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REVIEW



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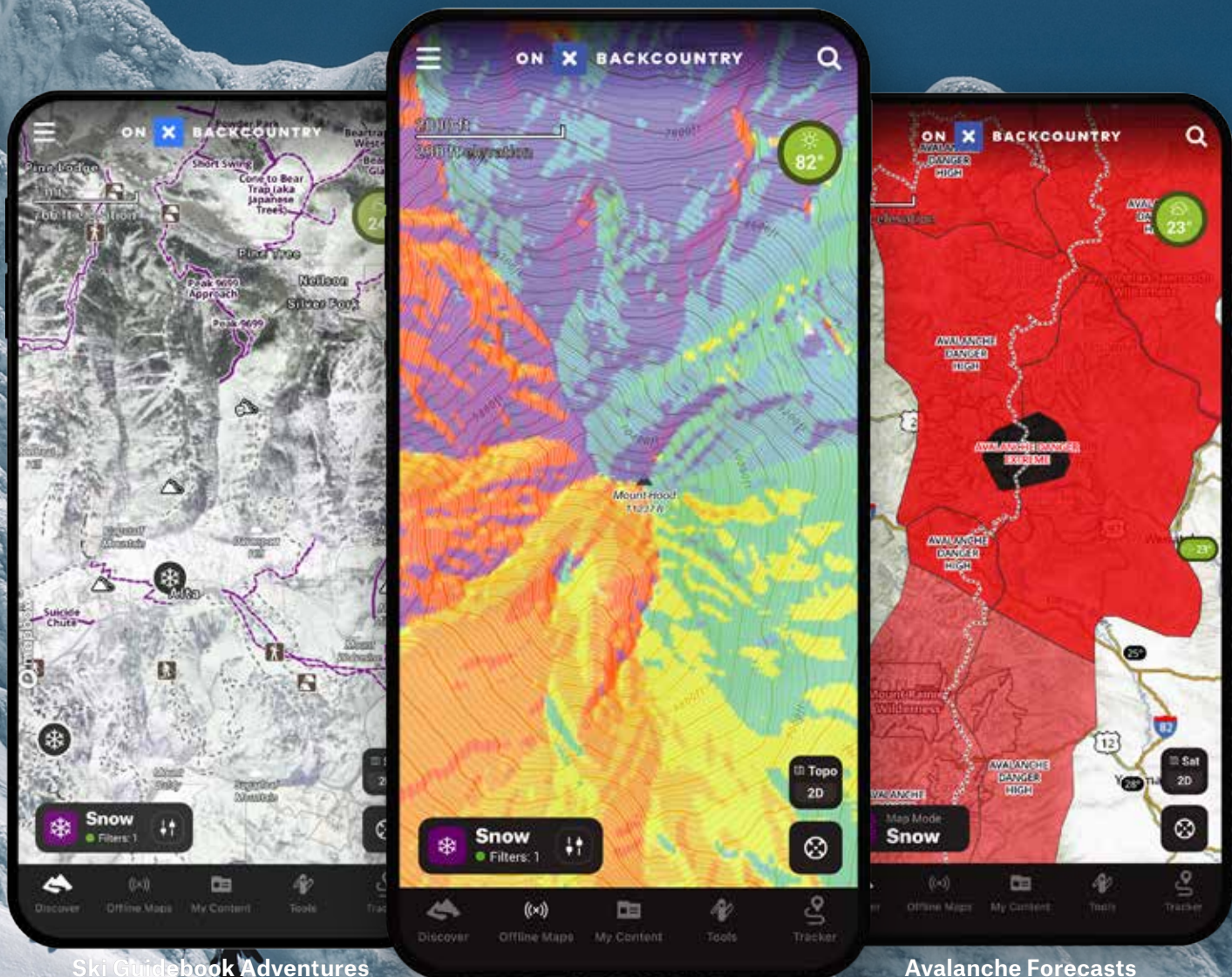
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The American Avalanche Association promotes and supports professionalism and excellence in avalanche safety, education, and research in the United States.

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the AVALANCHE REVIEW

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SPRING 2023

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ON THE COVER

The Ophir Road was hit by a natural avalanche on January 18, taking out power and communications lines and blocking the road. The next day Telluride Helitrax was contracted by San Miguel County to perform avalanche mitigation before road cleanup crews would clear the debris and reopen the road. We see here West Badger path running with an exploded shot previously placed and detonated by helicopter deployment. ■ MATT STEEN





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FROM THE EDITOR

**Photo Contest
Snow Shapes**

Images from Antarctica.  HP BOYLE

What a winter, folks. Here's a mantra from Mike Ferrari (Patrol Director at Mt. Rose, NV) for us:

Coffee, Advil, shovel, pull stuff up, blow stuff up, wind watch, go left and right, whiskey, sleep, repeat

Perhaps by the time you are reading this, we will have transitioned to spring? But then where does all that snow go? Down the rivers, across the roads, into your basement.

So many times this winter, I have heard A3 members say, "I am trying to think of something to write about for TAR..." Here is your chance: in the long months after the April TAR and before winter rolls around again, reflect on your year in the snow. What were your highs and lows, your learning moments, the videos you replay in your head, the questions that recur, the stories you want to tell?

Here's a couple of my projects for next volume; I'm sharing them with all of you so that I'm accountable:

- A personal case study that leads to a conversation/round table about peer leadership. Got any stories of how to make good decisions with your buddies as an off-work guide, forecaster, and/or educator?
- A written essay version of a presentation on Resilient Organizations that I created for the Big Sky Ski Patrols before Thanksgiving. This was a graduate-level seminar guided by the likes of Laura Maguire, Steve Conger, Dale Atkins, and Dave Zinn. Might show up in segments, as it's meaty.

I know many of us are looking forward to ISSW in Bend, but not everyone can attend. I'd like our December TAR to present a wide picture of the event. Who wants to report back for TAR from your perspective? Let me know if you are interested. I'm recruiting reporters from these fields:

- Forecaster
- Guide
- Ski patrol
- Researcher/scientist

In this issue you'll find a delightful array of stories around our central theme of **Crowns, Powder Clouds, and Turning Around**. The Photo Contest call-out brought in reams of amazing shots, which we divided into **Crowns and Powder Clouds** (cover, centerfold, and sprinkled through the issue), **At Work** (Last Lap on the back page), and **Snow Shapes** (also scattered through the issue). Congratulations to Matt Steen of Telluride Helitrax whose dramatic San Juan powder clouds scored him the cover. *Turning Around* comes from Joe Stock's eponymous blog post that, because I continue to refer to the skills he discusses, I persuaded him to share with TAR (page 26).

You'll also find a spread that celebrates the impactful career of Karl Birkeland: the best way we could pass a card "around the office" for folks to sign. Love you, Karl, thank you so much for your friendship and professional support all these years. Now that you're retired, let's ride!

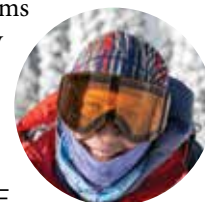
Also in this issue, you'll find an interview between avalanche master Ron Perla and Jason Albert (formerly of Wild Snow). Ron has been a great supporter and wily critic of TAR for many years; we appreciate his incisive intelligence and continued involvement in the avalanche world. In her dissection of a near-miss on page 30, Jenna Malone bravely tackles the hardest factors to analyze—her own personal and human factors. Road maps of our next steps as an industry and a community in human factors research and education come to us from Kelly McNeil, Pascal Haegeli, and Sara Boilen on pages 18–21.

From the science side, a radiation recrystallization avalanche cycle in Utah accelerated learning for Dave Kelly and Mark Staples of the UAC. See their report on page 38, along with further information about transceiver interference.

Scattered throughout this issue, you will discover gems that hopefully make you think: one from Drew Hardesty made me examine my own assumptions, as did another from Pat Gault of the Alaska Avalanche School.

I'm out of room and it's still snowing. Enjoy this issue and stay in touch, friends.

—LYNNE



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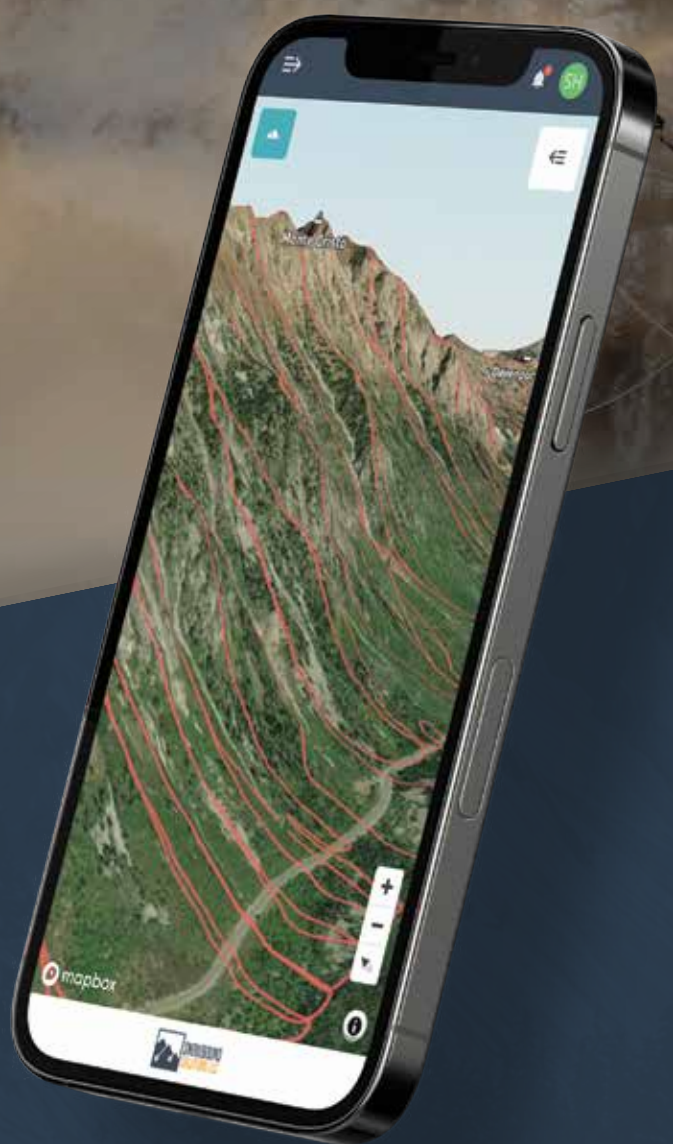


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FROM THE EXECUTIVE DIRECTOR

Before we officially close the door on the 2022–23 winter season, I'd like to share several important updates on behalf of the American Avalanche Association (A3) Board and Staff.



In January, **Jen Reddy** became the new Education Manager at A3. This appointment is exciting both because Jen has been a valuable member of the A3 team for the last two years (as our Member Services Coordinator) and because it represents a commitment from A3 to continue our support and oversight of the Professional Training Program for avalanche education in the U.S.

A little about the position... Following the Pro/Rec avalanche education split in 2017, Pro Training Course Providers and A3 have worked closely to deliver high quality and consistent education. As with all new endeavors there is more to be done and areas to improve. The Education Manager role is a newly developed, full-time staff position intended to lead those efforts. Jen will oversee all aspects of A3's Pro Training Program—including but not limited to ongoing provider reviews, new provider assessment, Pro Training Workshop facilitation, and proficiency and guideline adjustments. In addition to this work, Jen will also support the A3 Education Chair (Liz King) with A3's recreational avalanche education program. Jen will be the first full-time staff member dedicated to education work at A3.

A little about Jen... Jen brings a wealth of experience to this new role, including work as an avalanche educator for the American Avalanche Institute, Jackson Hole Outdoor Leadership Institute, and AIARE. Jen is also actively involved with Teton County Search and Rescue, the Bridger Teton Avalanche Center Foundation, the Teton Backcountry Alliance Steering Committee, the Responder Alliance SAR Task Force, the Teton Interagency Peer Support Steering Committee, and the ICAR—Avalanche Commission.

"The first five years of running Pro Courses have given us a tremendous amount of data, experience, and insight. I'm looking forward to collaborating with Course Providers and the Industry Advisory Group to continue to develop and advance the education proficiencies and guidelines. We have a solid foundation to build upon and it's exciting to envision the future of professional avalanche education in the US."

—Jen Reddy

Additional Staff Updates... Replacing Jen in our Member Services Coordinator position will be **Clare Menzel**. In addition to her passion for the avalanche industry, Clare brings a quiver of skills specific to nonprofits and communication, including time as a journalist for *Powder*. Clare will split her time between A3 and Flathead Avalanche, where she manages their friends' group communications. Those who know Clare from NRSAW will agree that her energy and passion will be a welcome addition to the A3 team.



Fun Fact: In May 2022, Clare earned her MA in history and philosophy at Montana State University with a thesis about the ethical knowledge and cultural identity that Dolores LaChapelle created in relationship with snow and avalanches.

These staff transitions mark positive forward progress at A3, and they put us on the right track to continue implementing our strategic plan. I hope you will join me in welcoming/congratulating Jen and Clare!

See you in the fall,
—JTN

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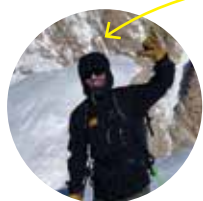


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METAMORPHISM



BRIDGER-TETON AVALANCHE CENTER UPDATE

A whirlwind of change hit the Bridger-Teton Avalanche Center this season. Hiring three new forecasters, transitioning to the new National Avalanche Center website platform, a second season under the new directorship of Frank Carus, and some unprecedented storm totals have made this season one for the books. Under Frank's leadership, this new team is comprised of the institutional "weather guru" knowledge and forecasting abilities of Mike Rheam alongside the fresh talent of Jackson Knoll, Alex Drinkard, and Gabrielle Antonioli. They are grateful to be a part the unique Wyoming snow community and aim to create an ever-improving and thoughtful forecast amongst other useful products for their diverse array of users.

Frank Carus started with the US Forest Service at the Mount Washington Avalanche Center in 2011 and is the Director of BTAC. Since college, Frank put his degree in Geography and Environmental Studies to use guiding climbs and ski mountaineering trips or personal trips to the Alps, Andes, Patagonia, and the western States. He has a passion for learning and has taken the AMGA Alpine, Ski, and Ski Mountaineering guide courses and has been a certified Rock Instructor since 1996. Working vacations take him around the country to teach technical rope rescue, fight wildland fires, or work as a mountain guide. Frank is also an Adjunct Professor in the Wilderness Medicine Program at Dartmouth College. The human relationship to risk-taking is an endless source of fascination for Frank.

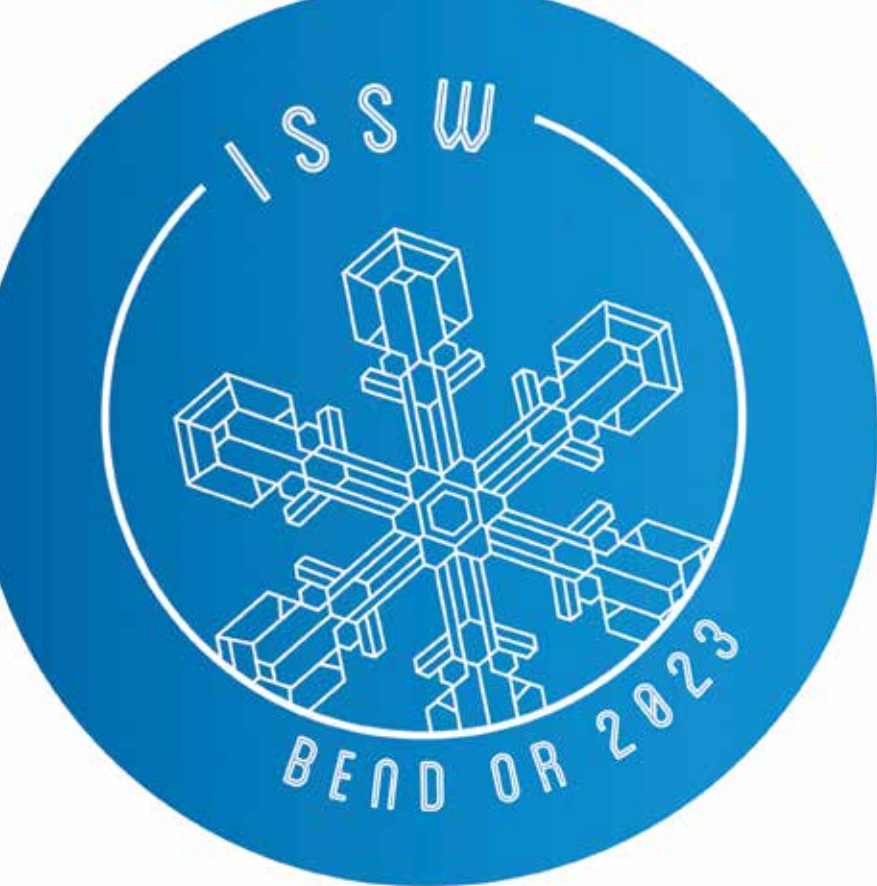
Gabrielle Antonioli was fortunate to grow up exploring the mountains of Montana near her hometown of Butte. She started climbing and backcountry skiing in college, and eventually developed a deep passion for the study of snow. Gabrielle is also the project lead for the A3 Resilience Project, works in

conjunction with Boise State University CryoGARS group, and forecasts for the Going-to-the-Sun Road in Montana. This season she has enjoyed building the community stoke in re-envisioning an avalanche center, both with new and old tools, and hopes to keep that ball rolling in a good direction.

Alex Drinkard grew up in Spokane, WA where his fascination for mountains and deep powder snow began. He started with the US Forest Service working seasonally in silviculture while obtaining a BS in Environmental Science from Portland State University. Transitioning to wildland fire enabled him to spend winters in beautiful British Columbia gaining extensive motorized and non-motorized backcountry knowledge, collecting snow data as a volunteer pro-observer for Avalanche Canada. Since 2020, he has worked for the Bridger-Teton with the snow ranger program and avalanche center. As one of the Forecasters, Alex is stoked to work with the incredible local community of snow enthusiasts to continually evolve and improve BTAC.

Jackson Knoll says he's from Idaho but he also spent part of his youth in northern New Mexico. A stint at both Montana State University and CU Boulder helped Jackson realize that his fascination with snow and weather might not be normal. Jackson became a meteorological technician with Grand Teton National Park in fall of 2022 and tries to assist the Bridger-Teton Avalanche Center. When he is not in a snowpit Jackson can be found wandering aimlessly through the mountains.

Mike Rheam has been fascinated with snow science since he moved to Jackson. This interest eventually led him to be lead forecaster for the BTAC where he has worked for over 20 years. He has also been the snow safety coordinator at Jackson Hole Mountain Resort and in the spring, he can be found forecasting and guiding in the Tordrillo Mountains of Alaska. ●



WELCOME TO ISSW 2023

BY KEVIN GROVE & ZOE ROY, ISSW CO-CHAIRS

October 8–13, 2023

We are incredibly honored, humbled, and stoked to have you all ascend, descend, traverse, and/ or side-slip(?) to Bend in October for ISSW. The most passionate and dedicated group of snow and avalanche professionals will gather for a week in Central Oregon to merge theory and practice, collaborate, share new ideas, connect, hug, and socialize with old and new friends. The Central Oregon snow and avalanche community has made great strides in avalanche education, outreach, and forecasting over the past ten years. For the first time, this season the Central Oregon Avalanche Center issued avalanche advisories seven days a week, a huge accomplishment and achievement for our budding community.



