

38.3

FEBRUARY 2020

THE AVALANCHE REVIEW

PROBABILITY & LIKELIHOOD

An avalanche off the north face of Colfax Peak (one of the satellite peaks on Mount Baker, part of the so-called "Black Buttes"). This area avalanches periodically, though not typically as big as what you see here. This avalanche crossed the "normal" climbing route on Baker, the Coleman-Deming route. This is on the upper Coleman Glacier. *Photo John Scurlock*



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Keep Current with the Avalanche World!

Renew Your Membership

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

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



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Please send submissions to:

Lynne Wolfe — Editor
tel: (208) 709-4073
avalanche.review@avalanche.org

Design & Production:

McKenzie Long — Designer
tel: (513) 515-0723
mckenzie@cardinalinnovative.com

Business, Subscriptions, & Advertising:

Dan Kaveney — A3 Executive Director
tel: (307) 264-5924
dan@avalanche.org

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- General Member**—no experience needed
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FROM THE EDITOR

BY LYNNE WOLFE

So far we have had two sunny days in 2020. Snowy and windy, roads closed. Here's when we execute what we've been training for. Yup, that untouched alley looks enticing, but what's underneath? Still those October facets? You know what you WANT to do, but what's the right thing to do?

This year I've been digging into the Conceptual Model of Avalanche Hazard (CMAH) (see selected reprints on page 28 of this issue) as part of my homework for teaching in the Pro Track. One of the segments that jumped out at me was titled "Likelihood," with sub categories Sensitivity to Triggers and Spatial Distribution. The descriptors stand for what we can test and sense and quantify. I strongly believe that good education helps you make better decisions in the moment, not just understanding broad concepts. What does "Possible" look like/ feel like/ where should we ski this next line?


Remember the college course Rocks for Jocks? Maybe we need an updated version of Statistics 101 for Backcountry Travelers? I have tried to provide some introductory reading materials for that class in this issue of TAR. Papers from Jimmy Tart and Scott Thumlert (beginning page 31) discuss whether terminology carries the same meanings to various user groups. Jenna Malone read the book *Thinking in Bets* and immediately knew that Annie Duke's insights fit seamlessly into the avalanche world (page 34). I've been chewing on a few quotes from that book as I work on this Probability Project for TAR. "Treating decisions as bets" sent me to pattern recognition once again.

Right about now you might ask "What's the difference between likelihood and probability?" In basic dictionaries each word is used to define the other, but it turns out that there are some subtle distinctions. I asked Eeva Latosuo to help shine some light on the issue on page 27.

The more we use the structure of the CMAH in our everyday practice, from pro-level observations to the simpler structure of a Rec 1 class, the better we can communicate across skill and experience levels. Bruce Tremper and Grant Statham both bring their characteristic clarity of writing and insight into CMAH creation to this TAR (pages 28-29).

In other features, Jake Hutchinson brings us insight from the military world in "Left of Whoomph," on page 38; Chris Wilbur delves again into Colorado's record-breaking winter of 2018-19 from an engineer's perspective (page 22). Ron Simenhois shares his research into the importance of friction in avalanche release, on page 20 and Dick Dorworth shares his unique and nuanced perspective on page 24

As part of the overall A3 Inclusion project, Emma Walker interviewed four of our female wise ones for TAR; you'll find part 1 of this series on page 11.

At BendSAW I met John Scurluck, whose work I'd been admiring for years. He generously shared some of his striking photos—cover and centerfold shot—thank you John. You'll find plenty of other rich material in these pages; despite how difficult it is to get people to write over the holidays, our pages are stuffed with education insights, poetry, art, SAW reports, and more. 



One of two sunny days so far in 2020.
Photo Peter Thurston





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2019 ICAR AVALANCHE COMMISSION REPORT

BY MIKE FINGER AND OYVIND HENNINGSEN

Here are some highlights from the 2019 International Commission for Alpine Rescue (ICAR) Avalanche Commission. Please see the full report for more in depth coverage, annual reports from individual countries, vendor highlights, and field day coverage.

