “It” means. Undoubtedly, this means the forecast, but what part of the forecast? Is it the Bottom Line? Or can it be more than that? The bottom line is an aggregation of the devil and the details. It’s comprised of avalanche problems, location (aspect/elevation/slope specific details), likelihood (sensitivity, spatial distribution), size, and stability trend. Below are just a couple examples of getting it wrong:

- Right avalanche problem, wrong location.
- Right avalanche problem, wrong likelihood.
- Right avalanche problem, wrong size.
- Right avalanche problem, wrong trend.

Let’s look at my own numbers. Twenty years forecasting, averaging 40 forecast mornings per winter. This calculates to 800 BOTTOM LINE forecasts, which can be broken down into 20,000 forecasts over 20 years. It’s quite possible that I’ve been wrong before.

The journey or the destination? Sidney Dekker, Annie Duke, and others encourage shedding the hindsight bias in favor of looking at what may have been a reasonable judgment with the facts, experience, and motivations at hand. In poker, if I hold three kings, I will almost always bet the farm. It may be that my opponent holds four 2s; but most would make my bet again ten times out of ten. This is a reasonable and understandable judgment call prior to knowing the outcome. Annie Duke discriminates between poker and chess where the first involves uncertainty while the second does not. Mathematics is not a forecast and vice versa.

The key point here, in trying to answer the question *What does it Mean to be Wrong?*, should move upstream from the confluence to gauge the difference between two blown forecasts—one with the right process and the other without.

The more interesting question is Why Do Forecasters Blow the Forecast?

The reasons avalanche forecasters blow the forecast are three-fold.

1. They Blew the Weather Forecast

If they blow the weather forecast, then they are likely to blow the avalanche forecast. Expect 2" of snow with no wind but instead receive 12" with moderate wind? Hmmm. Expect overcast skies but instead see greenhousing? Yep, blew that one too. This is why forecasters often hedge and write words such as may, possible, probable: you get the picture.

2. They Misunderstood the Nature of the Snowpack

There are myriad reasons here: lack of data or field time; inexperience; failure to appreciate the complexity or to adequately view "non-events" with suspicion.

3. They Misunderstood the Nature of Themselves

It should be recognized that forecasters may blow the forecast in spite of themselves. Much of the literature examining the "human factor" in recent years may also be applied to the forecaster. Some of the heuristics and biases are the same:

- Ego/Reputation—Hate to Cry Wolf
- Impatience/Message Fatigue
- Ego (not appreciating uncertainty)
- Anchored to previous forecast (Expert Halo?) or efforts to be consistent
- Overcompensate for yesterday's blown forecast
- Cognitive Dissonance—Discounting contradictory evidence
- Personal Near Miss or Fatality in Zone
- Consistently Over Forecast ("I've been burned too many times")

What's the Goal Here?

This brings about understanding the goals and objectives of the forecast. Is the goal to save lives or is the goal to accurately portray the conditions as they are? If the only goal is to save lives, then most mountain passes and highways would be closed from November to May.

If the goal is to portray conditions as they are *and will be*, then we are bound to make mistakes, but it must be worth it for the greater public good because agencies employ people to make judgment calls and forecasts. And yet there is often great tension between the two. The answer of course is *both*.

Which brings us to the economist Peter Donner's paper *Bias, Variance, and Loss*. Donner hits upon a number of interesting topics, not the least of which involves the asymmetry of loss in regards to bias. Overforecasting can be expensive (margins) and often leads to a deaf audience...and if a tool is not a tool, then it is a rock.... and rocks should be thrown through windows. Just ask Homeland Security about their Homeland Security Advisory System aka the "Terror Alert Level" (lasted only from 2003 to 2011 because they never used the bottom two levels..and people stopped paying attention!) Underforecasting leads to...well, it leads to Jan 5, 2019 in the Wasatch, the nine skier-triggered avalanches and the Blue Ice incident (see TAR 37.4). Blown forecasts have consequences.

What led to my blown forecast?

A good sampling of "all of the above." I'll briefly address each category.

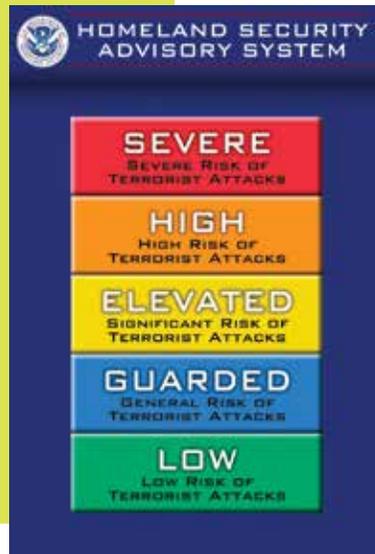
I blew the weather forecast. The southwest winds arrived earlier and stronger than I expected.