Bend in October is idyllic. Mountain biking, hiking, fishing, climbing, beer drinking, and paddle boarding on the Deschutes River are all top notch. We have no doubt that ISSW in Bend will be an adventure and we are looking forward to the wild ride.

As you well know, ISSW has a rich history and we are planning, preparing, and doing our best to make this year's ISSW a memorable one. We can feel the wave of energy gathering momentum. We can sense the enthusiasm, passion, intellect, curiosity, and drive that you will all bring and share at ISSW. We have all lost friends and loved ones within our professional and recreational communities. We will honor them at ISSW by continuing to move the needle forward on understanding, learning, and sharing new ideas, practices, techniques and so much more.



A dedicated Science Program team of Erich Peitzsch, Simon Trautman, Scott Savage, and HP Marshall is working hard to deliver an outstanding science program including standard length and lightning quick oral presentations, poster sessions, moderated panel discussions and more. Katie Warren is spearheading Diva Night and an A3 after-party will undoubtedly be memorable. In 1998, ISSW was held in Sunriver, just 20 miles south of Bend, and we are thrilled to bring it back to Central Oregon this fall. Abstract submissions are ongoing now through April 16 and registration opens in March. We look forward to seeing you in October. ●

From the archives: ISSW 2006, issue 25.2: Jayne Thompson, Amy David, and Erica David (the amazing Pinedale high school grrls) who gave this presentation *When the Dust Settles—A Multivariable Study of the Patterns of Near and Far Dispersal of Windblown Particulate Matter*, and Sarah Carpenter, the PAWS course organizer, pay close attention as Chris Landry explains the Swamp Angel site's instrumentation. ■ JOHN STIMBERIS



(Amy Jane this picture is to make you smile during your ACL recovery.)



ISSW Volunteers Needed

BY PAUL DIEGEL

Want to expand your avalanche network? Give back to the avalanche community? How about get a break on admission to the Fall 2023 International Snow Science Workshop in Bend, Oregon?

The ISSW organizing committee is looking for volunteers to help out October 8–13. Spots are available to stuff swag bags, register attendees, sell ISSW swag, run microphones during the sessions, help with poster session set up, coordinate evening social events, and more. Putting on a successful ISSW is a team effort and we need more team members to share the fun and effort.

We're looking for people to sign up for half-day and evening volunteer commitments and will give 1:1 credit for hours worked—work two half-day shifts with no admission cost and get another day of free admission. Along with getting a great deal on the admission price and a limited edition t-shirt, you'll perform a great service for the avalanche community and get the opportunity to hang backstage with the rich and famous rock stars of the avalanche world! For more information or to sign up, shoot a message to paul@issw2023.com. See you in Bend! ●



Bend ISSW 2023 Diva's Night

CELEBRATING OUTSTANDING WOMEN IN THE AVALANCHE INDUSTRY

BY KATIE WARREN

While the definition of a "DIVA" has changed over the years, I believe it is essential to recognize the word's origins as a compliment to acknowledge successful women. The word diva is derived from the Italian word for a female deity. It was then adopted to describe world-renowned female performers or the broader definition of "a woman of rare, outstanding talent."

It is this latter definition that the avalanche professional community adopted to recognize female-identifying avalanche professionals who have made outstanding accomplishments and contributions to the professional community.

BRIEF HISTORY OF AVALANCHE DIVAS

- Idea first conceived at the 2004 ISSW in Jackson Hole by Nicole Greene, ISSW 2006 Co-Chair, and Divas Committee member Aleph Johnston-Bloom
- Partnership with Leslie Ross of Babes in the Backcountry of Breckenridge, CO, USA
- First Divas Event, *Ladies Night* at the ISSW 2006 in Telluride, CO
- Our premiere as the *Avalanche Divas* at the ISSW 2008 in Whistler, BC, Canada
- It has continued as a successful and inspiring event at every ISSW that has happened since 2006, including two in Europe.
- Honored women from many countries who have contributed to all aspects of the profession.
- Added a travel grant program to provide financial support to women presenting at ISSW.

OUR MISSION

- To honor women who have made significant contributions to the field of snow and avalanches
- To offer female attendees the opportunity to gather, share information, and network with other professional women in the industry
- Provide mentorship opportunities with experienced snow and avalanche professionals to newer members of the community
- To preserve the history of women's contributions to this field
- To create a support network and legacy of women in the industry
- To eventually establish a non-profit organizational structure and scholarship fund

designed to empower women who are crossing new boundaries in the field of snow and avalanches.

CALL FOR NOMINATIONS

After the series of postponed and canceled ISSW events due to the COVID-19 pandemic, we are excited to be planning a celebration for women industry professionals at Bend ISSW 2023. The Diva's planning committee needs your help identifying women of "rare, outstanding talent" to induct into the Avalanche Diva's ranks.

Do you have a female-identifying avalanche professional you would like to nominate? Please send a resume for that individual to Katie Warren at avalanche.divas.us@gmail.com. Nominations will be accepted through **June 31st, 2023**.

Please include the following information for the nominee.

- Name
- List of accomplishments and/or contributions to the professional avalanche community.
- A brief description of why you believe your friend, mentor, or colleague should be recognized. (200–300 words)

The Avalanche Divas will also be offering travel grants to female-identifying presenters. So, if you are submitting an abstract, stay tuned for more information about grant applications coming in May.

We would like to thank all our past and present sponsors and Divas committee members who have all made this a reality. We would also like to thank ISSW 2023 for making Diva's night part of the program. Hope to see you all this fall in Bend! 🍷



KATIE WARREN'S

primary backgrounds are as a Stevens Pass Ski Patroller and as a highway technician with WSDOT's North Central Region. She now enjoys working with the Northwest Avalanche Center, issuing backcountry avalanche forecasts for the east slopes of the Cascades.



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ABSTRACTS

- January 16 - Abstract Submission Opens
- April 17 - Abstract Submission Deadline
- June 1 - Oral/Poster Abstract Acceptance Notification
- August 31 - Oral/Poster Submission Deadline

REGISTRATION

- March 1 - Registration Open
- May 18 - Early Registration Deadline
- July 13 - Regular Registration Deadline

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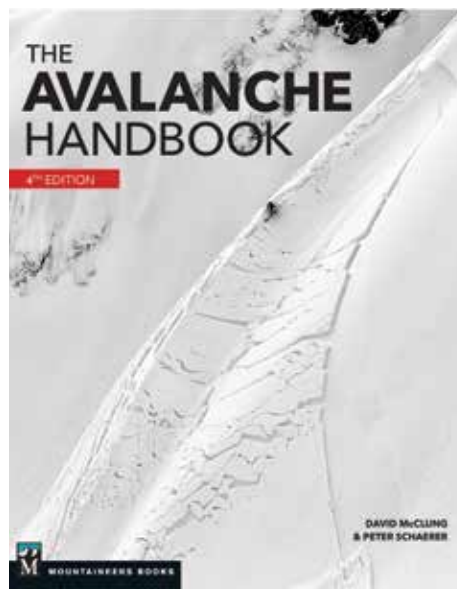
THE AVALANCHE HANDBOOK

The 4th Edition

BY DAVID MCCLUNG

The 4th Edition of *The Avalanche Handbook* was published in December, 2022. It is the legacy of a tradition which began in 1961 as USDA Handbook 194 with the title *Snow Avalanches*, written by Professor Ed LaChapelle. The next edition was entitled: *Avalanche Handbook*, with authors Ron Perla and Pete Martinelli in 1976 as USDA Handbook 489. Following closure of both the avalanche research stations at Alta, Utah, and at the Rocky Mountain Forest and Range Experiment Station, in 1993, Peter Schaerer and I here in Canada revived the book under the title *The Avalanche Handbook* (called the 2nd Edition). It was published by Mountaineers Books in Seattle with a subsequent edition published in 2006. The thread with link to Professor LaChapelle continues since 1961 since both Ron Perla and myself, as lead authors of the last four editions, were doctoral students of his.

The new edition contains many changes which have evolved over the last 16 years in avalanche research and technology. Some of these changes may seem subtle to readers. There has been a virtual “explosion” of published papers not just in the proceedings of the ISSW but also in peer reviewed papers. The choice of what to include among these contributions has been in order of priority: 1. Field observations and field measurements; 2. Laboratory measurements; 3. Models. Models come and go but good data are immortal. In each of the three categories there will be limitations to be considered with the limitations generally increasing with category number. Even though the book is technical, the focus is still on diagrams and photos



The Avalanche Handbook can be found at your favorite bookseller or www.mountaineers.org/books/books/the-avalanche-handbook-4th-edition

rather than equations and the audience is still wide. With a similar view as from Dr. Perla, we felt there should be at least one book which technical concepts should be adhered to, and not oversimplified, while still maintaining relevant issues important for general safety.

A few important changes are listed below.

1. Emphasis that, in fracture, alpine snow is a quasi-brittle material which requires a finite sized weak zone within the weak layer before avalanche initiation which we cannot normally locate or measure. This fundamental property forms the risk (probabilistic) basis for all slab avalanche forecasting and it implies a number of other important, fundamental aspects about avalanche release and motion. It is the reason that the book is almost entirely risk based.
2. A new chapter on Risk Management. The chapter features an introduction to subjective probability and its use with link to Bayesian updating in regard to decisions. The chapter includes a number of applications such as updating the Conceptual Model of Avalanche Hazard, a time-based system for decisions in guided helicopter skiing and a hazard analysis for skier/board triggering based on fatality statistics. The latter suggests that the highest hazard is for buried weak layers between about 0.6–1 m.
3. Updated time series on Swiss, Canadian and American fatalities. All three nations show declining fatalities with time which is a testament to the good work from avalanche courses and avalanche bulletins. Updated avalanche fatalities on the 8000 m peaks in high mountain Asia.
4. A heavily revised Chapter on Safety and Rescue helped immensely with input from Manuel Genswein from Switzerland.
5. The section on application of explosives was revised with the important help of Braden Schmidt of CIL explosives.
6. The effect of El Niño, La Niña on snow and avalanche patterns is discussed based on 30,000 recorded avalanches over 30 years in British Columbia. The contrast gives clues to climate change since El Niño, La Niña present two different climate scenarios: warmer with less snow and colder with more snow respectively.
7. Incorporation of the revised International Classification of snow from 2009.
8. Inclusion of the Extended Column, Propagation Saw Tests and Deep Tap tests and their limitations.
9. Discussion of Fracture Mechanics applied to avalanche release including the important concept of bridging which is fracture mechanics based and also dynamic fracture mechanics once the shear fracture initiates.
10. A revised discussion of return periods for avalanches and implications for land-use planning in snow avalanche terrain. ●



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DAVID MCCLUNG has devoted fifty-one years to avalanche research, and it is still ongoing. International Fellow of the American Avalanche Association. Professor Emeritus, University of British Columbia.

STACKING THE ODDS: A MEDITATION

BY GRANT GUNDERSON

I find it more than a bit ironic that **this book with my image of @queenofthemnt on the cover** arrived in the mail today after **the tragic event of losing @kylesmaine last week**. Over the course of my career, I have provided cover images for a half dozen or so avalanche educational books and countless more supporting images to educational courses pro bono in hopes that others can learn from the learning experiences I've had in the mountains. At the end of the day all we are doing is trying to better stack the odds in our favor with better safety equipment, more knowledge, better techniques and procedures, and finally experience.

We are working/recreating in an ever-changing natural environment where Mother Nature can be a real bitch if she wants to be. There will always be risks involved as the only way to eliminate them is to be 100% mistake-free in avalanche terrain all the time. That's just not possible as no one is ever 100% perfect at anything. While I understand the consequences of these risks all too well with the countless friends I have lost over the years to the mountains, last week's accident has made that fact more real to me than ever.



However, I think it's important that we also recognize that everything we do in life involves risks (some we understand better than others) so it's important we don't stop living our lives and that we embrace the joy that can come from the risks that time spent in the mountains provides us.

There is no such thing as an "expert" in snow science, so no matter what your experience level is, do something to try to better stack those odds in your favor whether it's improving your safety gear, practicing more with those you recreate with, taking another avalanche and or mountain first aid class, refining your procedures, or working on improving group dynamics. Even if you only improve one aspect you are still better off having stacked those odds just a bit more in your favor. ●



From the peaks of Switzerland and the ski culture of Japan to his home turf of Mt. Baker, **GRANT GUNDERSON'S** iconic images have captured the action and essence of skiing, biking, travel and adventure around the globe.

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KARL Birkeland

What a huge part of US Avalanche work Karl has been, in every way...on every level. From research to forecasting to patrolling and ski area operations to education...Karl has brought something to each of us. And although no longer working for the NAC/FS, we all know he's not done yet!

—Janet Kellam



Conducting a fracture study.

■ COURTESY KARL BIRKELAND



A professional snowpit. ■ ALEC VAN HERWIJNEN



Karl testing head hardness. ■ ETHAN GREENE

30 DECEMBER 2022

Dear Friends and Colleagues,

Many of you already know that today is my last day as a Forest Service employee. It's tough to believe, but I managed to somehow hold on as a federal employee for 32 years! For me the FS has been an amazing place to work, allowing me to turn my passion for avalanche science into a fulfilling and rewarding career. However, my most meaningful and enduring memories will be of all the great folks I've had the privilege of working with over these past decades. I've had too many mentors to list, all of whom helped me take a somewhat unique path through the avalanche industry in general and the Forest Service in particular. I've been fortunate to work with researchers, graduate students, interns, avalanche forecasters, ski patrollers, heliski guides, avalanche educators, and many others that have become leaders in the avalanche industry, great colleagues, and lifelong friends. A huge thanks to all of you.

Years ago when my friend and supervisor Liz Close retired, I said to her: "Liz, you can't retire! You've been my guardian angel in the Forest Service for years!" She wisely replied: "Karl, now it's your turn to be the guardian angel." I took those words to heart and tried to enhance and protect our avalanche programs, and to give those working in the program the latitude and flexibility to creatively find new and better ways of improving public avalanche safety.

Now I'll pass Liz's words on to the rest of you both in and out of the Forest Service: "It's your turn to be the guardian angels of your avalanche programs."

As I retire, Simon Trautman is stepping in as the Acting Director of the National Avalanche Center. Most of you know Simon well and also know he is certainly up to the task at hand. Hopefully the agency will be able to advertise and permanently fill the NAC Director position soon.

Though I am retiring as a federal employee, I am planning to stay involved in the avalanche industry for a while longer in a couple different roles. This will include part time work helping the NAC through the upcoming transition, and working on some fun special projects with the Friends of the Colorado Avalanche Information Center. I hope to also stay in touch with all of you. Feel free to reach out to me by email or phone (contact info below).

Finally, this spring Simon and I are planning an informal retirement get together in southern Utah—probably near Gooseberry Mesa—for a few days of hiking, mountain biking, camping, storytelling, and hanging out. We are tentatively planning for mid- to late-April. If you are interested, email me (email below) or Simon (Simon.Trautman@usda.gov) and we will make sure you get the details. I hope we get to see many of you there.

Take care,

Karl

Karl.AvySci@gmail.com
406-570-SNOW



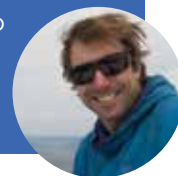
I'VE ENJOYED A FEW COLLABORATIONS WITH KARL AND NUMEROUS TURNS AT MIKE WIEGELE HELICOPTER SKIING. WHEN WORKING TOGETHER ON A RECENT VIDEO ABOUT SLAB AVALANCHE RELEASE, KARL EXPLAINED THE EFFECT OF RECENT LOADING ON THE CRITICAL CRACK LENGTH WITHOUT MAKING ME FEEL LIKE I'D BEEN SCHOOLLED! KARL IS AN ASTUTE SCIENTIST, WONDERFULLY CURIOUS, CONSISTENTLY POSITIVE, FUN TO DO ANYTHING WITH, AND—MY HIGHEST COMPLIMENT—AN EXTRAORDINARY EXPLAINER OF SNOW AND AVALANCHES!

—BRUCE JAMIESON



I met Karl Birkeland nearly 25 years ago when Ethan Greene and I passed through Bozeman, MT on our way toward a kayaking adventure in Canada. The 19-year-old me didn't know who the guy was other than a generous fellow who welcomed a couple of stinky paddlers into his home. We crossed paths again in an avalanche class he was teaching in 2009, we connected as I moved into the early days of my professional snow and avalanche career as a ski patroller, and he encouraged me as I followed a pathway toward avalanche forecasting. Twenty-three years ago, when we crashed at Karl Birkeland's home, I didn't imagine that I would be working in the next cubicle over, learning from, and skiing powder with him. Here is to our mentors and our mentors' mentors. Thanks for everything, Karl. I look forward to spending more time wandering the mountains with you in your retirement.

— Dave Zinn



The first time I met Karl was at the 2002 ISSW in Penticton, where we discussed the pros and cons of recording fracture character and shear quality in stability tests. Since then, our paths have crossed numerous times, and I always enjoy our discussions about snow and thinking about new things to measure in the field. I was therefore delighted that in January 2020, Karl came to visit the SLF in Davos, Switzerland on a fellowship for four months. Although his stay was abruptly cut short due to the corona pandemic, we had a great time with him, drinking good coffee and beers, enjoying the ski fields around Davos, shoveling snow from the bunkers, and actually doing some good science as well.

Perhaps the most memorable day was 31 January 2020, when we spent a day hunting whumpfs with our feet in the water. Wearing our insulated rubber boots and our trusty old snowshoes, we managed to trigger plenty of whumpfs and even a small avalanche in a creek in the Flüela valley just above Davos. We collected great data while pushing the limits of extreme snowshoeing to a whole new level. Despite his rather short stay in Davos, with his kind and approachable demeanor and his contagious enthusiasm for anything related to snow, Karl made a lasting impression on many people in our team and the SLF as a whole. Thank you, Karl, and we wish you all the best in your future adventures, with or without snowshoes, and hope to see you in Davos again soon!

—Alec van Herwijnen, on behalf of the Avalanche Formation and Dynamics team at SLF



I met Karl in 1990 when he started the avalanche center in Bozeman. Even then he was known as the “man” when it came to avalanches, and over the decades his status has not diminished. He has the rare quality of being able to explain hard concepts to simple minds, something I personally appreciated. Over the years I have worked with Karl and drafted behind his intellect and research. As a practitioner, Karl gave us the tools to do our job better and safer. He and Ron Simenhois perfected the ECT, a staple of our field work. And my favorite was his research showing that we did not need to be on a steep slope to get true stability test data since a shallow-angled slope would work just as well. That study saved lives and is worthy of a medal, or at least a beer. His humor, humbleness, one-eyed athletic ability, and passion for the snow is something that I will forever appreciate.

—Doug Chabot



I met Karl in 2006 while collaborating on the Extended Column Test. Since then, I have had the privilege of working closely with him on many projects. Working with Karl has improved my ability to approach, analyze, communicate new ideas, and drop bad ideas. Karl has encouraged me to pursue new ideas; my journey in the avalanche field would not have been as enriching without his influence. But one of the primary reasons I continue seeking his collaboration is that I have become a better person while working with Karl.

The first time Karl and I spoke, I noticed how open-minded he is to new ideas, no matter where they come from. This became clear from time we spoke; Karl was happy to listen to a new idea from a foreigner with limited English from a mostly-desert country. Karl is kind, generous, supportive, and approachable. For all of the papers he has published and all graduate students he has helped, he still remains humble. He is often the smartest guy in the room, yet he still makes others feel good about themselves and their contribution. Karl is quick to mention that other people may have a better insight into different aspects of our work and is never shy about bringing them into the fold.