The Avalanche Commission is in a rebuilding phase and working groups were created to establish priorities, directions, and long and short-term goals. Working groups were formed to focus on four specific topics:

- Avalanche Commission Recommendations and Goals
- Prevention: Strategies, Statistics and Trends
- Industry Partnerships and Collaboration
- Research, Design and Science

Plans and personnel:

- We plan to introduce a new collaboration platform to help delegates collaborate on projects during the year.
- Stephanie Thomas from Teton County SAR was appointed vice president of the avalanche commission. A new president of the commission will be elected next year.
- One theme that came up multiple times was how can we better focus on sharing experiences and lessons learned from rescues in other countries?

Notes from MRA avalanche commission delegates' presentations at the conference

Michael talked about how to come up with a backcountry avalanche incident plan for your rescue organization and things to consider in such a plan. He asked the question 'How do we get better at avalanche rescue?' and asked the other country delegates what data they were collecting regarding professional avalanche rescue. How many people were involved, what search techniques were used? What technique was used to find the victim?

Oyvind gave the US accident report and noted that, in this last season, 19 of 25 fatalities involved a persistent weak layer (F, SH, DH). This is a continuing trend and why? Over the many years he has spent in the avalanche industry as a backcountry and mechanized ski guide, avalanche educator, and mountain rescuer it is becoming clearer and clearer to him that if we truly want to reduce avalanche fatalities we need to get a better handle on dealing with persistent weak layers. What are some possible causes?

- Avalanche education is not focusing on the difficulty of this problem?
- Backcountry users are overestimating their ability to manage this problem?

- Avalanche centers are not clearly communicating the dangers with this problem?
- Or is the reason the human brain? We are not good at or even capable of dealing with high degrees of uncertainty, high quantities of variables and variations, and a long time span of uncertainty

Teamwork in the Tetons:

CODY LOCKHART

Cody described the response to an avalanche accident in the Sickie couloir on Mt. Moran in Grand Teton National Park. The mission was completed successfully largely due to the unified interagency response by Jenny Lake Rangers and Teton County Search and Rescue. Together they have built a strong integrated group of resources. The accident, mission, and subsequent reflection led to the start of the Backcountry Zero vision and community initiative to reduce fatalities in the Tetons. It also led to the creation of the Teton Interagency Peer Support group which provides peer mental health support to first responders. The accident left many of the responders with mental health challenges and an awareness of something missing in their training and their support system. Now they have implemented a psychological program to provide

support and proactive outreach to make sure that everyone on the team is mentally healthy.

Drones

There has been an increase in the use of drones for avalanche control and forecasting purposes throughout the world. It was suggested that drones could be utilized to assess danger to rescue teams, as avalanche "lookout," or to mitigate danger by explosive control of slopes. Drones are currently experimented with to deliver AEDs in several cities and could be used similarly in avalanche accidents for delivering ventilation equipment, first aid and rewarming gear etc. Dr. Will Smith from Teton SAR commented that they are currently working on this in the Tetons.

Forging a better chain of survival in avalanche terrain: HEIKO STOPSACK

Following an avalanche accident, it is important to render first aid as quickly as possible. Stopsack asked what can we do to improve the survival chances for the victim? Is the recreational user fully prepared to respond to an avalanche accident? Can we forge a stronger link in the avalanche chain of survival? We have provided gear, we have taught avalanche terrain travel and companion res-



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cue skills, so what is next? He thinks we are missing an opportunity to teach good quality CPR; in this respect maybe we should treat avalanche rescue like an urban cardiac arrest event? He recommends that we incorporate high quality CPR into avalanche rescue courses as he believes that this might lead to higher survival rates. Most avalanche victims die from asphyxia, so being able to clear an airway and perform CPR is very important to survival chances.