I misunderstood the Nature of the Snowpack. The range had been hammered by north and east winds the previous few days. South faces held bulletproof sun crusts. I pictured wind damage and-only later—areas of wind slab.

I misunderstood the Nature of the Myself. We'd had consensus for my previous day's Low danger and I was probably anchored to that. I knew we'd be at Considerable the next day and felt a Low-to-Considerable jump would well capture that danger trend. I also spiraled into forecasting philosophy at 0530: 'We really don't use Low and Extreme as much as we should.'

A quick digression on Low. It seems to me that Low is different than the other forecast danger ratings insofar as how many adjust their habits and protocols, and not necessarily in a good way. Risk

We need to understand the goals and objectives of the forecast. Is the goal to save lives or is the goal to accurately portray the conditions as they are?



Costs of Overforecasting: Homeland Security Advisory System discontinued in 2011 because there were no published criteria for the threat levels, and more importantly, the lower two threat levels were never used, therefore the public stopped paying attention.



The obvious cost of underforecasting.

compensation (homeostasis) is not a new idea to the avalanche world but when that "glowing orb of green" is at the top of the page, something changes in brain chemistry. We may more commonly travel solo, become lax in our travel habits, and seek out more unforgiving terrain where even a small harmless avalanche is not so harmless. Traumatic injury becomes the result.

And in perception, I wonder if Low reduces the five-point scale to a binary one: it's either dangerous or it's not...and now it's viewed as "not dangerous". What has been an unacceptable risk is now acceptable. Similarly, I wonder that Low may convey more certainty than all the other ratings. And perhaps it should. In a recent study on forecast verification last year, Statham, Holecsi, and Shandro found that Low was the most accurate at 84%...and things became less accurate as the forecast danger increased. Flipped upside down, this points out that one in every six forecast Low ratings is wrong. How's that for spin? But "less wrong" than any other level.

What to do?

The list is certainly incomplete but considerations for both the forecaster and the public moving forward -

For the **forecaster** in the hotseat:

- Communicate/gain consensus among the forecasting team when possible
- Do a Pre-Mortem before you publish the forecast: How will you be wrong and what will happen?
- Appreciate and communicate uncertainty
- Remember it's a forecast (not Back, Now, or Wishcast)
 - Choose impact over criteria (Hurricane Sandy/Katrina)
 - Remember the asymmetric costs between blown over/under forecasting
 - Psychology of glowing green orb of LOW danger and how it may be viewed by the public
 - Who's the Audience? 32% only use the bottom line (St Clair, Finn, Haegeli)
 - Know that once in awhile you're going to make mistakes.... And when you do, own them. (Just try not to make the same mistakes.)

The bottom line for the **public**:

- The forecast is guidance not gospel
- Know who's in the forecast office
- Choose terrain in case you and/ or the forecaster is wrong
- Appreciate the uncertainty (esp with persistent problems)
- Forecast is only ONE element of ALPTRUTH

And yet.

The last man gestured. He said that plans were one thing and journeys another. He said it was a mistake to discount the good will inherent in the old man's desire to guide them for it too must be taken into

account and would in itself lend strength and resolution to them in their journey. ●

Thanks to the all forecasters who contributed their thoughts and well-earned wisdom to the piece. To Laura Maguire, Russ Costa, Jenna Malone, Zinnia Wilson, and many others who added to and

clarified many of the points herein, the essay has greatly improved through their efforts.

Avalanche professionals spend a lot of time talking about the limitations of the human brain to make decisions in the mountains, but what about the decisions forecasters make in the morning based on the public danger scale we work within? Do we understand and apply the term 'unlikely' in the same way? Does the public understand the difference between LOW danger with persistent weak layers lingering in the snowpack versus LOW danger with less consequential avalanche problems? For those who lay awake at night worrying about such things, I hope this story and study offer some perspective.

On Saturday, February 3rd, 2018 I issued the following bottom-line statement for Turnagain Pass, Alaska:

"A generally LOW avalanche danger exists in the mountains surrounding Turnagain Pass. Although triggering an avalanche large enough to bury a person is unlikely, isolated slabs 1-2' deep can still be found in very steep or wind loaded terrain, LOW danger does not mean NO danger and evaluating the consequences of the terrain will be important before committing to a slope. Additionally, watch for cornices or triggering loose surface snow that can be fast moving and knock a person over. In the periphery zones of Girdwood to Portage Valley and Johnson Pass more caution is advised where a slab could be larger and more connected."