Research and science have little value without the people driving them and the people enjoying their discoveries. Karl is a brilliant researcher and scientist who has inspired many other people and me in this community. Every time I work with Karl, I get a glimpse of the person I aspire to be.

Karl—I know you are just retiring from a job and are not going far, but I speak for many people when I say thank you for everything you have done.

— Ron Simenhois



Karl provided me with guidance since my first cold email looking to volunteer at the avalanche center as an undergrad to my first tv interview as a forecaster for the GNFA, and beyond. To think he has provided unconditional support for probably hundreds of professionals in the snow and avalanche community is one of his many great contributions, and a display of his selfless, caring personality. He has inspired a countless number of snow professionals to be our best, and he works hard to be available when needed. Not to mention, most of us would not understand concepts like fracture mechanics without Karl's clear presentations about complex topics. Thanks, Karl! I look forward to more meetings on skis instead of in the office.

— Alex Marienthal



Karl Birkeland with grand mentor Peter Schaerer in the Cariboo Mountains

BRUCE JAMIESON

RETIREMENT—KARL, NOW YOU ARE PART OF AN EXCLUSIVE CREW OF FOLKS THAT CAN LOOK FORWARD TO MONDAYS! YOU HAVE EARNED IT! THANK YOU FOR YOUR CONTRIBUTIONS OF NEW KNOWLEDGE AND SKILLS TO AVALANCHE SCIENCE, AND FOR THE SUPPORT AND ENTHUSIASM YOU HAVE GIVEN TO MEMBERS OF OUR PROFESSION, WHETHER WE BE OLD, SEASONED PROS OR YOUNG, GRADUATE STUDENTS WITH EYES WIDE OPEN. I HAVE LEARNED A LOT FROM YOU AND LOOK FORWARD TO LEARNING MORE.

—DALE ATKINS



Congratulations on retiring from full-time work at the Forest Service NAC Karl. Starting the GNFAC and moving the NAC so far forward are huge achievements, but your lasting impact on students and avalanche professionals is truly profound. Your talent and passion for identifying research questions, working to answer them, and effectively sharing your work with both practitioners and researchers stands out. Personally, I'll always appreciate your willingness to answer my questions, especially in my early Big Sky days when many folks in your position would not have given me the time of day. I'm excited to see what you accomplish now that you are free to focus on your snow and avalanche interests without the red tape that comes with a full-time "day job." Enjoy your new-found flexibility, both personally and professionally.

—Scott Savage



(see next page for a stunning Joe Stock image from that day)

MAN, KARL LOVES TO SKI, AND HE'S SO FUN TO BE OUT THERE WITH. TWO SESSIONS AND 19 RUNS THAT DAY... NOT BAD FOR A SCIENTIST!
— HENRY MUNTER



■ SIMON TRAUTMAN

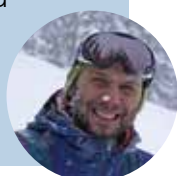
Karl Birkeland recently retired after a long tenure as the Director of the National Avalanche Center. Karl's expertise and years of contributions have allowed for great strides in knowledge and techniques used to study snow and avalanches. From Karl's early days as a ski patroller at Snowbasin Ski Resort in Utah to becoming a respected leader in the snow and avalanche community, Karl's diverse history with snow as both a skier and a scientist shaped his approach. Karl helped to develop innovative concepts that have been used by the full spectrum of people interested in snow and avalanches – from weekend recreationists to scientific avalanche researchers. There is no question the backcountry community is safer as a direct result of Karl's contributions to the field. Even while putting so much energy into his profession, Karl made his family a priority – sharing his love of skiing and the backcountry and now his daughters have become some of his strongest backcountry partners. Karl, the snow and avalanche community cannot thank you enough for your contributions, passion, and leadership, and we wish you the best with your next chapter!

—Eric Knoff



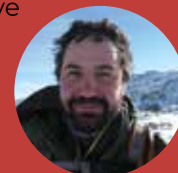
Karl's curiosity, kindness, and supportive nature had a critical impact on my path in the avalanche community at a very early stage. In 2000, Karl was the papers chair for the ISSW in Big Sky, which was my very first ISSW. After my (somewhat theoretical) presentation on scale issues and avalanche forecasting, which looking back was a bit out there, Karl approached me with enthusiasm and wanted to talk about spatial variability. It was an amazingly warm welcome to the international avalanche research community. One year later, Karl was the editor for my first avalanche-related article I submitted to CRST for publication. The quality of my initial submission was rather questionable, but it did not stop me from making some big concluding statements. Karl's review and feedback was firm but supportive, and he patiently shepherded me through the process of turning my paper into a meaningful contribution. I often think back to this experience when I review obvious student papers for journals now, and I remind myself that constructive feedback, support, and kindness can go a long way. Thanks, Karl! It made a huge difference.

—Pascal Haegeli



Karl—Congratulations on your well-deserved retirement from the US Forest Service. You've had an amazing career with the agency and I hope this landmark provides a chance for you to reflect on the many things you have accomplished. To list a few within the USFS: starting a new avalanche center, starting a research program at the National Avalanche Center, bringing avalanches to Washington, and establishing avalanches as a hazard addressed by USFS programs. This is an impressive list by any standard. However, it does not adequately describe the true impact of your career. Your enthusiasm for learning and approach to research generated ideas and guided our understanding of snow and avalanches, influencing nearly every part of the work we do. These same qualities also intrigued, inspired, and eventually consumed friends, colleagues, and many students—who in turn went on to contribute to the snow and avalanche community. Although we know they are many, these accomplishments cannot be counted. For me personally, this landmark is bittersweet. Our friendship began at the same time as your career with the USFS. Your impact on my life and career is immense, but hard to measure. I am sorry to see you leave the green uniform behind, as I could always turn to you for help and count on you for guidance. However, I too have been consumed by your enthusiasm and creativity in the past and know that your retirement is really just the beginning of the next chapter.

—Ethan Greene





JOE STOCK

I first heard about Karl more than 20 years ago as I finished up my geology degree. At the time, I had more money left in my GI Bill, and figured that graduate school would be a good way to focus on skiing and climbing while maintaining a thin veneer of respectability. The only trick seemed to be finding something interesting to study. As I was researching various programs, I stumbled across a page titled “So you want to be an Avalanche Professional?” on the American Avalanche Association website. As far as I could tell the page was a catch-all for information on a variety of jobs, but the part that got my attention referenced the snow science program at Montana State University (of which Karl was a major part). This was definitely interesting! At the time, I had an idea one could study snow, but no idea one could make a career out of doing so. Anyway, I was intrigued, one thing led to another, and 18 months later I started classes at MSU.

I’ve been lucky enough to work with Karl in one way or another since then. His academic contribution to our understanding of avalanches is remarkable and most of the structure of the US Forest Service Avalanche Program can be traced to him. More importantly, he is fun to work with and has had a personal and positive impact on an inordinate number of individuals in the snow and avalanche community. I think this positivity stems from the fact that he is approachable, cares deeply about doing good work, and that he actively promotes others who do the same.

Thanks so much Karl and I’m looking forward to the next 20 years!

—Simon Trautman



I’ve come to learn that guidance and shared experience might be the two most invaluable things in life. This is perhaps most true when said shared experience comes in the form of powder skiing. I can’t imagine the number of folks in the snow community that Karl has freely offered either, or both, to. If you’re lucky, you were able to partake in both simultaneously. I also can’t put into words the work legacy Karl has crafted as Director of the National Avalanche Center and mentor to so many. He opened doors for my career that might’ve otherwise stayed shut and taught me how to mentor others. Even after a long day when I’m strung out with an impending storm or overload of work, if someone reaches out, I take the time to listen, engage, and respond. An eternal observer, he also imparted to me one of the most important fundamental concepts to forecasting and studying snow: there’s beauty (and science) in simplicity. Simple concepts or curiosities are sometimes overlooked for more complicated or technological answers and experimentation. One of the toughest things about snow is the requirement of the observer to foster an intimate enough relationship and understanding of snow in a dynamic environment in order to design experiments and craft hypotheses that have practical applications. Sometimes all you need is a question, a cardboard box for making a slab, and a mentee willing to dig some pits to set in motion another twist on the ascending spiral. Though I’m sure we will all miss his availability for feedback and his dedication to work, some well-deserved biking and free-time skiing are in order.

— Gabrielle Antonioli



The first time I met Karl Birkeland he was kind, welcoming, and generous with knowledge. In a room full of experts, his presence was comforting at one of my first Snow and Avalanche Workshops; I was new in my role with A3 and intimidated, to say the least.

Karl’s impact on our community can be seen not only in the hard science but also in the collaboration and kindness he imparted to so many of us. His mark on A3 and this community is unparalleled. Thanks for everything, Karl!
—Jayne Thompson Nolan



FULL CIRCLE:

PART 4

NEXT STEPS IN A CROSS-DISCIPLINARY APPROACH TO PUBLIC AVALANCHE SAFETY

BY KELLY MCNEIL & PASCAL HAEGELI

This is the final article of a season-long series intended to introduce avalanche practitioners to the public health concepts of behavioral and social sciences and to posit a process for a public health-oriented approach to the avalanche industry.

Throughout this season, we've reviewed public health concepts and their potential applications in avalanche education and public forecasting. While those articles take a deeper dive into each concept, let's start with a quick refresher for some context. **Social science** is the study of how people interact with one another. It includes anthropology, economics, psychology, and sociology, among others. **Behavioral science** is the study of when and where individuals engage in specific behaviors; it's done by examining social influences, motivation, and conscious thought. Public health uses both social and behavioral science theories and approaches to inform interventions and initiatives.

As an industry, there has been a long-standing awareness that human factors play a role in avalanche accidents. As Atkins (2000) wrote: "Avalanche accidents are a human problem." There's some precedent for using social and behavioral science to understand how people interact with each other, social influences, motivation, and conscious thought. Fesler and Fredston (1994) noted different human factors that are major contributors to avalanche accidents. Their research discussed 15 contributors to "human factors" that can lead to avalanche accidents.

"To prevent avalanche accidents and to save lives," Atkins wrote in 2000, "there needs to be a better understanding of the dynamics of human errors and how they lead to accidents." In the early 2000s, McCammon (2002, 2004, 2009) investigated the potential influences of inappropriate heuristics in decision-making in the backcountry following the heuristics and biases research of Kahneman and Tversky. Using accident records, he showed that personal decision tendencies and social dynamics that work well in other contexts might lead winter backcountry travelers to unknowingly expose themselves to higher levels of avalanche hazards. McCammon's Heuristic Traps represent a milestone in our community's awareness of human factors, and for most of 20 years, this work has been used and taught to try and understand why people make the decisions they do when traveling in the backcountry.

But there is much more to do! In TAR 42.1, the article "Beyond Facets: Evolving the way we think about the human factor" mentioned that McCammon himself never "meant for his research to be an answer;" he conducted his research in hopes that it would be the starting point for further studies (Boilen, Riggs Meder & Walker, 2022). We also know from behavioral

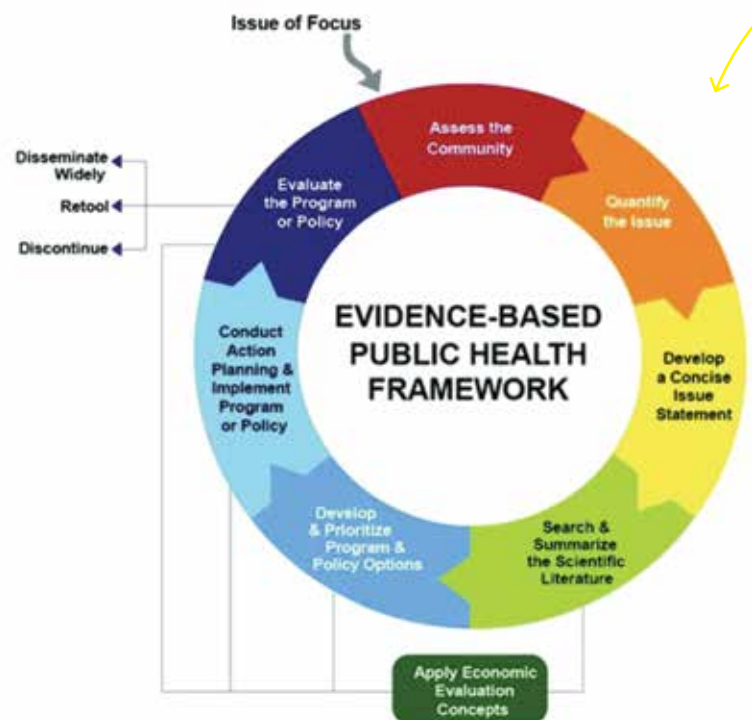


Figure 1: Framework for training public health professionals in evidence-based decision making. Jacob et al. (2018)

science that simply being aware of an issue does not lead to behavior change. So instead of just using theories from psychology and behavioral economics to highlight flaws and challenges in our assessment and decision-making processes, **we should use social and behavioral science methods to better understand what backcountry users currently do, what works for them, and what does not.** We can then use these insights to develop, provide, and test specific teaching and communication strategies that resonate better with the practices and needs of backcountry users and ultimately promote behavior change.

For many years, social and behavioral factors were not being examined or studied, but that is changing. Currently, Pascal's research group at Simon Fraser University in Vancouver conducts interdisciplinary research to better understand how recreationists and avalanche professionals currently make decisions about avalanche risk, how they understand and use the existing products, and how their practices relate to the backcountry experiences they are hoping to have. The goal of this research is to create the foundation for developing evidence-based tools to assist backcountry recreationists and avalanche professionals in making informed decisions that work within their personal contexts. At UiT, The Arctic University of Norway in Tromsø, the Center for Avalanche Research and Education (CARE) is an interdisciplinary research center focused on understanding decision-making in the face of uncertainty. Researchers are in the process of surveying students after they complete their avalanche coursework to understand their change in knowledge. Here in the U.S., research is being done to assess the knowledge, attitudes, and behaviors of Recreational Level 1 and Avalanche Rescue students six weeks, one year, and two years after their course.

So what are our next steps? Humans are hard to study; human behavior is complex, hard to measure, and multifaceted. But by incorporating social and behavioral science, research, and existing frameworks, we can continue to gain a better understanding of our population, how to develop and

deliver information, and evaluate what works and does not work. We need to continue to understand human behavior—and not just how to inform, but how to influence it. Rather than becoming experts ourselves, a cross-disciplinary approach would mean working with experts outside of our field: experts in anthropology, behavioral economics, cognitive psychology, consumer behavior, social psychology, education, and sociology, who already have a unique understanding of human behavior from their perspective and research. This approach will not happen overnight, it takes time and dedication from both sides to learn and understand the other side’s perspective and contributions in order to develop meaningful approaches and methods. In order to make this a reality, we need investment from our community and a shift in thinking. Let’s bring them into our community and learn from each other.

As mentioned in the first three articles in this series, evidence-based strategies from these other disciplines help us understand (and influence) decision-making. Existing frameworks, theories, and models could be useful for our work. So let’s bring this conversation full circle with the application of the framework for training public health professionals in evidence-based decision-making. This framework provides us with guidelines for conducting research—and seeing where gaps exist (Figure 1).

The framework starts by **assessing the community**: we need to have an understanding of our various user groups, where and how often they travel, and what each needs to know in order to make informed decisions. Do these groups need different information and education? The more we understand the answers to these questions, the better we can provide what they need. **The next step in the framework is to quantify, understand, and research the issues—something we need to do in the realms of avalanche education, forecasting, and messaging.** What are experts outside our field seeing in these areas? This will lead to a further understanding of existing evidence-based strategies for behavior change, how to influence group dynamics, communication and listening, and factors for high-risk decision-making. **The third step in the framework is to develop, prioritize, and implement programs.** We can incorporate behavior change theories and test whether they are an effective way to change behaviors, not just knowledge. All of these programs and communications need to be based on

Humans are hard to study; human behavior is complex, hard to measure, and multifaceted. But by incorporating social and behavioral science, research, and existing frameworks, we can continue to gain a better understanding of our population, how to develop and deliver information, and evaluate what works and does not work.

measurable outcomes and objectives, which will lead us to the next stage of the framework: effectively evaluating forecasts, curricula, and marketing messaging. We need to know if our programming is meeting our measurable objectives and outcomes. Are we actually doing what we think we are doing? Does the population understand what we’re saying—and is it actually influencing their behavior? Without evaluating our programs, we cannot say we are being effective; we don’t know if we don’t measure it.

Once we evaluate our programs, we can take that information and disseminate it to the entire industry so we can all learn and continue to improve. Much of this work has already begun, and it is exciting to see it continue. There are many possible approaches, and we are interested to hear what other avalanche professionals see as paths forward. We invite anyone interested in evaluating their existing programs and considering applying behavior change theory to improve them to this conversation—all our work can only be improved by collaboration.

Special thanks to Emma Walker for her editorial help throughout this series. ●

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PASCAL HAEGELI is the NSERC Industrial Research Chair in Avalanche Risk Management at Simon Fraser University.

Toward a conceptual framework for

Sense- Decision- making in the backcountry

BY SARA BOILEN

There are some in the avalanche field who believe that our work on human factors is sufficient. Our research continues to focus primarily upon the realm that includes snow mechanics, weather, terrain, and improved technology. While these factors are undoubtedly important, without humans we would not have human fatalities in avalanche terrain. We need only scroll through our own contact lists to see that it is not merely newbies without beacons who die from trauma and asphyxiation in the places we love; our friends, colleagues, and experienced users die as well. **We can and should do better.**

The theory and supporting research is clear: “Human factors are the cause of most avalanche accidents involving avalanche-aware people.”¹ However, as Ian McCammon highlighted more than a decade ago, “precise definitions of human factors are surprisingly difficult to find.” Indeed, the phrase *human factors* does not seem to have a clear, specific definition but instead seems to include subjective factors such as cognitive biases (heuristics), risk tolerance factors, and group dynamics that contribute to decision-making but are not aligned with the objective information available from the snowpack, weather, and terrain.

Without a solid, agreed-upon conceptual framework, our community lacks a common language, shared understanding, and, subsequently, a universal curriculum on the topic.

In truth, we (we, meaning avalanche professionals but also psychologists, public health experts, anthropologists, philosophers, risk experts and others) know a lot about the so-called human

factors. We know that cognitive biases don’t only affect decision-making but also have profound impacts on our perception, which here we will refer to as sense-making. We know that group dynamics impact our ability to see things clearly. We know that good communication and facilitation improves outcomes, and that poor communication and deficient facilitation impairs them.

We know that when it comes to cognitive bias, as Dr. Kahneman explains, “talk alone will not eliminate them.” That is, “knowing you have biases is not enough to help you overcome them. You may accept that you have biases, but you cannot eliminate them in yourself.”²

Researchers suggest that we overcome bias not through internal systems of awareness, but through organizational systems and processes that combat bias. Guides and avalanche professionals have long utilized systems and checklists to derail natural bias tendencies.

The early AIARE curriculum, as described to me by Brian Lazar, involved “teaching a repeatable decision-making process that involves checklists.” He told us that he still uses a checklist remarkably similar to the one that they originally came up with. This checklist became the AIARE decision-making framework which is now included in all of their field manuals. This system is an attempt to combat the negative influence of human factors on group and individual decision making.