Should Airbags be Mandatory Avalanche Safety Equipment: CHRISTOPHER VAN TILBURG

Dr. Van Tilburg presented the history of the avalanche airbag and the current ICAR recommendation on airbags: "The efficiency of the transceiver in combination with probe and shovel, and of airbag systems has been

proven." Other organizations such as the Wilderness Medical Society have endorsed airbag use in their guidelines: "Travelers entering avalanche terrain should consider using an avalanche airbag." Dr. Van Tilburg presented that a study by Haegeli, et al showed that airbags worked in reducing morbidity and mortality by about 11%. Dr. Van Tilburg stated that there are still questions and research to be done regarding airbags such as:

- which inflation method is best?
- what is the optimum size of the airbag?
- does the shape of the balloon prevent trauma?
- does the balloon create an air pocket or protect the airway for asphyxia prevention once buried?
- should an industry standard for canisters be developed?
- Should airbags be used with air diverters?

He outlined several barriers for universal use of airbags:

- Size and weight
- Cost
- Training burden
- Possible exclusion of coverage if mandatory recommendation not followed
- Lack of authority recommendation

He ended his presentation by asking the audience if ICAR has a duty to make a stronger position on airbag use as an organization? Quite a few comments from the audience ensued both in support and against.

VEGARD OLSEN and DR. JULIA FIELDER presented on an avalanche accident in the Tamok Valley in Tromso in Northern Norway

In Norway an avalanche rescue took several weeks because of weather and unstable snow conditions. Due to the delay, they experienced a lot of pressure from the media and a lot of time was used to educate the media and the general population about the danger that the rescuers were facing. When conditions allowed, they shot the slope 25 times with a Daisy Bell and dropped 100kg of explosives before inserting rescuers. Waiting for conditions to improve and reducing hang-fire by explosive control are valid risk mitigation tools for rescuers. ●

Oyvind Henningsen was born in Norway. In the USA since 1989. Married to Jana and together they have 6 children. Owner of company that provides fish processing machinery. Active skier and climber. Team Coordinator and rescue technician EMT at Snohomish County Helicopter Rescue Team. MRA avalanche commission delegate to ICAR.



Michael Finger is the Assistant Commander for Salt Lake County Sheriff's Search and Rescue team. He has been an active MRA member for over 15 years and serves as alternative US ICAR delegate on the avalanche committee. Michael is also an active ultra-trail runner, climber, and backcountry skier. He has completed numerous ultra-trail races in the Mountain West and Europe.







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METAMORPHISM

When the legend becomes fact, print the legend

BY JERRY ROBERTS

There was a fine retirement party last night...with food and an open bar! (thank you Telluride Helitrax owner Todd Herrick)...



Three of the four Telluride Helitrax originals. Dave Bush, Speed Miller, and Mike Friedman. (Mark Frankman MIA)

Speed (Brian) Miller recently retired from Helitrax after 36 years in the saddle. A long and storied career for a guy that came to Telluride in the mid 70's to ski bum & survive. He along with Mike Friedman, Dave Bush and Mark Frankman became friends in the early years of a broken down mining community that was evolving into a ski resort and started Telluride Helitrax in 1983 against all odds, a dry continental snow climate and no money. What were they thinking? They sold the company in 1999 and Speed continued guiding another 20 years without an accident which is a real feat considering most snow-safety pros would probably bet against a heliski operation's success in this historically unstable snowpack.

My cap (along with many others) is off to this guy that brought and developed a very unique set of skills that enabled him to successfully enjoy a long, safe and colorful career accented with style. He's dodged the odds in spite of skiing 150 days a season. Clients and fellow guides I think would agree, Mr. Miller is like an old Buick Roadmaster, a classic, genuine original.

*thirty six years
so many turns ~
now an uncharted horizon*

A great line from the movie *The Man Who Shot Liberty Valance*: "when the legend becomes fact, print the legend."

Jerry Roberts is the chief meteorologist and bottlewasher at Mountain Weather Masters.



There is over 400 years of avalanche professional experience in this photo. Left to right: Bill W, Eddie Garcia, Randy Elliott, Bob Dixon, Jim Humphries, Doug Richmond, Dene Brandt, Ray Dombroski, and Jon Euland. Photo courtesy Doug Richmond

Backcountry Access Welcomes Craig Hatton As New General Manager

BOULDER, CO (December 10, 2019)—Backcountry Access, Inc. (BCA) is pleased to welcome **Craig Hatton** as its new General Manager. Craig has a profound knowledge of the snow safety category on a global level, gained from 26 years working at Black Diamond Equipment, Inc.