Around 4:30 pm CNFAIC received a report of a skier-triggered avalanche on Twin Peaks, an area just South of Turnagain Pass, but within the forecast zone. We would come to find out two skiers were ascending an established skin track on a steep northeast aspect and heard a loud 'whumpf' as the slope released. The person in the lead was above the crown and the second person was able to

self-arrest on the bed surface. They had been part of a group of five that set the skin track that morning. Another group of three had followed their route with a total of 10 people exposed throughout the day. The avalanche was very large, D2.5, with a 1400' crown averaging 2.5' deep. Most of the debris had funneled into two very steep gullies and stopped abruptly in a flat creek basin 2600' below. This avalanche would have been un-survivable if anyone had been caught.

This was the first LOW danger advisory of the 2017/18 season for the alpine elevation band due to a variety of persistent weak layer problems over the entire winter. It had been nine days since our last snowfall event where 19" of low-density snow was recorded at the Turnagain Pass SNOTEL site. We had moved into a high-pressure window with clear skies and temperatures in the teens. Besides a brief period of strong easterly wind the day after the snowfall, the wind remained below 20 mph all week.

Throughout the week, hundreds of slope testers pushed into steep terrain all over Turnagain Pass and it was no surprise we received a handful of reports of human triggered avalanches. A reactive layer of buried surface hoar was sitting below the new snow and several snowmachiners and skiers triggered soft slabs in steep terrain. All of the activity was small and isolated and not quite large enough to bury a person.

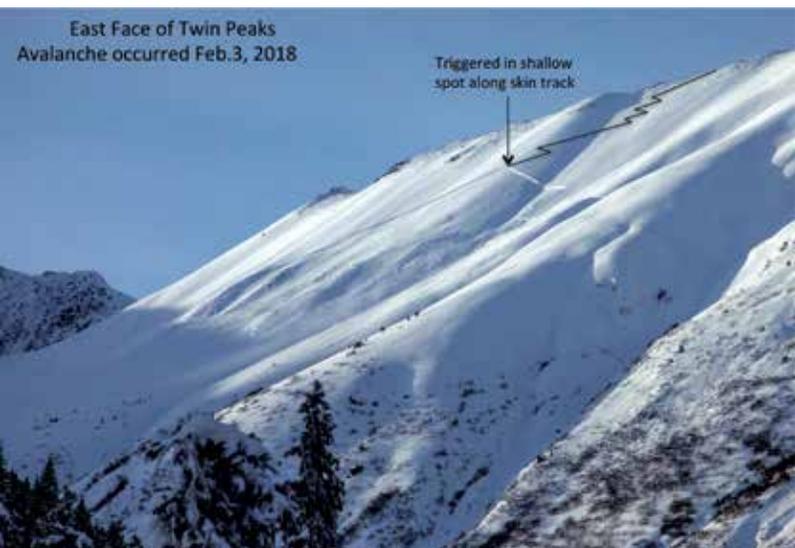
The decision to go to LOW was not easy and was not made alone. Our forecasting team had met the day before, as we usually do on Fridays, for a stability meeting. We discussed the length of time since any notable weather and how the slab was faceting away with cold temperatures. We discussed the reactivity of the weak layer and all agreed that triggering a small isolated slab in extreme terrain was still possible. Based on observations from the week, we didn't think the slab was large or connected enough to bury a person. We all agreed that there was more uncertainty in the periphery zones where we had less information. We discussed that the slab could be thicker and more connected in the coastal areas of Portage and

Scary LOW

BY
HEATHER
THAMM

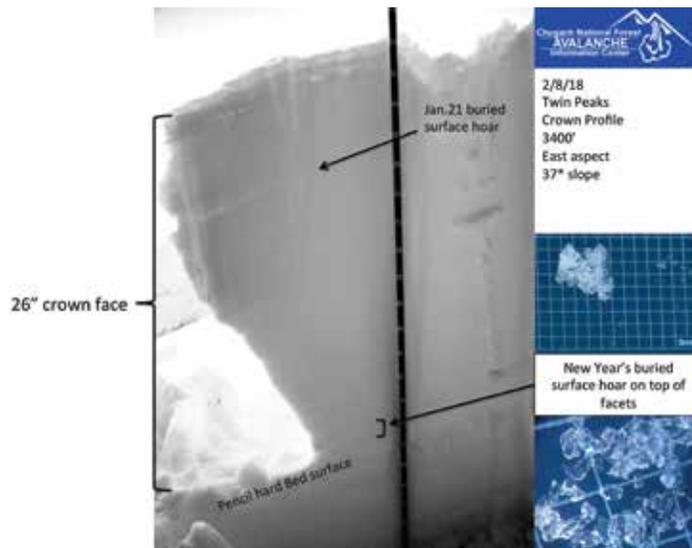
Girdwood that typically receive more snowfall. We debated the potential for a deeper, more dangerous avalanche on basal facets in the drier interior area of Summit Lake. We also discussed leaving the danger at MODERATE, but dreaded losing credibility with the public. The number of tracks visible in steep and technical terrain was hard to ignore. By the end of the day we decided Turnagain Pass was truly at LOW danger and speaking to the uncertainty in the periphery areas was the best way to handle the messaging.