Meanwhile, AAI, sharing the notion that decision trees would be more helpful if the user had access to them throughout their tour or ride, developed a pocket-sized guide that offers checkpoints and questions to prompt good decision-making when approaching avalanche terrain. Others such as Pascal Haegeli and Ian McCammon developed and provided our community with tools such as ALPTRUTH and the Avaluator, checklist models designed to offer frameworks that might combat errors in sense and decision-making.

Despite these innovations, we continue to lose friends and community members to avalanches that, in hindsight, appear avoidable. Back in 1994, Doug Fesler, Jill Fredston, and Bruce Tremper reminded us that, in accident reviews, “While some accidents are the result of not recognizing potential hazard, most accidents occur because the victims either underestimate the hazard or overestimate their ability to deal with it.”³ Indeed, systems aimed at addressing bias can create their own problems by narrowing one’s focus and reducing the sense-making required to operate in a highly unpredictable, risky environment, particularly for individuals who lack knowledge about the environment. Further, we know little about how often practitioners utilize these systems outside of courses.

Without self-awareness and communication, individuals attempting to sense- and decision-make in avalanche terrain often struggle (or fail) to implement these effective mitigation, prevention, and debrief systems. In addition to an understanding of avalanche problems and basic mechanics of how avalanches occur, we must also teach community members essential soft skills that will allow for the effective implementation of sense-making systems.

Every educator has observed a course participant who, despite knowing what to do in a rescue, dives into the scenario without communicating with their group, checking that the scene is safe, and ensuring that all members present have switched their beacons to ‘search.’ This behavior is not reflective of a deficiency in the hard skills related to search and rescue but rather

inadequate self-awareness and communication that easily can tank a rescue operation. In other words, whether you will be able to access your hard skills effectively in the context of, for example, a rescue scenario will depend on your soft skills and your training and practice integrating and applying the two. Our group sense- and decision-making is only as good as our communication and self-awareness and it's time we started teaching these skills to our course participants, community members, and partners.

In TAR 41.3, I provided a mad-libs style activity to help increase self-awareness and spark conversation about risk tolerance, goals, and communication styles among backcountry users. This is the most popular slide in any of my presentations to date. Obviously, students like it because it's witty and interactive, but I think more importantly, because it is applicable and helpful. As a therapist of nearly two decades, I can confidently say that insight comes naturally to few and sharing that self-awareness is an even rarer talent. If we were all excellent and knowing ourselves and sharing that self-knowledge eloquently, I think I'd be out of a job (which would be great; I'd get to ski so much more!).

So, while the avalanche community is fortunate to have long understood the dangers of the cognitive traps known as heuristics, and luckier still to have wise leaders who have created and shared protocols and systems that help reduce the effects of those heuristics, I believe that we still lack the soft skills that would allow for the effective, regular implementation of these systems consistently enough to further reduce avalanche accidents and fatalities. Certainly, we still lack a widely agreed upon, research-based framework akin to the Conceptual Model of Avalanche Hazard for human sense-making and decision-making.

A group member might notice a peer's confirmation bias or sunk cost bias, but how are they to address it? How is a snowmobiler to know what their risk tolerance is, especially compared to their new riding buddy? When we're debriefing, how is my friend supposed to tell me I made them nervous? We give students tools, but do we really properly equip them to use them?

Additionally, the focus on human factors research, theory, and education has long focused on decision-making. We propose that sense-making is just an important area of focus. As Laura Adams highlighted in her thesis, "We create and construct knowledge through a process of perceiving and understanding experience and events."⁴ What we perceive and how we perceive it impacts the sense we make. Our subjective reality transforms into a (perceived) objective reality upon which we base every decision that follows.

I have teamed up with a group of thinkers and researchers (including but not limited to a public health expert, a pedagogical professional, a cultural anthropologist, and a philosopher) to examine and address this problem thoroughly. As previously stated (TAR 41.1), we aim not to diminish the importance of snow mechanics and behavior in the world of avalanches but to augment our understanding of how and why human-involved avalanches continue to happen. Further, we hope to deepen our understanding and develop appropriate and useful learning objectives and guidelines to help those teaching recreationalists and professionals who travel in avalanche terrain stay alive. The goal is to provide practitioners, researchers, and educators with current, universally agreed language and understanding of the human factors. We also realize that we are not the first to undertake this effort. Many have come before (and I hope will join our ranks again) and we are immensely grateful for their contributions. What we are suggesting is a systematic and collective approach to a long-standing, perplexing issue so that we can successfully and collaboratively move the conversation forward. First, we hope to create a working title and definition of the obstacles to objective sense- and decision-making in the backcountry. Then, we will draw upon the literature to understand these obstacles thoroughly. From there, we can co-create educational and practice models that will address these dilemmas and share this knowledge widely. Finally, we will evaluate these models and the related education to ensure we are succeeding at what we set out to do. We will see you at ISSW in Bend where we hope to draw from the collective wisdom of our community. If you're interested in participating, please reach out: drsaraboilen@gmail.com. Until then, enjoy the mountains and remember to check in with the snowpack, check in with your group, and check in with yourself! ●

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LETTER OF SUPPORT FROM IAN MCCAMMON

Back when I was a fledging avalanche instructor, I sure had a lot of ideas about how to help my students. Fresh from a science and engineering education and with years of backcountry experience behind me, I assumed that avalanche safety was about understanding the physical hazard and knowing how to choose terrain to match the conditions.

Then the death of a friend prompted my research into repeated patterns in avalanche accidents, and I began to understand the sinister influence of our unconscious blind spots in avalanche terrain.

And honestly reflecting on my own near misses, it wasn't long before I came to the unsettling realization that, given a bad day and exactly the right circumstances, I might be the next avalanche victim. And if that was the case, how truly effective were my avalanche classes?

That's why I am thrilled by the work proposed by Sara Boilen and her team. The project has many points of light, but at least two stand out: First, by moving away from "human factors" (see TAR 29.4 for how the term handicaps our progress) and focusing instead on the broader process of "sense-making," Sara's group aims to free us from outdated thinking and map the complex psychology of avalanche terrain.

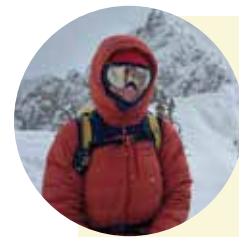
A second point of light is her team's intent to evaluate the effectiveness of their resulting framework. In a recent study of avalanche literature since 1905, and I found over 50 checklists, mnemonics, visual constructs, and conceptual models designed to help people navigate avalanche hazard. As far as I could tell, not a single one had been rigorously evaluated for its effectiveness. It's hard to move forward if we are not learning what works and what doesn't.

The work of Sara's team is exciting because it has the potential to create an entirely new, empirically grounded narrative about why people die in avalanches. And once applied, perhaps it will give us roadmap to revising our avalanche classes and bringing more people home alive.

Certainly, we still lack a widely agreed upon, research-based framework akin to the Conceptual Model of Avalanche Hazard for human sense-making and decision-making.



IAN MCCAMMON is a retired engineer. He is shown here with Árnason's Sun Voyager, symbolic of "the promise of undiscovered territory, a dream of hope, progress and freedom."



SARA BOILEN is a clinical psychologist in Whitefish, MT. She is fascinated by how humans make decisions.

wherever

humans concern themselves with its potential for use. I am firmly rooted in this view after years of climbing out of the hole of post-war imbalance, a lot of psychedelic therapy, and periods of isolation in the backcountry up to five-weeks in length. Somewhere in that time, it became apparent that like avalanches, the fallout of trauma is a problem because of human-constructed society and all its self-proclaimed import. Through the lens of Nature, however, trauma is the effect of a cause, an opportunity to learn and grow, a memory that is properly filed away once the unnatural pressures and expectations of the Western society are left far behind.

“Society is the problem!” I proclaim without context. I’ve been in my own head again.

The students are confused. I bring it back around. “Ok. Let’s try this.”

I erase FACETS from the whiteboard and replace it with a gigantic “I”.

“Let’s start from the beginning,” I say, “Intention! What was your intention when you spent thousands of dollars on a backcountry setup? Who or what convinced you to do such a thing? What did you imagine in your mature mind that you’d be doing on those skis or that splitboard? Exactly how much safety did you expect to achieve by purchasing this education?”

I receive a smattering of lightweight answers. It’s apparent that none of them had much forethought beyond just wanting to do something new and interesting. I do not judge them for this. If I’m honest, that’s exactly where I started. But why not Nordic skiing? Why not buy an alpine setup and become a patron of Arctic Valley or Skeetawk—the mom-and-pop alternatives to Alyeska, which has all but turned its back on Alaska locals to wash the feet of wealthy heli ski clients and tourists? I can see in their eyes that deep down inside, they know why they want to be in the mountains. But they lack the language.

“On behalf of the ski industry and ski culture, I offer you an apology,” I say, “You’ve come here to find a soul in a soulless society but these days, such a narrative does not exist outside of cheap marketing.”

Whatever small protrusion of responsibility I had held onto gives way and I fall with gravity into the abyss of a reality I cannot help but speak to.

“The mountains don’t care that you want to ski.” I say, “Listen, landscape has a purpose and ultimately, its reason for existing is to absorb organic matter and fertilize soil.”

The students’ eyes are locked on me, trying to figure out where this all fits into what they’ve paid their hard-earned money to learn.

“If the mountains had their way, they’d lanche all of us and pulverize our bodies into something fungus could get to work on. So, I’ll ask again. Why do you want to go there?”

I stand with my palms facing up like I’ve just asked a stump question that only the most intellectual among them might answer. But there is no angle. I’m a stubborn pragmatist. Nobody moves. Nobody makes a sound. The other two instructors look confused in the back of the room.

A woman raises her hand and tosses an answer my way, “Commitment?”

A man in the first row sits back in his chair, “I was going to say Acceptance.”

My shoulders drop and my head bows and I want to spend the next hour drawing out the timeline of human existence to show that our relationship with landscape for the vast majority of our existence was relational, reciprocal and not what it is now—as consumers viewing it as a product. I want to tell them that the human factor is obsessed with convincing itself that it can avoid death somehow, even as it enters terrain whose sole purpose is to produce destruction for the sake of rebirth. And I want to tell them that that’s exactly where they need to be to save themselves from this hell of an incidental existence—that their mental health is a function of their proximity to Nature. Where else in outdoor recreation is there an opportunity to hold conference and bring-in landscape as the primary subject? It wasn’t too long ago that humans didn’t need to be clued-in to that reality.

I place the marker I’m holding back on the tray and take a breath. “Let’s go over some case reports,” I say. Time to stop thinking so much. This isn’t the time nor the place. Everything, including the universe, must fit inside a box.

But it never will. We can show the big lines being skied on screens and encourage people who just want some semblance of freedom to come learn how to do that same thing. But very few will break from the rapid fire of Instagram influencing to find the truth. The soul of backcountry skiing is not in the skiing. It is in the relationship built with weather, the snowpack, and landscape.

And like the most meaningful kinds of love, it requires your life.



PAT GAULT is a former Air Force Pararescuer (PJ), Denali Climbing Ranger, and Alyeska ski patroller. He currently lives in Anchorage, AK and teaches for the Alaska Avalanche School.

Factoring Humans

I tense as I teach a classroom full of level one students the FACETS acronym. “Familiarity!” I say. “Acceptance! Commitment! Expert halo! Tracks! Social prooof!” They’ve all been magically transported from their couch into the backcountry, having little understanding of why they want to go into avalanche terrain. Yet, for the purpose of this class, they are somehow familiar with it and it draws them into its teeth to the point of acceptance. They are committed to an agenda and there’s always that one know-it-all gaslighting them into a shitty situation. Tracks or no tracks? Follow the herd to safety or be a bright and shining individual in this economy of freedom? And finally, the apparent reason we are all there—to let the other humanoids know that we were; and that we’re badass and totally unique.

I propose to my students that we do away with FACETS altogether.

“This is getting stupid,” I say, “Let’s talk for real. Let’s shoot the shit for a while.”

I ask them why they are there. Why is a group of grown adults (most of whom cannot link turns) at a three-day course in southcentral Alaska so that they can gain the conclusive wisdom of entering deadly terrain? The vast majority have a prepared answer, like a quote from a Jeremy Jones book written over and over until memorized. It says something about wanting to be safe and not being a liability to others.

“So, why not just, you know, like, not go into avalanche terrain then?” I ask.

This seems to stump many of the students. One guy raises his hand.

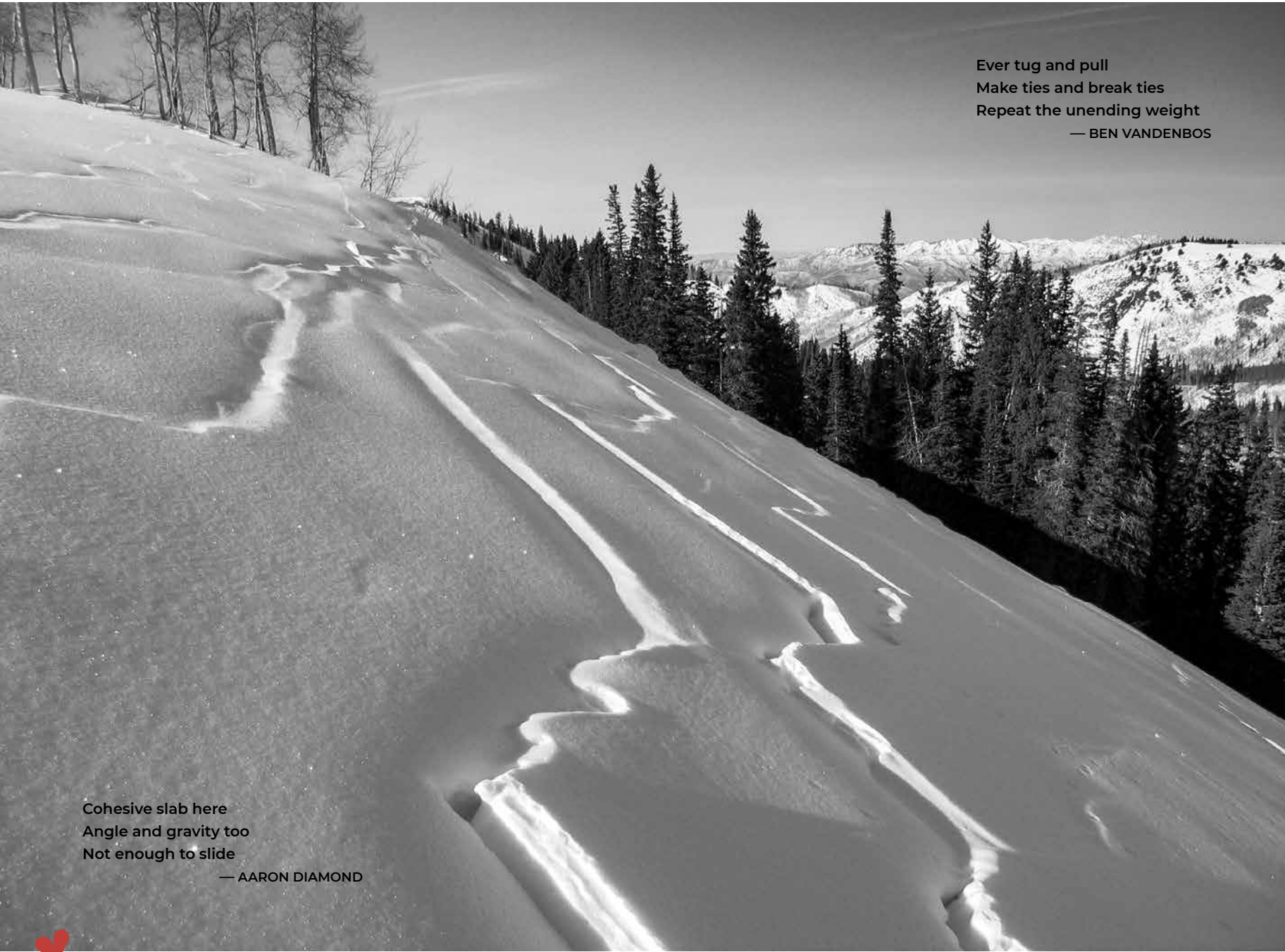
“Because my partner is an avid backcountry skier and I’d just like to have the opportunity to do it with him.”

On day three of the course, this gentleman will politely drop out and go home. He will say: “I’ve decided that this scares the hell out of me. But thanks for at least showing me what terrain to avoid.”

But for now, on day two, this man and the rest of the students are listening to me talk about the human factor, the one variable that makes avalanches a concern.

I am the worst possible instructor to teach this particular class. I tend to side with Nature

BY PAT GAULT



Ever tug and pull
Make ties and break ties
Repeat the unending weight
— BEN VANDENBOS

Cohesive slab here
Angle and gravity too
Not enough to slide
— AARON DIAMOND



📷 PETER THURSTON.

▼ AAS Level One students learn snowpack assessment in the highly variable, unforecasted, and easily accessible Chugach Front Range. 📷 PAT GAULT

▼ Croy Canyon near Hailey, Idaho: widespread and touchy conditions in a March avalanche cycle. 📷 BEN VANDENBOS





▲ January 19, 2023, Telluride Helitrax performed aerial explosives deployment after a significant storm hit the San Juan Mountains. This avalanche in the East St. Louis added to debris burying the road to Ophir. 📍 MATT STEEN

▼ Gobblers Knob into Butler Basin, Utah. Elevation: 10,200' Aspect: NE Slope Angle: 39° HS-N-R4-D4-O. Bruce Tremper said he's never seen it run that big in his 30-year career. 📍 TRENT MEISENHEIMER



▲ A natural D2.5 persistent slab on Ruby Peak near Crested Butte failed during a storm in mid-January. 📍 ERIC PHILLIPS



▲ The January 12th 6 to 16' crown on Gobbler's Knob was visible from miles away. 📍 MIKE FINGER

Crowns





Powder Clouds

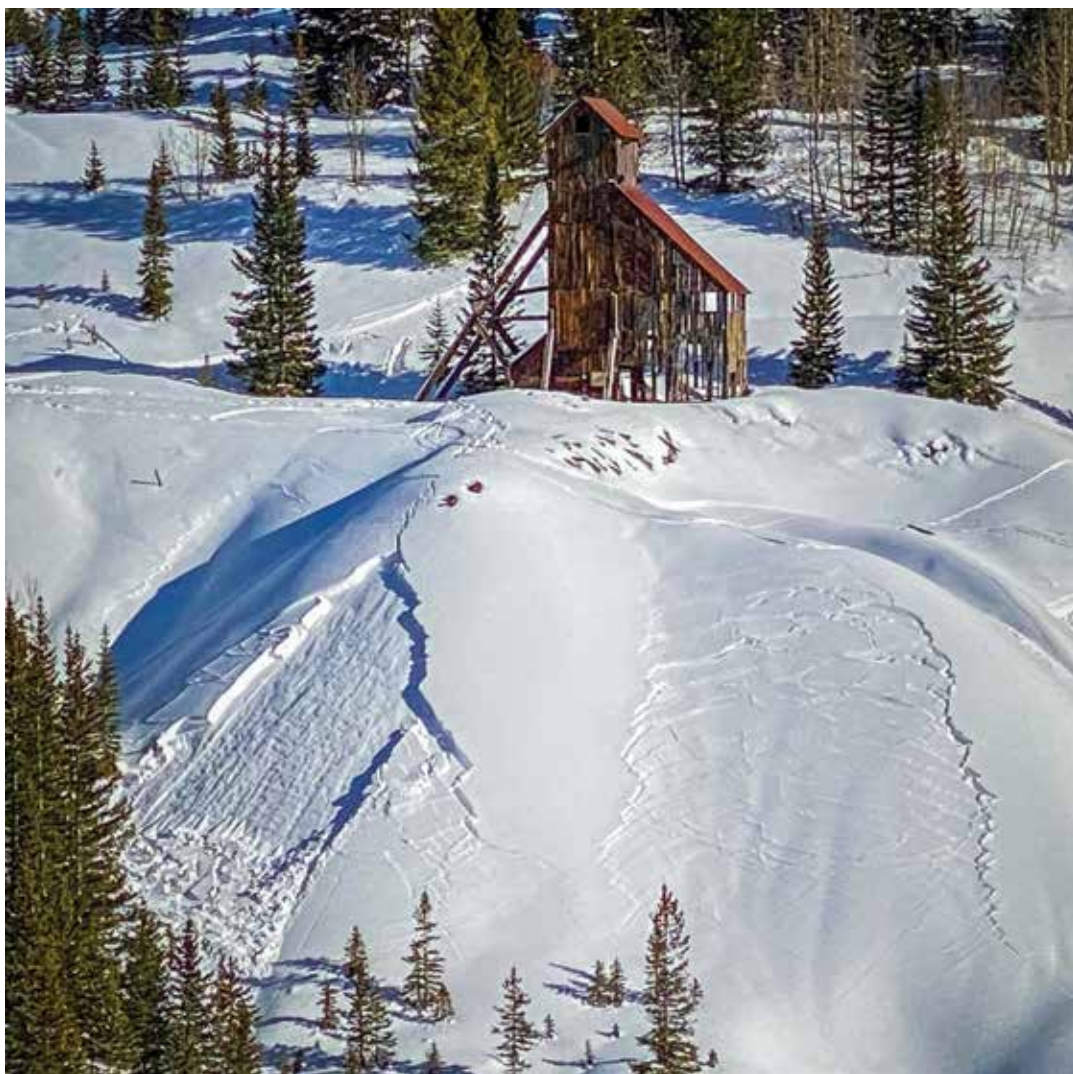
Photo Contest Images We Love 

▲ At the head of the Telluride valley sits a beautiful amphitheater with avalanche paths that loom over 1000' cliffs. Telluride Helitrax performs aerial explosives deployments, sending clouds over the faces.