Craig grew up in Salt Lake City, Utah, where he began skiing at an early age. He was one of the original employees at Black Diamond (BD) after the company moved to Salt Lake City in 1991—and one of the early members of the well-known Wasatch Dawn Patrol crew, consisting mainly of BD employees. Craig held various roles at BD, including outside sales, product management, and business unit director for their global ski category.

Craig has taken over the reins from former General Manager Bruce "Bruno" McGowan, who co-founded BCA in 1994 with Bruce "Edge" Edgerly. Edgerly remains in his current role as Vice President of Global Marketing. Hatton and Edgerly will team up to expand BCA's role in the global marketplace.

"I'm excited to join the team behind the most trusted name in backcountry safety," says Hatton. "I will strive to preserve and nurture the strong culture behind the BCA brand as we move into the next decade."

BCA is celebrating 25 years in the industry this season with its "25 Years Deep" brand campaign and the launch of its much-anticipated Tracker S avalanche transceiver. The company is best known for inventing the world's first digital avalanche transceiver, the Tracker DTS, and for popularizing the use of avalanche airbags and user-friendly backcountry radios. ●



Craig Hatton has experience on skis as well as in the avalanche industry. Here he anticipates the excitement of a Canadian hut trip (top), and puts in some product-testing time (below). Photos Chris Clark

Women's Inclusion Project

PART 1

BY EMMA WALKER

How can we diversify our membership? The outdoor industry has been asking itself this question lately, and subsequently has come up with a number of thoughtful answers. A3 is doing the same thing: Our membership is predominantly white and male, and lately we've been examining what it takes to make our organization more engaging to a wider set of potential members.

Halsted Morris moved this conversation forward back in October when he initiated a conversation about inclusion among the A3 board members. Halsted's primary sentiment was this: "Simply put, I would like more women to join and be a part of A3. When they do join, I would like them to feel the respect they deserve," he wrote. "A3 can be the tool for women to feel dignity in the avalanche business." He then issued both a challenge and a welcome in his "from the President" columns in TAR 38.1 and 38.2.

Here in the avalanche world, we're fortunate that we have a number of female role models to look up to. (Especially in Alaska, as you'll notice in this issue. Is there something in the water—or the snowpack—up there?) We thought that understanding what makes them tick might shed some light on how we can diversify our ranks.

So Lynne Wolfe came to town, and in my cozy Boise living room, we volleyed questions back and forth: What did we want these women to tell us? What did we want newcomers to our field to know? We also asked aspiring snow scientists what they wanted to hear. Their questions are reflected in the interviews you'll read here.

Armed with interview questions we couldn't wait to learn the answers to, we reached out to women who've been working in our field for decades as forecasters, educators, and guides. Lynne and I each had the privilege of asking these questions of our own mentors—Janet Kellam and Eeva Latosuo, respectively—and their answers continued to inspire us. We hope you learn as much as we did from these pillars of the avalanche community.

Melis Coady

Executive Director, Alaska Avalanche School • Anchorage, Alaska

Melis Coady's wide-ranging educational career spans two decades, during which she's worked as a field instructor for NOLS and the Wilderness Medicine Institute, a senior guide for the Alaska Mountaineering School, and as a climbing ranger in Denali National Park. Melis has skied and climbed on all seven continents, and has served as the Executive Director of the Alaska Avalanche School since 2016.



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

MC: When I was 20, I thought losing youthful boldness was death. I didn't yet know that youthful boldness was, in fact, a recipe for death. At twenty, I never would have believed

I would be more skilled (and more fun to be around) with age. Unfortunately, you can't fast forward—you have to bumble your way through your twenties to be rewarded in your 30s, 40s, and hopefully beyond. I'm dying to know what my 60-year-old self would tell my 42-year-old self.

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

Here is the scary thing: It took me an incredibly long time to understand I had a job in the avalanche industry. In the late 1990s, I self-identified as a climber and mountaineering guide. Working in Alaska, we almost never wore beacons; the thinking was that if you gave cornices and seracs a wide berth, you'd probably be okay. We also thought that if you waited 24 hours after a storm for snow slopes to either stabilize or shed, you were probably good to go. (I'd say that is still a stigma the climbing industry has to overcome.)