After two separate trips to the accident site, we determined the weak layer was neither of the layers I referenced in the forecast that day. It was a combination of buried surface hoar mixed with near-surface facets buried during a big storm over New Year's. We had thought this layer had gone dormant following a widespread wet avalanche cycle where it rained to 3000' and re-froze. It had been 18 days since that storm cycle ended and no other activity had occurred on this layer. Many of our observations in the alpine showed inconsistent propagation on this layer or we couldn't find the layer. For reference, most of the starting zones are around 3500' with a handful of peaks above 4000'. The crown of this avalanche was at 3400'.



Twin Peaks Avalanche crown

Crown profile



A few days after the incident, *The Avalanche Review* arrived in my mailbox with the headline “Are We Good, Or Just Lucky?” One of the articles featured a preliminary study by Jason Konigsberg from the Colorado Avalanche Information Center, looking at trends of persistent slab avalanches in Colorado following snowfall events.

“We’ve had ten days of high pressure and no one has reported an avalanche in a week. The snow structure is bad, cracks are propagating in snowpack tests, and the snowpack still seems scary. Triggering an avalanche is now unlikely, but the expected size is still in the D2 to D3 range. The weather forecast describes more of the same, clear skies, light winds, and no precipitation. What should a regional scale backcountry forecast center tell the public about backcountry recreation tomorrow and what is the avalanche danger under these circumstances?”

Reading his opening paragraph filled me with a sense of relief followed by anxiety. It was reassuring to hear another avalanche professional struggle with this question, but it reminded me of all the times I’ve prayed for snow during high pressure systems hoping to avoid the decision to go to LOW.

The final 2018 ISSW study by Konigsberg, *Release of Avalanches on Persistent Weak Layers in Relation to Loading Events in Colorado*, investigates how many days precede a loading event before triggering a persistent weak layer becomes unlikely. Using seven years of avalanche data and weather history from ten forecast zones in Colorado, they found only 1% of avalanches (18 out of 1802) released after 10 days with no measurable snowfall. This study also examines a few more loading event scenarios, but “days without precipitation” matched the same weather pattern I was most interested in. I couldn’t help but wonder: how does Turnagain Pass’s weather history and avalanche data measure up? Is the Twin Peaks incident an outlier for our region? Does our far northern climate have a similar pattern compared to Colorado’s Continental climate?

As luck would have it, our intern last winter, Nikki Champion, a recent graduate from the Civil Engineering program at Montana State University, was eager to take on this project. She used similar methods as Konigsberg’s study over the same 7-year period (2011–2018) and her results showed a similar trend. After 10 days of no precipitation 99% of avalanches (158 out of 160) had occurred. Since Turnagain Pass can represent any of the three snow climates from any given year, Nikki also approximated the snow climate of each season using the same methods Wendy Wagner applied in her paper *Investigating the Snow Climate of Turnagain Pass, Alaska* (2012.) Nikki’s analysis found four out of seven years represented a Coastal snow climate, two years represented Intermountain and one season represented Continental. This ratio was similar to Wendy’s finding between the years of 1982 to 2012 for Turnagain Pass.



Nikki then compared the snow climate years to the length of time before avalanches stop being triggered. For the solo year representing a Continental snowpack, the final avalanche occurred on the 17th day of no precipitation. For the two years representing Intermountain, the last avalanche occurred on the 5th day without precipitation. For the years representing a Coastal snow climate, the final avalanche occurred on the 9th day without any precipitation, which happened to be the Twin Peaks accident.

Although the dataset for Turnagain Pass is very small, it was a helpful exercise to see the decline of avalanche probability following dry periods for our region. Looking at avalanche activity through this framework allowed me to embrace the Twin Peaks accident as an “unlikely” event despite feeling surprised by its size. When I reflect on the forecast I wrote that morning, I recall a great deal of struggle to write within the green color. My bottom line statement reads more like MODERATE danger despite the LOW verbiage. I recently listened to Drew Hardesty’s podcast, “*An Avalanche Forecaster, a Meteorologist, and an Economist Walk into a Bar.*” They debate whether the goal of an avalanche forecast is accuracy or to prevent accidents. My inclination is to say both, but I’m not sure it’s possible in this situation. Having multiple weak layers and such variable conditions across a small region makes choosing one color to fit a complex message very challenging. When I asked one of the members of the party involved why they chose the Twin Peaks route, he said because the avalanche danger was LOW. In this situation a more effective message would have been to keep the danger at MODERATE and speak to lower probability in Turnagain Pass.