▣ MATT STEEN

◀ San Juans 2020. Storm slab over facets. The left path is steeper and a touch more NW. It had a more well preserved basal weak layer with a lower sun angle early season. The right path is due west and less steep. ▣ JAYSON SIMONS-JONES

▼ We intentionally triggered two avalanches on the Lacuna Glacier in the Alaska Range after an overnight storm dropped 30cm of new snow. We were still surprised when we remotely triggered the bigger one on the left. ▣ AARON DIAMOND



Turning punny

The Importance of Failure in the Mountains

STORY & PHOTOS BY JOE STOCK

Last spring a buddy and I rappelled into a chute in the Chugach Mountains. We tossed our skinny ropes from the second rap station. They tangled and caught in the rocks. We pulled, but they wouldn't budge. The sheath of one tore on a sharp edge. We cut the remaining rope free and climbed back to the ridge. I hoped nobody would find our abandoned rope and learn about the debacle.

Mountain objectives can be elusive. The size of the objective doesn't matter; it could be a 3,000-foot wall of rock and ice or a low-angle powder ski run. If the objective challenges the mountain traveler, there is potential for not achieving the objective. In some cases the mountain or weather could simply defeat us. Other times we use poor judgment and make seemingly dumb decisions. In the best case, this means turning around. In the worst case a fatality. Regardless, the objective wasn't achieved and the trip can be considered a failure.

The dictionary defines failure as lack of success. The word failure packs a negative punch: failure is perceived as bad. To avoid the stigma, other terms

are commonly used in the mountain idiom: to bail, turn around, retreat, to be defeated and to make an attempt.

Mountain failures can be attributed to either external or internal factors or a combination of both. External factors are from the environment, such as avalanche, rockfall or weather. Internal factors are from our own limitations such as fear, or lack of experience or strength.

While failure is initially frustrating to mountain travelers, with experience they learn to accept it as an integral and important part of being in the mountains.

WHY IS FAILURE DIFFICULT?

Humans are hard-wired to succeed. Plus, social norms reward success and punish failure. We crave that pat on the back and the sense of completion that comes from success. The problem with striving for success in the mountains is that it's often all-or-nothing. Return from an expedition and people ask, "Did you get to the summit?" Reach the summit and you've succeeded, don't reach the summit and you've failed—and failure doesn't feel good.

Another difficulty with failure is that it takes self-control—to resist the powder slope that you're 99.9 percent sure is stable, to back off the frozen waterfall when the bowl above moves into direct sun. The Stanford Marshmallow Experiment highlighted the importance of self-control. Scientists placed kids in a room with a marshmallow. If they didn't eat the marshmallow within 15 minutes they could have two marshmallows. In

TOP: Chugach National Forest Avalanche Center Forecaster John Sykes on O'Malley. MIDDLE: The King of Stoke Roger Strong on O'Malley.

BOTTOM: Jeff Conaway and Eric Parsons turning around on a 30-degree slope in the Talkeetna Mountains because they got a bad feeling.

a follow-up study years later, kids who waited 15 minutes had better life outcomes. This is called delayed gratification: exchanging a small reward now for a bigger reward later. In the mountains, the big reward is a long life. Most long-time mountain travelers have learned that the real objective is to come back alive, with all their fingers and toes.

Turning around is not easy. Most agree that turning around is more difficult than continuing. Some say it's the hardest act in the mountains. Extreme skier Andreas Fransson said he was most proud of the runs he didn't take because backing off is harder than dropping in.

WHY FAILURE IS IMPORTANT

At the most fundamental level, turning around is how we avoid accidents. Failure is also how we learn, find adventure, and gain trust.

Success feels good, but it teaches us little. Alpinist Marc Twight calls it "the tyranny of success." When you succeed at something challenging, it is difficult to know why you succeeded. Was it luck or are you just really good? Steve House writes, in *Beyond the Mountain*, "Success, when achieved, is deceptive—for there lies praise, closure, and achievement. Failure is the more valuable fruit, borne as it is from the knurled vine of process."

It is through failure, and its inevitable analysis, that we learn the most and get better at our craft. Twight calls failure "The Schoolroom." As an Anchorage professor reminded me, "You can be told an important concept ten times, but nothing teaches you faster than screwing it up." For example, the quickest way to learn about avalanches—although not recommended—is to almost get killed by one.

Failure is also fundamental to adventure and the allure of the mountains. Adventure requires an unknown outcome, and the possibility of failure. If you always achieve your mountain objective, then you aren't challenging yourself. It is okay to simply enjoy the mountains while working toward objectives within your ability, but true adventure and challenge come with a high chance of failure.

Great successes ride on the back of failures. Adrian Nature's 1998 solo ski descent of Denali's Wickersham Wall—perhaps the most significant ski descent in US history—took several years of attempts. The household oil WD-40 was developed on the 40th try. Thomas Edison's light bulb on the 10,000th try. Likewise, having an article rejected or severely criticized during the review process leads to a better published article, if the author is persistent and willing to learn from mistakes.





TOP: The King of Stoke Roger Strong on O'Malley.

RIGHT: Third Edge owner and guide Brad Cosgrove



A final reason we need to be able to accept failure in the mountains is to build trust. You learn to trust yourself, knowing that “If it gets bad, I can turn around.” Also, your history of turning around lets friends and family rest easy knowing you will turn back if it gets bad.

HOW TO TURN AROUND

Fundamental to turning around is discussing options with your group while trip planning. “Let’s give the North Chute a try. If that doesn’t work we’ll ski the trees.” Without options you’ll blunder single-mindedly into true failure—an accident.

For mountain travelers, the desire to achieve single-minded goals can kill us. If turning around is so difficult, why not include it as one of the trip options? Look for reasons to turn around. If you can’t find any, continue on. But listen to your gut instinct if things feel weird. Correct the error

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before it becomes an accident. Have lower expectations, then be surprised by a success. As the Kiwis say as they leave the hut for a wall of rock and ice in the Southern Alps, “Just going for a look.”

A third tactic to make turning around easier is to focus on the experience rather than the end point. Practice mindfulness: look around and try to live in the moment. Have objectives, strive for objectives, and yet commit to the process. By engaging in the process you’ll enjoy the trip more and your heightened awareness of the present will increase your safety.

Be proud of turning around. Get comfortable saying, “The mountain will be there next time.” It shows you are humble but have confidence in your skills. If you turn around, you will instinctively analyze what happened. Debriefing with yourself and your partners is a necessary part of the learning process.

I wondered what happened that day when I cut the rope and turned around in the Chugach Mountains. I have been rappelling for 30 years. It seems like it shouldn’t be an issue. But after a week of thinking, I narrowed my problem down to several mistakes, principles I’d learned in the past and needed to relearn. The first was that skinny ropes cut easily—use them with care around sharp rock. Second, tossing rap ropes often doesn’t work in the alpine—carry them down as saddlebags. Third, apply the steep skiers’ rule of climbing the line before skiing it. A week later, I returned and completed the project. I learned more from that descent than from any other. ●



JOE STOCK is an Anchorage-based IFMGA Mountain Guide with passion for working, dry rock, and his wife Cathy.



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Lessons from a

Near Misses

BY JENNA MALONE
WITH CONTRIBUTIONS FROM MIKE MORRIS

“Nearly every day, an avalanche professional or very experienced backcountry skier has had a close call,” noted Utah Avalanche Center forecaster Drew Hardesty, in his essay, “A Reckoning,” describing avalanche activity in the Central Wasatch between March 9 and 15, 2022. “The count is seven. (And these are the ones that have been reported to us.)”

Our close call, free lesson, near miss, lapse in judgment (or harsher term if you choose) took place on March 14, 2022, two days after a good friend was brought to the surface of the snow after being buried head-down for twenty-three minutes, still breathing and as close to death as any of us is ever likely to be and tell about it.

The Wasatch winter of 2021–2022 was notable for a six-week drought from early January through late February; both months produced less than 25% of the average monthly snowfall, creating the driest February on record. This followed a slightly better-than-average December, with 109” of snowfall.

The Utah Avalanche Center’s Greg Gagne wrote a “Week in Review” of the snowpack, summarizing storms, hazard ratings, and reported avalanches. **This was a sea of green (avalanche roses) for weeks.**

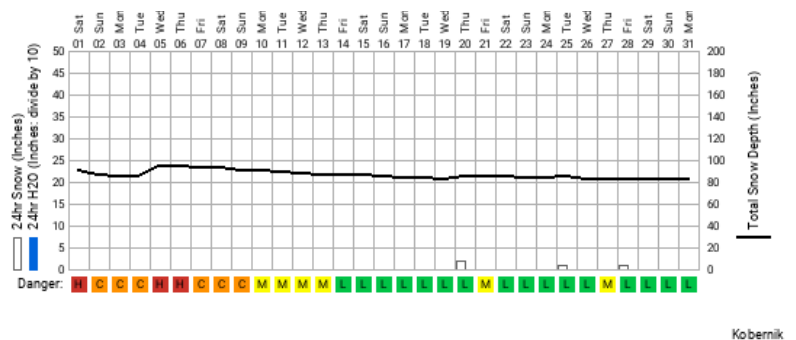
This period of high pressure resulted in faceting of the upper snowpack on the northern half of the compass at all elevations. The first storm to break the sustained high pressure on February 17 resulted in only four to eight inches of low-density snow, and, while the structure was poor, little to no slab developed over the weak layer. The last week of February produced

multiple small storms with moderate winds, and multiple soft slab avalanches were reported failing in the drought facet layer, 1 to 2’ deep. What was strange during those first few storms is that we weren’t hunting for a weak layer—it was easily found—we were hunting for a slab.

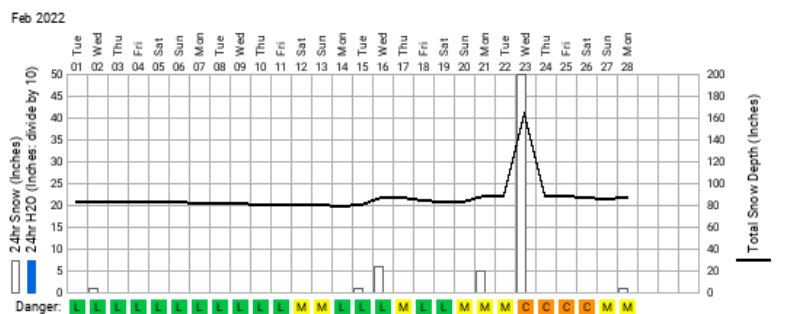
March 4 through March 10 was described by UAC forecaster Greg Gagne as “the stormiest week since December!” and produced 49” of snowfall with 2.6” snow water equivalent.

Between February 19 and March 9, twenty-four human triggered avalanches were reported in the Central Wasatch. More than half of these were outside the Cottonwood Canyons, in colder, mid-elevation areas with classically shallower snowpack, including Mill Creek, Porter Fork, Mt Aire, Summit Park, and Neff’s Canyon. High spatial variability was described throughout the range, with the combination of poor structure and sufficient slab suspected to be primarily in mid-elevation, shady terrain.

Storm totals for the week of March 10 were 24–48” containing up to 2.6” snow water equivalent (SWE) in Little Cottonwood Canyon, 14”–44” and 2.75” SWE in Big Cottonwood Canyon.



Kobernik



HS spike 2/23/22 is an error

Kobernik

On the morning of March 11, our guiding operation conducted explosives testing in an area near the southern boundary of our permit. This zone had a shallower snowpack, and we were able to trigger D1 to D2 avalanches. Hazard assessment was Level 3, or Considerable, in the high and mid-elevation, and Level 2, or Moderate, in low-elevation terrain. Avalanche problems were Persistent Slab (February 17), Wind Slab, Storm Slab, Dry Loose, and Wet Loose. Our strategic mindset was Stepping Out.

That same Friday, March 11, a long time backcountry skier reported a close call in Ivory Slabs, an east-facing slope at 10,300'. The skier-triggered avalanche was 2-4' deep, failing on the drought facets, and caught one skier who was able to ski off the slab to safety.

On the morning of March 12, our first sunny Saturday with finally a significant slab on top of the drought layer, the UAC's Drew Hardesty wrote,

"I know you're hungry. So am I. January and February were among the driest on record and now the powder is excellent. But here's the thing: the powder will also kill you in steep terrain. Trust me. Very experienced people have been surprised in recent days."

Later that morning, a guided ski tourer triggered an avalanche in Silver Fork and was able to ski off the slab to safety, but the guide, standing uphill from her in some trees, was caught, carried, and buried over a meter deep with his head down in a very steep walled terrain trap gully. His fellow guide organized and directed the group rescue, and she was able to clear his airway twenty three minutes later. Staff from our operation responded to the initial call for help and assisted in first aid and packaging of the patient. Fortunately, the burial victim quickly regained consciousness en route to the hospital, to the great relief of his partners and to the mountain community at large.

That same day, another backcountry skier with decades of experience was skiing solo and caught in lower Silver Fork, carried, and was luckily pushed against a tree and only partially buried.

March 13 was a no-fly day for our operation due to winds and light precipitation. No avalanches were reported to the UAC that day, but given the activity of the week, it seemed that very few skiers ventured into avalanche terrain. Our operation's Strategic Mindset was Stepping Out for two days prior; on this morning, having skied in much of our core terrain for two days, we changed our mindset to Status Quo.

I bolded what I view as contributory factors below...

Monday morning, March 14, was a **clear, beautiful morning**. Warming temperatures were forecast for the day. **Good news** was shared that **our friend, the guide who had been critically buried, was expected to make a full recovery**, and there was a sense of great relief in the room. Our operation's hazard assessment was the same as days prior, the avalanche problems were unchanged. We had received 12" of new snow with an inch of water in Big Cottonwood Canyon, but only 4" to 6" of snow and half an inch of water in Little Cottonwood. Northwest winds were moderate overnight. Forecaster objectives included assessment of *"new wind and temp slab development around tenure. Assess propagation potential of Feb 17th PWL."*

Few changes were made to the run list for our core terrain during the guide meeting. Mike asked the group to 'green' Barietto and Catcher's Mitt. **"I want to be able to give my client some lines in Mineral. I want Barietto."** And so the guide team agreed to 'green' Barietto. After the guide meeting, Mike and I planned our day. He told me that I should give him a heads up if I felt we were going into anything that made me uncomfortable. Mike said, *"I trust your judgment. We're a team, in this together, to do it another day."*

Our client had hired the helicopter for the day and was excited to ski. **He was just back from an Alaska heli ski trip that had fallen short of his expectations** due to a widespread surface hoar layer in the Chugach. "We couldn't ski anything. We saw tons of avalanches." This client is a very competent skier capable of ten plus runs in any terrain we ski in the backcountry. He had flown and skied with both of us previously and had requested Mike as his guide that day.

We started the day in Cardiff Fork of Big Cottonwood, a drainage our coworkers had skied two and three days prior. We were progressively moving through our open terrain. On our fifth run we moved into the Mineral Fork of Big Cottonwood, again surprised at the lack of ski tourers. No one was out. From the front seat, Mike swept the terrain and saw no skiers. We skied Moonlight, an E facing run that is less steep overall than Barietto, with a slope broken by benched terrain and trees. While skiing Moonlight, we probed the snowpack in multiple spots. We knew the drought layer should be present, but it was difficult to isolate it in hand pits or on probing. After skiing five runs in some of our best terrain, we had seen no signs of instability and with excellent skiing conditions. *"Our confidence was up. There is no way to get around that,"* Mike reflected later.



MARK WHITE

On our next lift, we were on top of Barietto, an east-facing planar slope in Mineral Fork of Big Cottonwood Canyon, starting at 9950' with runout to 8350'. The start zone is 37 degrees on a rocky slab; this pitch is sustained for most of the run. **Barietto is one of my favorite Wasatch ski runs:** sustained fall lines holding deep, cold snow. I remember thinking this is by far the best ski day I've had all year, and probably the best I'm going to get. Great pow, a strong client who is skiing solo and wants to get after it, our own ship... this day keeps getting better. When Mike asked me, *"Should we go to Barietto?"* I didn't hesitate for a second. I was all in. It was only once we looked at the start zone and a small voice on my shoulder said, "That's loaded," that I gave it a brief second thought. We talked about a ski cut.

Mike, *"We approached the run with caution, our guide senses were up. Everyone was armed and had eyes on. I made one move off the ridge. Throwing all my weight into the fall line and then immediately throwing skis across the fall line, the slab broke about 8 to 10 feet above me and was a soft slab 16" deep."*

I immediately saw the snow shift into blocks above as the slope fractured. "Dig in!" I yelled. Mike had already been holding his ground, angling edges hard into the slope and pushing weight on his ski poles dug into the bed surface. His skis didn't move.

The slab flowed over the rock step below Mike and stepped down 2+' deep, running full track (1600') and connecting into pieces of adjacent ski runs. While this avalanche was triggered



From Left to Right: Start zone of Barietto. Red X is where the lead ski guide placed a ski cut.

Avalanche debris in the valley bottom.

Avalanche debris looking up Mineral Fork. Note debris traveled up the opposite side of the valley.

■ JENNA MALONE

intentionally on a ski cut by the lead guide, it propagated wider and ran further than anticipated, with a crown fracture line approximately 2' deep and 600' wide. It ran 1600' to the creek and 20' up the far side of the drainage.