In hindsight, given the positive outcome of this specific event I wouldn’t change a thing. Luck in this case has been a catalyst for learning. If this accident hadn’t happened, my understanding of the nuances of our snow climate and avalanche patterns would never have evolved. However, taking what I’ve learned into the future and applying LOW danger to an unlikely *Persistent Slab* problem still remains a gray area. Although I feel more confident in my understanding of what unlikely looks like for our region, I’m still hung up on the size and consequences of a large or very large avalanche. The Twin Peaks avalanche was not a *small avalanche in an isolated area or extreme terrain*. I’ve noticed avalanche.org has removed the size definition from their encyclopedia, but most avalanche centers still reference the published North American Public Danger Scale in full. I recognize there has been a long-standing debate over the size definitions, and the National Avalanche Center guidelines emphasize travel advice over size for selecting the most appropriate danger. What remains unclear is how consistently avalanche centers are applying LOW danger to low probability high consequence problems and if the public understands the difference. ●

To read the full research paper, *Investigating Avalanche Release In Relation To Loading Events And Snow Climate In Turnagain Pass, Alaska*, by Nikki Champion, go to cnfaic.org:About> Resources > Further Reading.

OUR CHANGING

MOUNTAIN SNOWPACK



Dust on snow in the San Juan Mountains, Colorado. Photo McKenzie Skiles

BY DR. MCKENZIE SKILES

I grew up in Alaska, where the impacts from climate change are dramatic and undeniable. Year after year the start of the Iditarod marches farther north chasing continuous snow cover, ice routes and frozen rivers are breaking up earlier or not freezing in the first place, glaciers are thinning and receding, homes are literally sinking into the ground as permafrost melts. Almost everyone that spends time in the mountains, or around snow and ice has an anecdote (or five) about how things have been changing over their lifetimes. This could be that it no longer snows in the valley, cross country ski races can't be held where they used to be, or the local ski hill opens up later every season, or maybe it has closed all together. What is yours?

I also grew up skiing, and have a love for snow and the mountains many reading this article share. In college, I realized that I could combine my love of skiing with my interest in climate change. Now as a snow hydrologist I spend my time trying to put numbers on just how fast the seasonal mountain snowpack is changing, improving our understanding of what is driving those changes, and the implications for our water supply and mountain systems.

Temperatures and greenhouse gases have been rising, in lockstep, since the industrial revolution. Across all available records that can be used to reconstruct historical climate, there is no precedent for the rate of change we are documenting now. This is wreaking havoc on natural systems because it is happening faster than those systems have time to adapt and respond. What does this mean for the mountain snowpack? It means high mountain regions are warming and becoming more variable, more precipitation is falling as rain rather than snow, and snow is melting faster. The degree of impact varies seasonally and across elevation gradients, but for any given location, it is safe to say we can expect increased variability and cannot assume this year will be like the past. The new normal is that there is no normal.

It is worth noting that the changes we see around us are rarely just as simple as direct

impacts from rising air temperatures. For example, it is not actually air temperature that melts snow, in most places, the energy to drive melt comes from the sun. Freshly fallen snow is one of the brightest natural surfaces on earth, but over time snow ages, grains grow, and larger snow grains absorb more sunlight. This processes can be accelerated by warmer air temperatures, which speeds up snow metamorphism and ages snow faster. Also, the deposition of dark aerosols is very effective at accelerating melt because they immediately increase the amount of absorbed sunlight, and tend to stay at the snow surface even as it melts. This process isn't directly related to warming air temperatures, but is related to human activity; aerosols are primarily soot from incomplete combustion or dust from landscapes disturbed through land use change.

Recently the Intergovernmental Panel on Climate Change (IPCC) released a special report on the ocean and cryosphere (all frozen parts of the world) in a changing climate. The IPCC reports review all available research relating to how climate is changing now and into the future, and summarizes the findings. (<https://www.ipcc.ch/srocc/>) It is a rigorous process that takes time, and involves hundreds of scientists as authors and reviewers from all

over the world. I was one of many authors that contributed to the chapter 'High Mountain Areas'. Below I summarize some key take home points from the report that are relevant specifically to the mountain snowpack. I encourage interested readers to seek out the original report, which also covers permanent snow and ice cover and permafrost, it is freely available online through the IPCC website.