Once I knew that Mike wasn't going anywhere and we were all safe, I thought, 'I should be filming this, I should get my phone out,' but I couldn't. I couldn't do anything but watch this monster roar away from us. *"The dust cloud was enormous. Someone on top of the Ivory Flakes run in Cardiff shot a video that is haunting,"* Mike reflected.

Once the dust had settled, we collected ourselves and snapped some photos, then skied the bed surface to the bottom. I radioed the other guides and reported the avalanche. The helicopter returned for us, and we sheepishly loaded up and retreated to ski a few runs in Days Fork, after performing a thorough fly over of the entire Mineral Fork drainage. It was an unusually quiet day with very few backcountry skiers, likely due to the many reported avalanche accidents two and three days before. Per protocol, we had swept the terrain below our runs when we flew over from Cardiff, but I was profoundly relieved when we again confirmed there were no tracks between the head of Mineral Fork and Big Cottonwood Canyon Road. Mike described the video as haunting; while no one was in the runout or even the drainage that day, for some time, the size of the avalanche haunted me with what-ifs.

We were lured into skiing this slope for a myriad of reasons. Several decision-making traps were present, and at least a small variation in our operational protocol likely played a role as well.

We were both **familiar** with this terrain, and just weeks before, our operation had completed a longer run of consecutive fly days than in any season in its history. Obviously, conditions had changed, but having skied that run many times in better structure or lower hazard led us to trust it more than we should have, an example of **anchoring bias**.

We had a strong client who was skiing well, and as a small group, we felt **nimble** moving through more advanced terrain.

As an operation, we'd had a down day and hadn't skied the day before due to new snowfall and winds. On the bluebird morning of our near miss, there was a sense of gratitude in our professional circle after hearing that our buried friend was going to be okay, a feeling that the snow drought was over, and a hope that the snowpack would now begin to heal.

In terms of stability, we'd received far less snow and SWE than the March 9 storm, and after many days of human triggered avalanches and catch-and-carries, no avalanches were

reported on March 13. It's hard to know if this was due to less traffic or more stability.

We were skiing high elevation runs with start zones in the alpine, and, prior to the first week of March, most drought layer avalanches were reported in mid-elevation terrain. Again, the Ivory Slabs avalanche on March 11, E facing at 10,300' with a steep, rocky start zone, should have raised more alarms for us. Barietto's entrance is on a steep and rocky slab. A **blind spot bias** is one in which we receive data that argues against our current plan, but we ignore it, or twist it to fit our previously held beliefs.

As someone who tours more days than I fly, I've recognized that the helicopter gives me a sense of power. By being dropped at the ridgeline and not having to skin up a slope, I've **decreased my exposure** by hours, and I wonder if on this day it warped my risk tolerance and made me temporarily feel more confident in this terrain.

Mike and I each placed an **expert halo** on the other person, and on ourselves. He is a full-time lead guide with twenty-five years of experience at our operation, and I've worked there as a tail guide for fifteen years. Mike previously worked as a supervisor for Snowbird Ski Patrol, and we both work for Alta Ski Patrol in avalanche hazard mitigation. I'm a professional avalanche course instructor, which may have caused Mike to subconsciously think I would be the brake if I saw us **stepping out** into too-aggressive terrain. I had an equal voice in our decision-making, but I didn't use it. My avalanche avoidance voice was being drowned out by my "this is amazing powder skiing/ oinking powder pig" voice. **Scarcity** of good powder skiing up to that week in our season influenced us.

We likely gave ourselves undue credit for having successfully navigated the high hazard for several days, and for five runs that day. Skiing avalanche terrain is often described as a wicked learning environment, in that the lessons can be deadly, or they don't exist at all. Carl Sagan, astrophysicist, said, "An absence of evidence is not evidence of its absence." Persistent slab is notorious for this, as signs of instability with this avalanche problem are infrequent, and our stability tests are less reliable. Persistent slab is the avalanche problem in 70% of the avalanche fatalities in Utah since 1940 (Hardesty, *Expert Intuition*); in a study of Colorado fatalities over a fifteen-year period, persistent slab was the problem in 90% (Logan, Greene, *The Distribution of Fatalities by Avalanche Problem*). I suspect this percentage is quite high in accidents that involve snow industry professionals. **We made the common error of misinterpreting the lack of feedback on our runs in Cardiff and Moonlight**

as positive feedback, as it supported our narrative that we were smart, capable guides, making good decisions in a challenging snowpack.

So there's our story: how are we going to make sense of it, take some insight into the future and benefit from our "free lesson?" Here are a few potential tools:

Annie Duke coaches organizations on making better decisions when faced with uncertainty; she recommends finding a way to **operationalize skepticism**.

Gordon Graham, an expert on risk management in law enforcement and fire fighting, describes high risk, low frequency events (a fair description of persistent slab avalanches), and advises, "**SLOWWW down**."

Kevin O'Rourke, VP of Operations for a helicopter ski operation and a helicopter ski guide for more than 30 years, talks about the term "rolling," when the euphoria of the day and the quality of the skiing can get guides in trouble. "I first heard the term when I was a newer guide from some colleagues working in Canada. The idea is that we make these decisions about a run list, about opening and closing terrain, in a nonemotional, detached setting, without client pressure, or the pressure we can put on ourselves or each other, to find and open the best terrain." Don Sharaf, former owner of American Avalanche Institute and longtime Alaska helicopter ski guide, has said, "Make your deals early," referring to the importance of terrain selection in morning guide meetings, long before any of us are in the field. The powder pig may be quietly oinking in the background at the morning guide meeting, but she only gets louder in the field.

When Persistent Slab is the avalanche problem and we want to open terrain, or change our run list, our protocol is to get unanimous consent from all at the table in our morning meeting. **Perhaps we should slow the process down even further to encourage conversation, skepticism even, and due diligence?**

I'm trying to train myself to tune in to even momentary hesitation and speak it out loud (especially if I'm having an outrageously good ski day).

While several of our friends and colleagues had been caught in avalanches the days prior, in this situation we practiced what has been described as "**othering**" in avalanche accident review. Annie Duke, in "Thinking in Bets," describes how we lose learning opportunities when we dismiss others' poor outcomes as bad calls but give ourselves full credit for good results at least

partially influenced by good luck. "I never would have been there," a good friend said to me once after my husband triggered an avalanche that, luckily, resulted in injuries, not death, of a mutual friend. Dr. George Lowenstein talks about this empathy gap in his presentation, "Behavioral Economics and Avalanche Decision-Making." I imagined many backcountry skiers saying, "What were they THINKING?" after hearing about our avalanche. "That was a bad call!" yelled a friend into my voicemail. Guides commonly criticize other guides' decisions after an accident or close call. There is an inherent danger in traveling in avalanche terrain that we cannot mitigate to zero, but we want to believe that our own decisions are safer, better than those around us, that we would never make that bad call. I used to say that my goal in teaching Level 1 avalanche classes was to teach my students not to miss obvious clues, and not to end up in the news with the headline, "What were they thinking?" I now know what it's like to be the subject of such a news story. I'll never review someone else's bad call the same way. I'm not giving poor decisions a pass, but there are better and worse ways to criticize others' mistakes.

- The goal here is to foster a culture that reviews decisions and learns from accidents and near misses, even if sharing our close calls exposes us to criticism. Researcher and author Brene Brown advises that a growth mindset means choosing courage over comfort.

Traveling safely through avalanche terrain requires **both skill and luck**. As humans, we credit ourselves with skill when we get it right and blame bad luck when things go wrong.

- If we spend a lifetime in the mountains, at some point, we will make a mistake. Plan for it. Ensure that the mistake doesn't lead to disaster. Learn from it. Tell others about it. Don't make the same mistake again.
- Best practices, Best systems in our daily work as professionals, applied consistently over a career, can protect us against the worst outcomes.

There are systems as professionals from which we shouldn't deviate:

- the detailed morning meeting
- our checklists
- sweeping the run out for skiers
- holding on the ridge while we talk about where to ski, and where to regroup
- opening every run with a ski cut
- skiing avalanche terrain one at a time

I've worked part time for this operation for fifteen years and continue to watch and learn from the career professionals: **the systems can be life-saving**. Mike's aggressive and well-placed ski cut was an example of best practice in opening any run, and it helped us to be very lucky that day. It has been said, however, that ski cutting a PWL could be the right tool for the wrong problem. While this avalanche broke above Mike, it was a soft slab, and he was able to hold his ground. But we were surprised, and ultimately humbled. We had a best possible outcome in this case, but Duke instructs us to dissect our decision-making, not our outcome. When I reflect on this day, with the benefit of hindsight, I think that we shouldn't have opened new terrain with a strategic mindset of Status Quo, and an avalanche problem of Persistent Slab. I am also grateful for the placement of a ski cut that in this case spared us, despite a terrain decision that we both agree, in hindsight, was the wrong one. ●



JENNA MALONE works as a part time ski patroller at Alta, as an instructor for the American Avalanche Institute, and as a tailguide for a heli-ski operation. She is also a PA in Neurosurgery, Trauma, and Critical Care at Intermountain Medical Center. She has spent multiple seasons on Denali as a medical provider for Denali Rescue Volunteers.

22.23 Winter Public Pro Schedule

Bozeman, MT
Pro 1 Jan 8-13
Pro 1 Jan. 23-28
Pro 1 Feb 12-17

Jackson, WY
Pro 1 Dec 18-23
Pro 1 Jan 18-23
Pro 1 Feb 6-11
Pro 2 Jan 9-15
Pro 2 Feb 22-28

Salt Lake City, UT
Pro 1 Dec 11-16
Pro 1 Jan 9-14
Pro 1 Feb 20-25
Pro 2 Jan 30-Feb 5
ProAvSAR Jan 17-21

Estes Park, CO
(alpine guide specific)
Pro 1 March 5-10

Seven Utes Yurt, CO
(meals and lodging included)
Pro 1 Feb 21-26

MT. Baker, WA
Pro 1 Dec 9-14
Pro 2 Dec 16-22

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Editor's Note: Back in November, Jason Albert of Wild Snow interviewed Doug Chabot about forces at work in 30° terrain:

<https://www.wildsnow.com/33060/ron-perla-and-the-30-degree-threshold/>.

Doug referred to Ron Perla's snow research in the interview and I commented, after sharing the story with Ron, that Perla was pleased to see his work still relevant. Jason then persuaded Ron to answer questions about his life and work, which they were kind enough to share with TAR.

BY JASON ALBERT FOR WILD SNOW

A CONVERSATION WITH

P

E



Ron Perla working on slab above Alta village, 1968. Visiting scientist Charles Bradley, Montana State University, skinned up with me and took this photo.

Jason Albert:

For starters we have several generations of winter backcountry users who have had some formal avalanche education. Setting aside any semblance of humility, what would you want those users to know about you as a snow scientist?

Ron Perla:

Jason, what a great chance to get some things on the record. I have much to say. I'll throw in some history peripheral to your main theme.

My avalanche training was in Utah. In 1961, I joined the part-time, professional Alta ski patrol. In 1963 on ski patrol sweep I out-swam a size 3 down a gully that had been artillery blasted. It was my introduction to the post-control release. October 1966, I moved from Salt Lake City to Alta to work for the USFS, half-time as snow ranger, supervised by Ray Lindquist, and half-time as research assistant to Ed LaChapelle at the USFS Alta Avalanche Study Center. In those years, the USFS closed and opened ski runs, roads, village travel, and even ski-touring.

Training was fast, way too fast. My first task was to take revenge on the gully which nailed me in 1963 by bootpacking its depth hoar. I had a lucky escape on opening day of the 1966/67 season when I test skied but should have blasted. Spring 1967, I barely survived another size 3 over cliffs

when a cornice blasting operation went all wrong. I know what it's like to be tossed around, battered by big snow blocks and buried unconscious under the snow. Later, I participated in the attempted rescue of two young boys who did not survive. I witnessed from artillery positions size 4s which never failed to excite.

Turning to research under LaChapelle: we tested a variety of rescue methods and devices including transceiver prototypes, studied snow and its metamorphism with traditional and innovative tools, skied to numerous start zones accessible via lifts and skins to measure slab properties. We developed a theory of slab stress and failure, studied over 100 storm reports for contributory factors, rebuilt and better equipped our study plot, measured creep angles of snow, and wrote many internal and journal publications.

The Alta Avalanche Study Center was world class. It shared information with snow and avalanche scientists within and outside North America. It hosted visiting scientists and practitioners. It collected accident reports which were turned over to Dale Gallagher and Knox Williams for *The Snowy Torrents*. It held an annual school for foresters, ski patrol, military, and other select applicants. My career, my very being as an avalanche scientist, peaked during those years when I lived and worked surrounded by avalanche paths of Little Cottonwood Canyon.

In 1972, the USFS closed the Alta Avalanche Study Center. I was transferred to Fort Collins to work for Pete Martinelli. We made use of my intense Alta years to design a USFS national avalanche school and write an accompanying *Avalanche Handbook*. To seek information for the handbook, Pete had me travel west-wide USA, to Rogers Pass, and to a meeting in Switzerland. Also, I found time to perform more slab studies at Alta and in Colorado. I eked out a couple of publications on snow slab failure. Working for Pete



Ron Perla at a creep gage ready to be covered with snow on a test slope next to the Alta Avalanche Study Center. The gage was built by U of Utah, Geophysics (Prof. Bob Smith and team.)

and Geof Freer (BC Highways, Victoria) in an avalanche centre to be located in Golden or Revelstoke. It happened anyway, 30 years later.

So, I became a snow scientist under orders not to work on avalanches. With visiting scientists LaChapelle and Jeff Dozier and his students I was able to continue work on dry and wet snow and its metamorphism until my 1991 retirement from the Canadian Government. However, I did manage to sneak in a few avalanche studies and publications. Today, I sit in front of my computer modeling those avalanche vortices which tossed me around like a feather.

R

with colleagues Knox Williams, Art Judson, Dick Sommerfeld, and R.A. Schmidt were productive years.

In 1974, I moved to Alberta to work for the Canadian Glaciology Division, eventually settling in Canmore. My first task was to establish a snow lab next to the warden's study plot in the Sunshine ski area. We also built a weather station at the top of the Great Divide lift. Our main collaborator was warden Keith Everts. Next, we established a snow lab at the top of the Whistler ski area. Chris Stethem ran it and performed studies on slab weak layers. Also, we had a fully equipped snow lab in Canmore for intricate experiments on snow samples transported

down from Sunshine. Our first collaborator was computer programmer Tony Salway who worked on an avalanche forecasting model. We brought Dave McClung over from Norway to jump-start his long career in Canada. Dave continued his lab and theory work on shear strain-softening. We worked together on avalanche dynamic models.

In 1978, the Glaciology Division was absorbed by the National Hydrology Research Institute. Management deleted avalanche research. That marked the end of my hope to join other major players such as Peter Schaerer (NRC, Vancouver)

L

JA: Even trying to narrow down this further, what do you feel are your greatest contributions to the field of snow science and avalanche education?

RP: I'm not sure what will meet the test of time. Maybe some my slab mechanics work conducted in the USA and Canada could. My slab terminology is still used. The wedge density cutter caught on thanks to Kelly Elder's improvement. Perhaps an early avalanche two-parameter model could, due to its simplicity? I developed a particle model of avalanche flow in collaboration with Karstein Lied's team at the Norwegian Geotechnical

A

Institute. It was among the first to simulate entrainment and deposition patterns, and to use Monte Carlo methods.

Some of my snow properties work such as shear strength measurements are occasionally cited. My photomicrographs of metamorphosed snow grains appear in publications. In the dustbin of government publications, one of my personal favorites was measurement of the impact forces of large snow blocks falling from a high tower at our Sunshine lab. The large pressure plate at the base of the tower was moved to a stand just above a Rogers Pass shed. Unfortunately, the axe came down on our avalanche work before we could get meaningful results.

[On education, let's include some publications, schools, and workshops:](#)

The USFS 1968 Modern Avalanche Rescue is today hardly modern, but it did introduce John

Lawton's avalanche transceiver, contrasted with less practical options. The USFS Avalanche Handbook has so far survived as a template for the improved versions prepared by Dave McClung and Peter Schaerer. Those handbooks are our most cited and popular publications.

Besides the USFS avalanche schools, I'm proud Rod Newcomb picked me to participate in his American Avalanche Institute schools. I'm honored Liam Fitzgerald asked me to give a banquet speech at the Snowbird ISSW. That gave me a chance to revisit the life and death struggle of a USFS snow ranger. I devoted two years to organizing a 1976 international workshop in Banff and editing its proceedings; I was the primary motivator and helped organize workshops to honor Monty Atwater, Ed LaChapelle, and Binx Sandahl. I'm grateful to Bruce Jamieson (retired professor, University of Calgary) for many years of scientific exchanges. He invited me to give a series of talks on avalanche dynamics to his graduate class at the University of Calgary. He summarized much of my output on his www.snowavalanchearchive.com.



Our snow lab at Sunshine Ski Area. We moved snow samples from the corralled Warden's snowplot into a cold room on the left side of the lab. Glaciology technician Terry Beck did the lion's share of general contracting to build the lab as well the weather station at the top the Great Divide ski lift
 ■ RON PERLA, JUNE 1978



Terry measures the strength of depth hoar on Delirium Dive, Sunshine ski area. ■ RON PERLA, 1975



Terry sets world record for shear-frame size.
 ■ RON PERLA, 1975

Where did you first get the inclination you would dedicate your life to snow science?

In 1966, as apprentice to Ray Lindquist and Ed LaChapelle. Both were my heroes before then, but the move to Alta was decisive. Be prepared for funding problems if avalanche research is your career.

Can you give us a brief academic background so that others can learn about your course of study?

My academic background was desultory. It started with an undergraduate degree in electrical engineering (worked as an electrical engineer for seven years.) I added on education classes to qualify for teaching in Salt Lake City (taught high school physics for two years.) My PhD (U of Utah) is meteorology, although more than 50% of my classes were applied mechanics, physics, and mathematics.

I'm compelled to add that snow and avalanche studies benefit from a variety of backgrounds and skills. For example, much of the Handbook's popularity is owed to Alexis Kelner (Salt Lake) with his combined talents as illustrator, photographer, mountaineer and ski-tourer. Let's not forget that Monty Atwater's Harvard degree was English Literature. Medics tell us what happens when we are bashed or buried by an avalanche. Lawyers achieve a high degree of snow and avalanche wisdom. They ask the hardest questions. Good luck holding on as an expert witness.

Mostly, I share with other avalanche workers many years in the mountains.

What attitudes and behaviors have you seen change over the years?

I can't give you facts and figures, others can. Here's what I've heard and read. Despite enormous increase in backcountry use, despite increasing behavior to ski and ride lines we could never imagine in the 1960s, avalanche fatalities are not increasing to match those trends. Why? Surely because associations, centers, websites, educators in general are responding to match those trends. Surely because today's risk takers are increasingly more skillful backcountry skiers, riders, and escape artists. Surely, equipment is improving. Surely, guides are more professional (early heli-skiing had a sad number of fatalities.)

But there's something else. Call it collective consciousness in the backcountry. An increasing number of backcountry users correlates with an increasing number of observations and tests. Thus, safety can be enhanced by numbers if there is increasing communication, verbally, visually, and electronically. That appears to be the case.

What has stayed the same?

Nature's eternal randomness. Her power to surprise. ●



Admiral John Nyboer on left visiting Gretchen and RON PERLA at their Canmore home.