Mean annual air temperatures have increased in mountain regions.

Surface air temperatures are increasing at ~0.30 C per decade, which is faster than the global mean average of ~0.20 C per decade. This warming trend is consistent, but does vary by location, season, and elevation. There are no significant trends in precipitation amount, but at low elevations precipitation is more frequently falling as rain rather than snow.

Snow is melting out earlier, and there is less snow on the ground when snow is present.

There is high confidence that at lower elevations snow depths are lower and that snow is melting out earlier by ~5 days per decade, on average. The shift in snow cover patterns is due to two things; less snowfall due to more precipitation falling as rain (at low elevations) and earlier melt (at all elevations). This is primarily attributed to warming air

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temperatures, but increased deposition of dark aerosols is also contributing to earlier melt.

The increase in air temperatures and decline in snow cover will continue into the future. Rain-on-snow events will become more frequent.

Relative to the recent period of record (1986–2005), low elevations snow depth is projected to decrease by 10–40% (2031–2050). Warming, and snow decline, will continue into the future independent of whether fossil fuel emissions increase, decrease, or stay the same. To put this another way, while it may speed up or slow down, the train has already left the station in terms of warming and reductions in mountain snow cover. In addition to lower snow depths and less snow-covered area, there is high confidence that rain-on-snow floods will occur earlier in spring and later in autumn, and be more frequent at higher elevations.

This is and will continue to negatively impact mountain ecosystems, snow water resources, mountain recreation and ski tourism, and the aesthetic and cultural aspects of mountain landscapes.

Particularly relevant to this community is how climate change is impacting snow stability. Although more research is needed in this area, generally speaking, as snow cover declines at lower elevations avalanches are projected to decline in number and runout distance. Warming may increase stability by reducing formation of weak layers in dry snow, but avalanches involving wet snow will occur more

frequently, and perhaps even mid-winter. This is incredibly difficult to predict in any given location, because climate change means climate variability, and it may be most accurate to say that winters are going to get weirder and less predictable.

Relatedly, snow cover changes are impacting route safety, which has and will continue to reduce mountaineering opportunities. Also, less snow at low elevations is impacting operations at low elevation ski resorts. Although some have chosen to address this by supplementing their snowpack through snowmaking, these still require colder temperatures, and therefore snowmaking could be less effective in the future.

In addition to snow stability, recreation, and tourism there are some other very important implications. In many midlatitude locations water supply is reliant on the mountain snowpack, which is a natural reservoir, storing water through the winter and releasing it in the winter and spring. Globally, there are over a billion people that rely on snow and glacier melt to meet water demands. In the Western US up to 80% of our water supply comes from snowmelt, and when groundwater recharge is considered, that number raises to over 90%. The reduction of the mountain snowpack means that we will get less water from snow, more winter snowmelt, and earlier peak runoff. Our current methods for forecasting snowmelt are calibrated index methods that are based on the concept that this year will behave like previous years. This reduces our resiliency to adapt to

shifting snowmelt patterns and water resource availability.

The magnitude and manifestation of change is variable, but all available observations allow us to state, with high confidence, that the mountain snowpack is in widespread decline. The next logical question is, then, what can we do about it? Personally, I am adapting my research to fill gaps in our current understanding of how snow is changing. For example, there are very few long term high alpine observation sites, which means we have less confidence about how the highest elevations are responding to climate change. My research group is maintaining and installing new instrumentation sites, and applying new methods, like mapping with drones, to monitor snow at the highest elevations. There is a way for all of us to get involved, although I am not a policy expert, my best advice is to stay informed, seek out ways to get involved with climate advocacy groups (like Protect Our Winters), and most importantly, vote. ●

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FRACTURE CHARACTER IN ECTS?

A Question from Robby ReChord, Insight from Don Sharaf and Karl Birkeland, plus a document from 2018

ROBBY RECHORD: Lovejoy & I are teaching a level 2 down here in polished conditions. While talking about documentation we got into a discussion about NOT including fracture character, arguing it either propagates or not. I then dig into my files and there is Big Don in a video with a “ECTP 27 RP Q2.” The video is probably 10 years old. SWAG doesn’t include FC. I’m wondering if there is any evolution in thought on including fracture character in ECTs? Is it an attempt to convey information about friction?

DON SHARAF:

Short answer—

SWAG (and therefore Snowpilot) does not allow for FC or Q observations with ECTs and PSTs

Long Answer, AKA Rant Part 1—

Although it was not a universal decision after the last revision of SWAG, it was thought that FC or shear quality should not be included with ECT and PST scores. Simenhois’ latest research (published in TAR 38.3) shows that crack face friction is highly spatially variable (similar to strength in that regard). My feeling is that if you have LOTS of pit data (ie you are forecasting and lots of people are submitting pits) that trends and patterns may develop in ECTN vs ECTP, cut lengths, and sometimes ‘friction’ observations. Listening to Ian McCammon recently it might be that the term energy was actually the best term after all—again that will be somewhat, though not fully, dependent on slope angle.