JASON ALBERT lives in Bend, Oregon, where he writes about skiing, is the former editor of WildSnow, and aspires to love snow as much his dog Riley does.



Upslope of a highway shed at Rogers Pass. Terry next to our impact plate mounted on a steel stand installed earlier by Peter Schaerer and Paul Anhorn for their pressure measurements using small pressure cells. ■ RON PERLA, 1978



Snow Shapes

◀ Crystal Leaves (Surface Hoar) in Hyalite Canyon, Montana during an AIARE Rescue Course. January 12, 2023. **ZACH ARMSTRONG**

Crowns

▶ This was a SS-AB-R3-D2-I/O that occurred on January 25, 2023 on a SE aspect backcountry slope in the South San Juan Mountains. The avalanche was triggered with a 2.3kg air blast after 1kg protection shots were thrown on slope with no result. The avalanche hazard reduction efforts were performed by the guide staff of a backcountry ski guiding operation. The slope was worked in order to protect the snowcat road in the drainage below. The avalanche initially failed on a crust layer at the new/old interface, then stepped down into large facets near the ground. **TRAVIS LAVERTY**



RISKY Business at the 7/11

BY DREW HARDESTY

I was running late to the office but wanted to pick up some half-and-half for the morning tea. It was 3:45 AM. For almost 25 years I've sipped a liter of Earl Grey tea during the morning forecast shift. We share an office with the National Weather Service in downtown SLC.

I pulled into the 7-11 parking lot. Loud music thumped from a boom-box outside. Two impermanent fixtures leaning up against the ice machine peered out obliquely from behind the folds of their dark hoodies. I was not ready for what waited for me inside: mini-skirts with pumps, sequins and feathers. Makeup and cigarettes. White undershirts, earrings and tattoos. Self-unemployed CEOs of the black market. Adrenaline and ego were not the only drugs on hand. It was loud. Bad energy. Bad players.

One of the patrons filled a disposable tub with warm cheese out of a dispenser and dipped chips into it. As I walked by, he said, "Hey man, what kind of cheese is not yours?"

"Nacho cheese!!" Everybody laughed. And then it got quiet. All eyes on me.

It felt so combustible that, had I lit a match, the whole place would have exploded.

I am a trained risk professional used to dealing with complex situations and suddenly I faced a whole different scenario.

Where was the morning pre-plan? Where were the checklists?

What the hell was I thinking?

Later, as I was sitting in our office, I had time to think about the situation. Was I ever really at risk? Even though #nothingbadhappened, I had to settle for whole milk in my tea and not half-and-half.

.....

CONVERSATION STARTERS:

- Could it have been that I was the trigger for the combustible situation?
- Do our inherent biases pay off for us? When so or when not?
- If we don't learn biases from experience, how do we learn them...and are they applicable and appropriate across many environments?
- How do similar biases and pre-conceptions relate to traveling in avalanche terrain?

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DREW HARDESTY is a long time forecaster with the Utah Avalanche Center and recently retired as a climbing ranger in Grand Teton NP. You can find more of his writing or subscribe to his newsletters at drewhardesty.com. Drew is also the host of the Utah Avalanche Center podcast.

RADIATION & RECRYSTALLIZATION

A Wasatch Avalanche Cycle

BY DAVE KELLY & MARK STAPLES

INTRODUCTION

The winter season of 2022–2023 has been one for the record books so far with above average snow-fall and excellent coverage from the low elevation valley trailheads to the highest peaks.

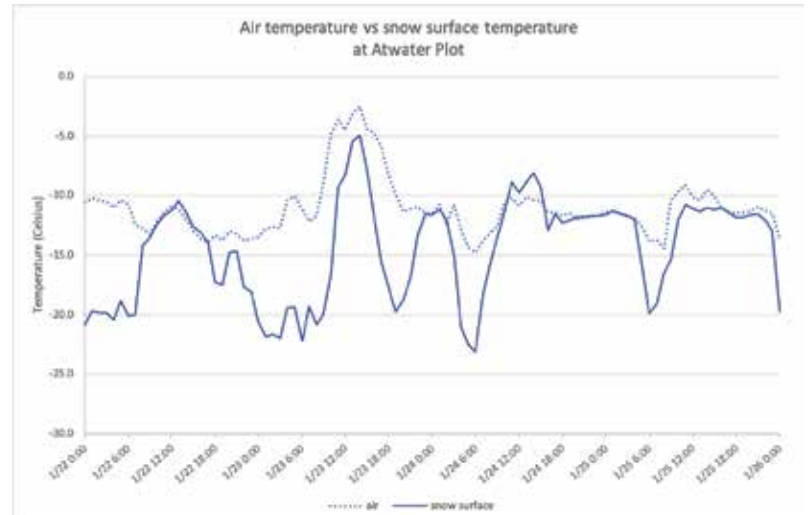
In late January 2023 during a brief period of sunny weather, some locations in the mountains of Central Utah formed a thin melt-freeze crust and small facets on southerly facing aspects over 30 degrees in steepness. This radiation recrystallization layer was buried and preserved by snow a few days later, and then it caused an avalanche cycle starting on January 28 when more snow and wind arrived. After this avalanche cycle, the Utah Avalanche Center looked back at weather data to identify how this layer was formed and preserved, communication challenges, and take-home lessons.

In this article we will discuss the process of radiation recrystallization (RR), the resulting crust/facet layer, how it was preserved, and finally buried. The focus will be on the process from weak layer formation to avalanche activity. For this reason, we refer to the resulting crust/facet combo as the RR layer to emphasize the process, not the crystal shape or form.

Radiation recrystallization (RR) occurs during a unique balance between solar radiation and longwave radiation. Snow just below the surface gains heat and sometimes becomes a melt layer while the surface snow loses heat by longwave radiation losses to clear, cold skies. This process can create a large temperature gradient, thus a large vapor pressure gradient which drives rapid faceting (Birkeland, 1998). RR layers can form often in Utah but are rarely preserved long enough to create an avalanche cycle. The faceted crystals are usually destroyed by high winds during pre-frontal passages, strong solar and heating, or other weather before being buried by subsequent snowfall.

FORMATION

To identify when this RR layer formed, we estimated near-surface temperature gradients using snow surface temperature measured at the Atwater Snow Study Plot located in Little



Air and snow surface temperature at Atwater Plot shows up to 10°C differences generally due to cooling from heat losses to the longwave radiation exchange with a clear sky. Notice how air temperatures and snow surface temperatures were much closer during a period of precipitation and cloudy skies near the end of this time period when the RR layer was buried and preserved.

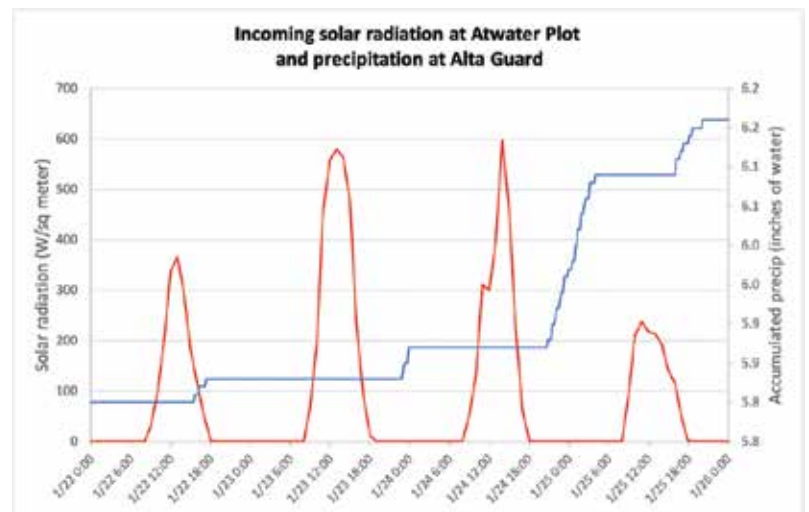
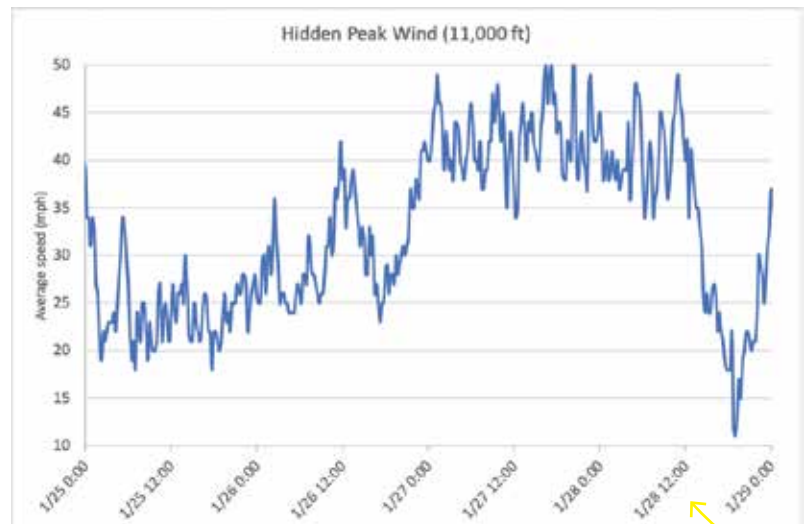


Chart of solar radiation and accumulated precipitation shows these periods of likely RR development and when it was preserved.



Hidden Peak winds showing marked increase in speed from the north-northwest on January 27, 2023.



This slide in the Provo Area Mountains was intentionally triggered by the last skier on the slope. The avalanche was on a southeast-facing slope at 10,000' and the weak layer was a layer of radiation recrystallization facets above a crust. ■ LOGAN COOKLER

Cottonwood Canyon, Alta, UT at 8,752'. The point of these calculations was only to estimate what the temperature gradients might have been. Actual measurements are very difficult to obtain.

Because there was a melt-freeze crust present, the near-surface snow temperature warmed to 0 °C during peak solar radiation, then melted snow crystals. To calculate possible temperature gradients, we made two assumptions. First, for depth of the melt layer, we assumed 2–3 cm based on observations during this period when the layer of facets above the crust was about a centimeter or two thick. Then, for snow surface temperature, we assumed that surface temperatures from the Atwater Plot were similar to ones in starting zones where avalanche activity occurred. Notice differences between

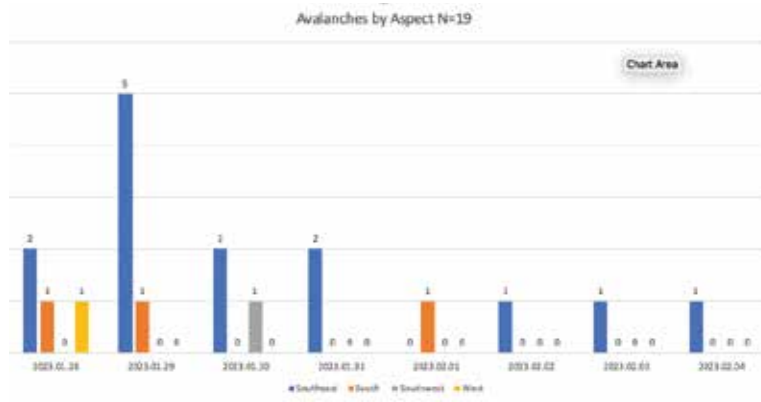
air temperature and snow surface temperature up to 10° C in the Air Temperature and Snow Surface Temperature graph. With these values, we estimated peak temperature gradients of 300–400 degrees Celsius per meter on January 22, 23, & 24. Combined with observations of snowfall and measured solar radiation (see included graph), these estimates helped us identify times when this RR layer likely formed.

Because cold clear skies are necessary for longwave radiation losses, we can identify those times during peak periods of solar radiation. Those dates were January 23 and 24. Cloudy skies on January 25 prevented both the solar heat gain from solar radiation and the longwave cooling that is required for the RR process. There may have also been a period of strong temperature

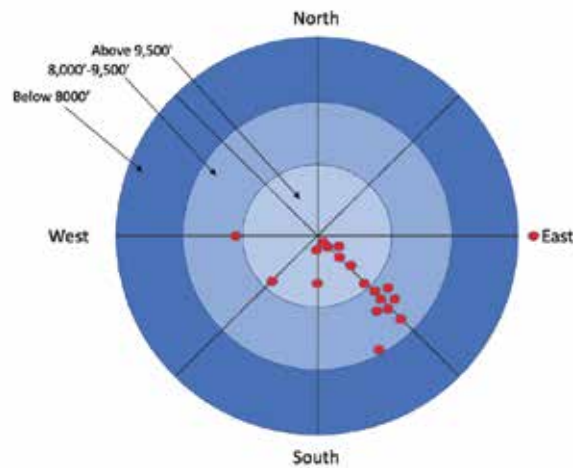
gradients on January 26 not shown in the chart above. There had also been some near surface faceting on earlier dates that may have been a blend of diurnal and radiation recrystallization.

PRESERVATION

The most important step in this process was the preservation of this RR layer by a storm with generally light winds that delivered 9.5" of snow containing .24" of water in upper Little Cottonwood Canyon and 3" of snow containing .10" of water in Big Cottonwood Canyon on January 25. The low-density snow that preserved this RR layer was subsequently covered by 18.5" of snow and 1.25" of water accompanied by increased west and northwest winds from January 26–28 ([Hidden Peak Wind graph](#)).



Avalanches on RR by aspect in the Salt Lake, Ogden, and Provo forecast regions N=19.



Avalanche heat map showing location and elevation of avalanches in the Salt Lake, Ogden, and Provo forecast regions from January 28–February 4, 2023.

AVALANCHE CYCLE

The development and subsequent burial of this layer led to one of the more extensive avalanche cycles on a RR layer in recent memory in the Salt Lake, Ogden, and Provo forecast regions. There were 19 reported avalanches on this layer from January 29–February 4, 2023 (*Avalanches by Aspect*). There were avalanches that could be traced to the similar weather conditions in the Logan and Uinta area mountains; however, the Manti-Skyline region did not appear to have this layer and did not have an avalanche cycle on southerly slopes.

These avalanches were primarily on southerly facing slopes with most (N=14) failing on southeast facing slopes at elevations ranging from 6,800' to 11,000' (*Avalanche Heat Map*).

The Utah Avalanche Center started to get reports of avalanches on this RR layer on January 28. The first slide that got our attention was in upper Little Cottonwood Canyon on a west facing slope at 9,900'. It was 2' deep and 300' wide and occurred in an area where many people go during periods of higher danger because this slope does not produce avalanches very often. Later that day there were reports of skier-triggered avalanches on southeast facing slopes in Big Cottonwood Canyon from 8,200' through 9,900'.

Another notable human-triggered avalanche occurred January 29 on Mt. Wolverine in upper Little Cottonwood Canyon. This slope is southeast facing at 10,400'. The avalanche was triggered by the third skier and broke 2.5'

NOTES ON THIS AVALANCHE CYCLE:

- The whole process from weak layer formation to avalanche activity can happen in just a few days or a matter of hours
- Preservation of the weak layer is key
- January in Utah seems like the ideal time for meteorological conditions to drive this RR process
- More research will need to be done to determine when faceted layers on solar aspects lead to avalanche involvements in Utah

deep and 450' wide. This was a close call and luckily this crew followed proper protocols by exposing only one skier to the slope at time, searched the debris, and reported this avalanche to the Alta Ski Patrol.

FORECASTER RESPONSE

While RR layers often form and sometimes get buried and preserved on southerly facing slopes, there are usually fewer human/avalanche interactions because most people ride northerly facing slopes that typically have better powder. During this time period, a series of storms kept the riding good on the solar aspects, so the human/avalanche interactions were greater than they may have been during other periods when an RR layer is buried. As forecasters, we brought this problem to the attention of the public through use of a publicly shared forecaster discussion on our website and social media platforms.

We identified this RR layer as a persistent weak layer (PWL) in the new/old snow interface in the Salt Lake, Ogden, and Provo area forecasts on January 30. We introduced the formation and preservation of the RR layer in a forecaster mindset video on January 29, and we put out another video speaking directly to the formation of the RR layer on January 31. We made PWL the primary avalanche problem on February 1 and removed it from the forecaster problems on February 5 when further observations showed extended column tests with no propagation results in locations that only six days before had been the culprit of avalanche activity.

FORECASTING CHALLENGES

One of the forecasting challenges during this event was that the increased hazard was on solar aspects where we don't normally see persistent weak layers that lead to avalanche activity. As forecasters, we had to adjust our pattern recognition and communicate that to our users.

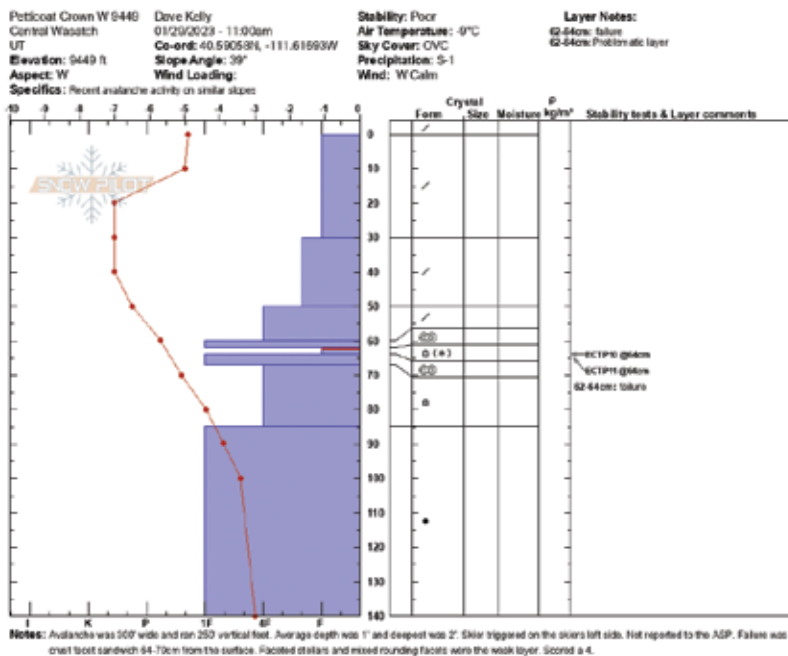
Another challenge was that RR layers form frequently and are generally disturbed prior to the next storm (McCabe 2008). As a forecasting team, we watch to see if any layer of weak faceted snow is buried or capped prior to the start of the next storm.

A take-home from this recent RR event was to identify what conditions are necessary to preserve this layer within the snowpack. This RR layer was quickly capped before it was disturbed leading to the avalanche cycle discussed. In this case, the 9.5" of 'capping' snow was followed immediately by 18.5" snow/1.35" of water, burying and preserving the faceted RR layer in the snowpack.

LESSONS LEARNED

The avalanches on this RR layer were short-lived (eight days) and primarily on southeast aspects, failing on a faceted layer associated with a crust. In this particular case, if you lost the crust, you lost the problem. There had been avalanche activity on south-facing slopes in 2012, 2016, and 2020 when a RR layer may have been the culprit in previous avalanche cycles. We have been combing through that weather data to see how frequently events of this type occur to help us identify this problem in the future. It can be easy to miss this avalanche problem because it is both short lived and often occurs when other types of avalanches are happening.

While we recognize that it is important to be aware of the formation of these weak layers and something to watch during periods of clearing



Snow pit by Dave Kelly and Patsy Marley. W Aspect, rider triggered avalanche from January 28, 2023. <https://utahavalanchecenter.org/avalanche/74340>

(no matter how brief), it is harder to gauge the preservation of such layers. Their preservation is a more important factor than formation. As a forecasting staff, we felt we did a great job isolating aspects where these layers were creating an avalanche hazard. While we could have more quickly acknowledged when these layers were preserved prior to the first avalanche on January 28, we are pleased with how we approached the avalanche problem and provided information to the public. We would like to thank our vibrant avalanche community in Utah who submitted observations and talked through their experiences during this brief mid-winter radiation recrystallization PWL event. 🍷

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DAVE KELLY is the newest member of the Utah Avalanche Center's forecasting team. He's had lots of practice shoveling porches, digging holes for avalanche search dogs, and building snow forts prior to joining the UAC, but after this winter, is researching used snowblowers.



MARK STAPLES has been the Director of the Forest Service Utah Avalanche Center for the last seven years. His greatest education has come from investigating avalanche accidents, literally walking in the victim's footsteps, and hearing stories from the people involved.

TRANSCIVER INTERFERENCE

Basic Public Messaging

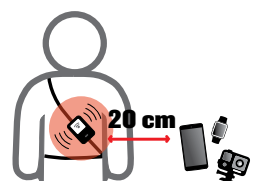
BY JAMES FLOYER

TRANSCIVER INTERFERENCE

KEEP YOUR DISTANCE! 📱

Electronic devices, metal objects, and magnets of any kind will interfere with your transceiver's signal if they are too close.

TRANSMITTING

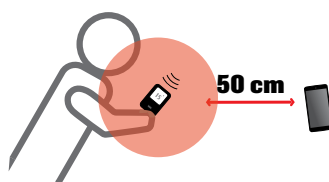


Always wear your transceiver at least **20 cm** away from anything electronic, metallic, or magnetic.

NO:

- Heated jackets
- Foil-lined jackets
- Magnetic jacket closures
- Chest-mounted cameras

SEARCHING



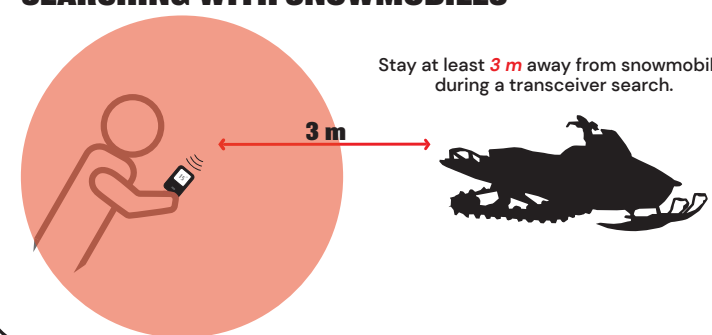
Increase the distance when searching.

Always hold your transceiver at least **50 cm** away from all electronics, metals, and magnets.

CAUTION

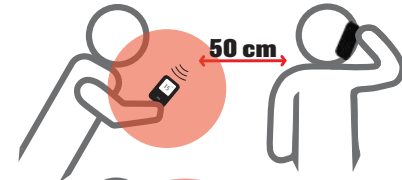
- Heated gloves and electronic watches **must** be taken off and stored away before a transceiver search
- Heated socks can interfere with your fine search when you're holding your transceiver close to the snow surface

SEARCHING WITH SNOWMOBILES

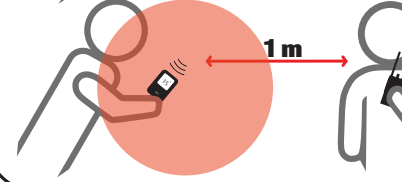


Stay at least **3 m** away from snowmobiles during a transceiver search.

CALLING FOR HELP




When *using* most communication devices, including analogue and FRS-band VHF radios, stay at least **50 cm** away from a searching transceiver.



When *using* a digital VHF radio, stay at least **1 m** away from a searching transceiver.

HELPFUL MEASUREMENTS



How many times have you gone into the backcountry and wondered: **“I’m more and more reliant on my smartphone and other devices in the backcountry these days. Is it OK to use them and how I can make sure they don’t affect my avalanche transceiver?”**

In September 2022, a group of interested parties gathered in Salt Lake City, UT for a workshop to discuss this exact issue—how to inform and manage the effects of interference on avalanche transceivers. Many avalanche acronyms were represented, including the AAA, AAI, ACMG, AIARE, AvCan, CAA, CAIC, NAC, NWAC, UAC, as well as the following equipment manufacturers: Arva, BCA, Black Diamond, Marmot, Ortovox, PIEPS, Alpride and Arc'teryx.

The aim of the workshop was to explore the state of knowledge of how transceivers are affected by items that cause interference—electronic devices, metal objects and magnets—and commit to a collaborative approach to informing users of these issues. Delegates committed to providing consistent guidance on how to manage interference, tailored to specific groups, such as general recreationists, educators, and professional avalanche workers. Adhering to the guidance should offer the best outcomes by minimizing the likelihood of interference affecting a search while maximizing search efficiency.

The following guidance is aimed at recreational users. It was crafted in the wake of the Salt Lake City workshop through a collaboration between the public avalanche safety organizations on the list above. It is available for download at <https://avalanche.ca/transceiver-interference-messaging>, and can be freely shared.

- The guidance accepts that users are likely to carry devices and objects that could interfere
- Most devices do not cause problems if kept at a distance of at least 20 cm (8 in) when transmitting and at least 50 cm (20 in) when searching.
- Some devices need additional consideration (e.g. smartwatches)
- Some devices should be avoided (e.g. heated jackets) 🚫



JAMES FLOYER is based in Revelstoke, BC and has been with Avalanche Canada forecasting avalanches since 2008. He currently oversees the forecasting and field programs there in his role as Program Director.



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LESSONS LEARNED ABOUT ELECTROMAGNETIC INTERFERENCE

BY CHRIS BREMER

*“The burned hand teaches best.
After that, advice about fire goes to the heart.”
—Tolkien*

On the afternoon of December 3rd, 2022, Snowbird patrollers were finishing a search of debris from an in-bounds avalanche. Ghost signals, reduced search radii, slow signal acquisition, and interference indications were ever present on the initial beacon search. In the middle of the search, the Incident Commander had the foresight to tell all participants searching on the debris to turn their radios off to reduce the interference. After this adjustment, the beacon search was concluded quickly, and the debris was eventually determined to be clear. Fortunately, no one was involved in this event.

After a standard debrief, questions remained, however. The usual question forecasters ask themselves lingered: “What can we learn from this avalanche and the weather events preceding it?” An additional question remained unanswered, though: “Why had our beacons acted so funny?”

Rewinding back to autumn 2022, Snowbird actively sought out and purchased a new radio system. Our older radios were digital Frequency Division Multiple Access (FDMA) radios that caused minimal interference to our beacons. The new radio system Snowbird purchased is based on Time Division Multiple Access (TDMA) technology. This type of TDMA radio is becoming more widely used year after year and allows a resort like Snowbird to provide more user groups with access to the extended coverage of our repeaters. Digging into literature regarding beacon interference from consumer electronics and radios, a 2018 ISSW paper by Forrer et al, “The Effect of Communication Equipment on Avalanche Transceivers” quickly provided insight into the problem. From the paper, we learned that our new TDMA digital radios created particularly more interference than our previous FDMA digital radios, confirming our experiences on the hill. We also reached out to our radio and beacon manufacturers to alert them to the issues we were experiencing.

My concern over the radio interference grew when I went with one of our newer patrollers to observe them perform a companion rescue drill. The new patroller moved very slowly in the signal search...and obtained their first signal with a distance reading of less than 20 m. This patroller had been introduced to beacon searching with a beacon subjected to significant EMI by their radio...yet this patroller did not know any better. To them, initial signal acquisition at <20 m was as normal as the need to move slow in the signal search. This new radio technology was resulting in new patrollers learning on beacons that were operating in a suboptimal range.

With experienced patrollers, the problem was the opposite in companion rescue drills. The seasoned patrollers, who had been trained years before on interference-free beacons, searched for signals quickly, as one should. When outfitted with the new radios, the slower signal acquisition caused by interference resulted in the seasoned patrollers skiing past buried targets, causing them to have to travel uphill to get to the buried beacon. The new radio technology was resulting in the need for patrollers with years of training and real-world experience to relearn beacon searching!

Our patrollers, both new and experienced, were not taught to search with beacons experiencing such extreme interference...Only recently has guidance arrived from the EMI working group, that recommends a separation of at least 1 m or more between beacons and digital radios that are turned on. In discussions within the avalanche community in Little Cottonwood Canyon, another suggestion came up, one that served us well on the December 3 search—“Turn off the radio for the beacon search duration.” These recommendations appear to be the tip of the iceberg as consumer electronics and communication devices become more and more powerful and interfering. Support and guidance from both our radio and transceiver manufacturers has been useful for us. It is certain we will need continued manufacturer guidance as sources of interference become more numerous. In the meantime, we will continue working to address how we search in the event of a patroller burial during avalanche mitigation, an in-bounds avalanche involving the public, or a backcountry call-out.

Radio users far outnumber avalanche beacon users and TDMA radio technology is here to stay. These radios will only become more common. It is up to us as beacon users to learn to adapt to these new and evolving, and often interfering, radio technologies. ●



CHRIS BREMER serves as a Snowbird Snow Safety Supervisor, AIARE Pro Instructor, and in the southern hemisphere in any way that extends his winter!

COMMENTS FROM JAKE HUTCHINSON

Last fall, a diverse group of international avalanche professionals, avalanche safety gear manufacturers, and public forecasters sat down in the conference room at Black Diamond with the common goal of sorting through the literal and figurative noise surrounding avalanche transceiver interference and how we message it. After two full days of collaborative discussion, debate, and information-sharing, followed by subsequent remote committee work, Avalanche Canada has released [this simple and comprehensive set of graphics](#) to hopefully help the entire industry communicate the same simple basics and put some of the disinformation and inconsistency to bed.

As an educator, it is great to not only have these simple graphics, but to know they are supported by the research and backing of all transceiver manufacturers on minimum required distances.

It's also nice to put the airplane mode, on/off, Bluetooth, call/don't call arguments to rest and just teach the basic 20/50 rule, to be able to communicate with professionals about how and when the other devices they use and carry may interfere, and steps to mitigate the interference. In closing, it was an honor to be part of a group of people with diverse vested interests come together for a common standard that will help to minimize the confusing and often conflicting info currently circulating the avalanche world.



JAKE HUTCHINSON is the Technical Director for AAI and Membership Trustee for the A3. He's currently in the slow process of relocating from the Wasatch to the Gore Range and raising/training two Malinois.



Snapshots from Gulmarg. ■ LEFT AND CENTER SHOTS COURTESY OF BRIAN NEWMAN, RIGHT, COLIN MITCHELL

Managing the risk to the guests at *gulmarg*

BY COLIN MITCHELL



Monkeys live in the forest in the lower part of the resort. I saw them every day; they were among the exotic inhabitants that add to the flavor. ■ COLIN MITCHELL

The main tool available for risk management was to close the upper Gondola. This was a great solution during big storms, but at some point, the lift needed to be opened. This left risk communication as the number one method for helping skiers manage their risk. The goal of any backcountry avalanche forecast is to influence the decision-making of the reader in a positive way. You present the evidence and your expert opinion, with the goal of convincing skiers to utilize terrain wisely, and avoid the most dangerous areas.

At Gulmarg, all my powers of persuasion were needed to keep the riders on track. We posted the forecast at the top and bottom of the lift, and I went to the top of the lift with my patrollers, and personally warned people, and encouraged them to read the forecast. We checked that they had avalanche safety gear. I started a Facebook page where skiers and guides could share information and observations from the backcountry and held twice-weekly avalanche safety presentations at one of the local hotels. These included a description of the resort boundaries, and the responsibility that skiers assumed when they entered

the uncontrolled terrain. The talks were held at the Pine Palace, which had the only legal bar in Gulmarg at that time, and offered the promise of an after party which helped draw big crowds. Gulmarg skiers are an international crowd. English is the default language for most of the skiers, but I estimated about 1/3 of the guests were Russian, and few had any English skills. I worked with one of the Russian tour operators to have my forecasts translated into Russian.

Gulmarg is an amazing resort with some of the best terrain, snow, and skiing I have ever seen. It was a remarkable experience, and despite the many challenges presented by the job, it will always hold a special place in my heart. ■



COLIN MITCHELL has worked many years as a ski patroller, ski guide, and forecaster in the US, South America, and Asia. He currently spends the northern winter as a Colorado Avalanche Information Center forecaster on US 550, and the last 10 'summers' forecasting in Chile, and in Bariloche, Argentina.

FROM BRIAN NEWMAN, SKI PATROL DIRECTOR

Gulmarg Avalanche Center (GAC) is a small non-profit avalanche center. Operating since 2008, GAC issues daily avalanche risk reports for the mountains surrounding Gulmarg ski area. GAC also provides a weekly avalanche awareness talk and periodic free avalanche education targeting locals and taught in Kashmiri/urdu. Currently, I am the sole employee and forecaster at GAC.

Gulmarg ski patrol is a separate institution with 15 Kashmiri ski patrollers. The men are full-time employees of the Gulmarg cable car or the department of tourism. During winter ski season the men are designated to the ski patrol team.

Go visit the website for our Gulmarg Avalanche Center: <http://www.gulmargac.in/>

Editor's Note: here is a second installment of our two-part series about Gulmarg.

CLARIFICATION

In the last issue, the article highlighting the Gulmarg avalanche programs mistakenly identified the courses provided to the local patrol and mountain guides as "Professional Level 2 Training Certifications." These were actually AIARE Level 2 courses, which used the former curriculum structure of Level 1 through Level 3, prior to the pro/rec split of 2017–2018.

FORECAST CHEAT SHEET

“First Down and Ten,” Avalanche Forecast Notes

BY HALSTED “HACKSAW” MORRIS

I read the avalanche center forecast daily. But because I often read two separate regional forecasts, I sometimes mix up the information between the two.

I know I can pull up the forecast on my cellphone, but I have a love-hate relationship with the device. I hate to pull out my cellphone while skiing and touring, dropping it, batteries getting drained by cold, etc. Also, it's usually buried deep in my interior pocket and it also means having to pull out my reading glasses and getting them on as well. Besides, how do you read the Lilliputian sized font in bright sunlight with polarized sunglasses? As you can see, a cellphone is not as easy to use as you'd think. There has to be an easier way.

The solution of how to do this came to me while watching a football game. Yes, that's right, football. Quarterbacks in the NFL often use a small playbook wristband on which they list the plays. Being able to check my forecast “cheat sheet-notes” easily while in the field has been what I've wanted for a long time.

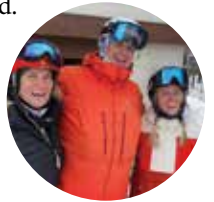
There is a variety of these “playbook wristbands” on the market. My Nike

playbook wristband has a transparent plastic cover as do a lot of other models. It is easy to slide my cheat-sheet notes under the plastic in a fairly large font. The cuff also fits over my jacket cuff and under my long sleeve mittens. So far, the plastic has not cracked in the cold.

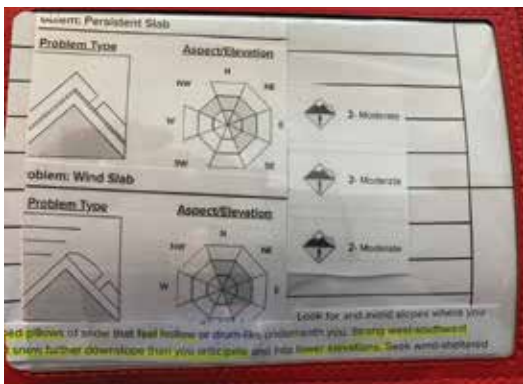
On Avalanche.org you can find all of the US avalanche centers' forecasts. Most of the centers have a means of printing their daily forecast on the website links. It's easy to print out the “problem type” section of the forecast. A few seconds later you can trim the section to fit inside the wristband window. Guides or search and rescue folks could use these wristbands for notes such as a list of multiple radio frequencies or a flowchart of rescue procedures.

The playbook wristband is the low-tec answer to quick-and-easy access to any avalanche forecast information you need.

They can be found online from Amazon and other football equipment sites with a price range of \$10-\$25. ●



Former A3 Board President Halsted Morris with wife Barb Garrett to his right and A3 ED Jayne Thompson Nolan on his left.

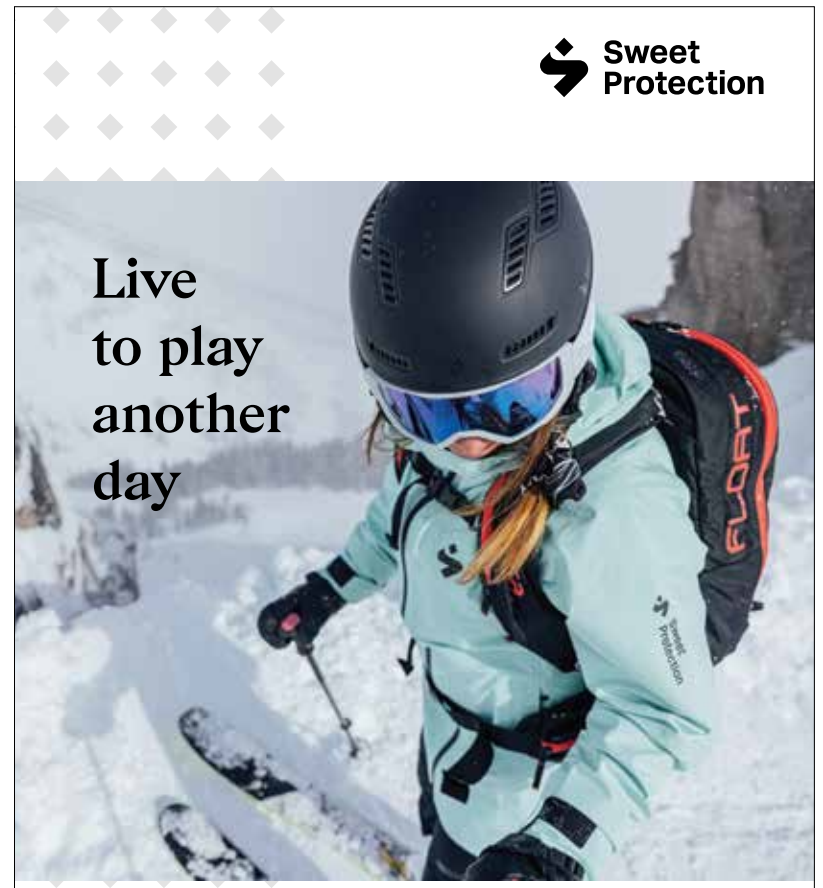



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▼ Pro 1 students hunt for answers at the crown of a D2.5 natural avalanche in the Mt Baker backcountry. The slide failed on buried surface hoar, and was triggered by a cornice failure tumbling down the cliffs above. 📷 JAKE HUTCHINSON



▼ WYDOT Avalanche team trucks and rotary plow staged below Glory Bowl slide path during a mitigation mission. 📷 BRENDEN CRONIN

AU

Work

▲ Irwin, Colorado. Blaster: Doug Krause. 📷 MARK GOBER

Photo Contest Images ❤️



▲ On January 7, 2023, I remotely triggered this slide on basal facets from approximately 300' away during a Rec 1 Course. The Danger was Considerable and Persistent Slab was the primary problem. Snodgrass Mt., East, BTL, 37 degrees. SS-ASrc-R1-D1.5-O. 📷 BILLY RANKIN

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photo credit: Dave Richards, Alta Ski Area, Utah

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