Bottom line—if a result cash registers into the pit I make note of that, but do not include that with my score reporting. If it is not a startling ‘pop or drop’ then I do not note it. As Kelly Elder states, half of my pit observations are notes and comments.

Rant Part 2

My consideration of fracture character comes from a few (among many) avalanche cycles where high angle ECTs >35 degrees consistently did not slide into the pit, even with full propagation (i.e. Resistant Planar results). Propagation on ECTs during those times were more correlatable to slab hardness and thickness than to weak layer properties. It was our forecast that given the seemingly high friction AND the very low slab continuity that that particular layer would not be a big player with subsequent loading. That forecast panned out, hence MY BIAS toward noting friction (or really its surrogate) on ECTs that Pop and Drop. Ron’s research showing the high spatial variability of critical slope angle as determined by the crack face friction component is eye opening and really downplays the importance of fracture character observations for pit observations. I still support noting fast responses on lower slope angles and resistant responses on higher slope angles. As a forecaster who gets to see many of these observations over time and through the season, it may give me a more holistic vision of snowpack behavior.

One other reason that I hang on to friction, against the advice of people far more informed than me, is that it might mean something more in the future. What if the fracture character observation does have some component of stored elastic energy release? Yes, slope angle is contributing a large part to that fracture character—no argument. But what about all 35 degree slopes producing different fracture characters at different times with different snowpacks. The angle is always the same, but the behavior can be different.

What if fracture character is telling us something about energy release from the fracture. Something is going on that we don’t fully grasp yet with the mixed mode anti-crack model. If the fracture speed observed in ECTs and PSTs is topping out at 60 m/s, yet actual fracture speeds based on Hamre, Simenhois, and Birkeland’s video analysis can be up to 400m/s, then the energy for that propagation is being added by some other factor than by a collapse driven wave alone. What if in our

further research we find that maybe it does matter whether the block slides into the pit, or not for similar slope angles. Might be nice to have that information to draw from...

Shear quality has become useless as we fail to agree whether observing displacement in a cross-slope or down-slope direction. Fracture Quality is messy. Sudden collapse involves a “noticeable collapse of the weak layer.” Noticeable is as bad as considerable—we can probably do better with our definitions. Some folks consider the noise of the collapse as noticeable and thus rate many FC results as SC. Other folks are looking for a discernible decrease of column height relative to the existing snowpack—both observations are noticeable, but in the bigger picture may mean different things.

Enough for this circular argument—we agree that commenting on FC or Shear Quality in the comments section of a pit is the best way to go. Speaking of going—I’m going skiing—noticeable sound of mic drop.

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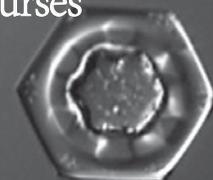
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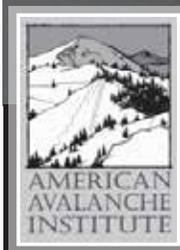
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ROBBY RECHORD: I just found this on the Gallatin NF avalanche center site: www.mtavalanche.com, under the Articles tab, originally printed in TAR 36.4.

Shear Quality or Fracture Character with an Extended Column Test—No Longer in SWAG or SnowPilot

BY RON SIMENHOIS, DOUG CHABOT, KARL BIRKELAND AND ETHAN GREENE

The 3rd Edition of *Snow, Weather and Avalanches: Observation Guidelines for Avalanche Programs in the United States (SWAG)* was published in the summer of 2016 with a few updates. One notable change is the removal of Shear Quality (SQ) and Fracture Character (FC) for the Extended Column Test (ECT) and the Propagation Saw Test (PST). This change has caused consternation with some professionals, including SnowPilot users who no longer have this field alongside the ECT.

The reason to remove it is simple: SQ and FC were developed as a proxy for crack propagation. With the addition of the Extended Column and Propagation Saw Tests, the proxy is no longer needed. The ECT and PST aim to provide a direct index of crack propagation. Recording

SQ/FC adds nonessential and redundant information to the already complicated task of evaluating slope stability.

Some SnowPilot users would like to use SQ as a way to describe the motion of an ECT after fracture. However, with an ECT, the movement of the block into the pit does not depend on crack propagation propensity, but rather on the balance between slope angle and friction. Given a steep enough slope, the ECT block will almost always slide regardless of crack propagation propensity. On the other hand, on low angle slopes an ECT block will remain in place even with a Sudden Fracture or Q1 shear. SQ/FC is not—and was never meant to be—a good test to demonstrate block movement, since it relies on slope angle vs. friction rather than crack propagation propensity. Instead, we encourage people to describe the block motion in plain language whenever it is needed.

SnowPilot allows the observer to include comments on a specific snowpit test and for the snow profile as a whole. These are very useful features and allow the observer to document notable observations that don't fit into one of the standard coded fields.

Don Sharaf writes one article for *The Avalanche Review* each year. In his remaining time he rests on the couch and eats popcorn. Except this year we convinced him to weigh in on a second article by disguising it as an email question.



Robby Rechord lives in Flagstaff and wanders around the west with his wife, Kate. He is the edutainment coordinator for Kachina Peaks Avalanche Center. He summers in the Grand Canyon rowing small boats through big rapids and taking long strolls to nap in the shade.



Hi Lynne—

I'm fine with you publishing that document. As you say, I think it clearly states where we are coming from with the PST and ECT and FC/SQ.

When we wrote that document, we also reached out to Bruce Jamieson and Dave Gauthier. We were all unanimous in not using FC/SQ with the ECT or the PST. The main reason is that almost every ECTP I've seen (guessing 99%?) would be a Q1 shear quality or an SP or SC fracture character. The same goes for any PST I've seen that propagates to END.

Some folks have wanted to use shear quality to better show that a Q1 fracture slides off after the test, and they have seen cases where this is critically important information. However, whether or not something slides off depends on the slope angle because it's a function of both the slope angle and the friction along the bed surface. I believe that it might be good info to know whether or not something slides off, but that is an extra piece of information that must always be accompanied by a slope angle (i.e., "the ECTP slid easily off the column on a 32-degree slope"). For SnowPilot pits we'd encourage folks to put this information in the comments section of a given stability test.

Hopefully this email adds clarity and not just more murkiness to the discussion!

—Karl Birkeland
Forest Service, National Avalanche Center

What do you think? Do you pay attention to "pops and drops" in your ECTs? Do you incorporate friction elements into your "sensitivity" assessments?

Continue the conversation via email to TAR before July 15.
avalanche.review@avalanche.org

CONTRIBUTORS



David Butterfield is a documentary and promotional filmmaker based in Sun Valley. His father Gordon was a 10th Mountain veteran, Sun Valley ski patrolman, and longtime presence in the ski industry.



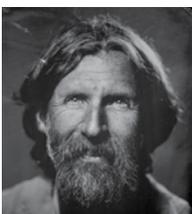
Pete Earle is a mechanized ski guide and forecaster based in Utah. He teaches pro courses for the American Avalanche Institute. In summer you can find him mountain biking, fishing, and chasing his wife and dog down trails.



After seven years of backcountry skiing, **Starr Jamison** lost three friends to avalanches and was hit by a car while bike touring. These incidences prompted her to create Survivors of Outdoor Adventures and Recovery.



Anne St. Clair gets excited to better navigate the intersection of human behavior and avalanche hazard. Anne is currently working as a forecaster with Avalanche Canada based in Revelstoke, BC, and she crosses the border to join AIARE's team of instructor trainers.



Drew Hardesty has been a longtime avalanche forecaster at the Utah Avalanche Center and just recently retired from a career as a summertime climbing ranger in Grand Teton National Park. He has *Moby Dick*, the Bible, and something by Cormac McCarthy on his bedstand.



Heather Thamm spent the last five seasons as an avalanche forecaster for the Chugach National Forecast Avalanche Information Center. She is currently pursuing studies in Fisheries and Wildlife Science through an online program at Oregon State University.



Before **Nikki Champion** interned in Alaska with the Chugach National Forest Avalanche Information Center she came from a background in Civil Engineering. Now she is finishing her first season forecasting for the Utah Avalanche Center.



Dr. McKenzie Skiles is an Assistant Professor at the University of Utah, and co-director of the Snow and Ice Laboratory. Her research aims to understand how much snow is in the mountains, how fast it will melt, and how that is changing.

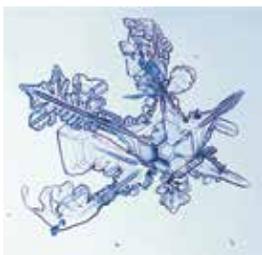


photo Kelly Elder

AVALANCHE ARCHITECTURE

The architecture of every avalanche always starts with the crystal type. Equal credit is due whether it is falling from the sky or being born on the snow surface. I think this is often overlooked by novices and experts alike.

Play Smart,
Howie from Alta



photo Heather Thamm



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