It's still very common for climbers to travel without basic avalanche safety gear, and many lack basic avalanche education. Sometimes it feels like the ski industry can take all the air out of the room. My motivation in di-

recting Alaska Avalanche School is to expand the reach of avalanche education. I believe climbers, splitboarders, and motorized users are recreating with outsized risk. First, their own sport cultures need to demand common safety standards from each other. And as educators, we need to include photos, language, and scenarios that apply to diverse audiences.

How have you seen the industry change since?

It is so nice to see professionals more openly sharing their mistakes. This year, presenters at both USAW and SAAW were so vulnerable about lessons learned. Forecasters Heather Thamm and Drew Hardesty dissected their public forecasts for days when the hazard rating was low but the public was triggering avalanches. Guides Ken Wylie and Pete Earle shared take-aways from free and expensive lessons in the mountains. *The Snowy Torrents* and *Accidents in North American Climbing* have been great resources, but a first-person account of an incident is amazingly powerful.

Who were your mentors? How did they challenge you?

My mentors were a large body of out of

shape, judgmental, and chauvinistic men. I worked as a mountain guide on Denali for 15 years. There, many of my mid-life crisis clients had convinced themselves that seeking youthfulness meant cheating on their wives, buying a sports car, or climbing a big mountain. I found early in my career they treated me poorly—and they taught me valuable lessons about how best to connect with and earn the respect of people very different than myself. At the outset, it felt like we had diametrically opposed definitions of success. It turns out we had the same definition. Success looks like developing a depth of knowledge in a difficult field, drawing on diverse leadership styles, deploying strategic decision-making, and having the discipline to stay the course with an unflappable work ethic.

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

Not to flirt. It makes other women hate you and it will erode your professional relationships with men.

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

I used to be a Luddite. I was the last of my friends to get a digital beacon and a smartphone. That all changed in 2012 on Denali. I was returning from the summit with a large group, and we got caught in a whiteout. I had brought and placed over 100 bamboo wands, each spaced at the distance of a rope length, so we wouldn't get lost. Now, the wands were

covered in rime ice, and we couldn't find any of them. I was stressed. Caring for a large group in a storm overnight at high altitude with only basic survival gear is my biggest professional nightmare, and it seemed to be coming true.

Luckily, with the use of a radio and another group with a GPS, we were able to get our team safely back to high camp. The descent took us longer than the ascent—it was an unacceptable amount of time to be out of camp in those conditions. I learned that it's important to embrace new technologies and make them redundant with old technologies.

Say you're working in the field, and a colleague you respect proposes taking a run you don't think is appropriate, given the conditions. How would you respond?

I guess it depends which colleague. It's easier to work things out with some personalities than others. Luckily, there are very few people I've worked with professionally that would be hard to work out a routefinding disagreement with.

How would you describe your communication and leadership styles?

I communicate assertively and try to be a transformational leader. I enjoy sharing a vision with a team and working towards it collaboratively.

Would you say those traits are typically described as "masculine" or "feminine"?

A good leader—regardless of gender—needs

to dip in the well of both masculine and feminine leadership styles. If you get too anchored into one style, you'll limit the effectiveness of your leadership. In parenting, they call it "good cop" and "bad cop." You have to be compassionate and firm. In working with groups of men, it's always felt a bit uncomfortable when I've put in situations where I had to put on the "head coach" routine and use very direct and decisive language—but it works.

Have your leadership and communication styles changed over time?

I hope so! Perhaps that's my greatest fear: getting stuck and not growing or improving. Today, I am more aware of reading body language and paying attention to people's actions. I anchor less to what people say. Likewise, I try to role model my leadership more with my behaviors over words.

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

I think in order to have a sustainable career, you have to balance the fun and adventure of being outside in the snow with the professional expectation that you will keep up your skills with continued learning and professional documentation. I think people try to typecast themselves—"I'm terrible with computers" or "I don't deserve to go out until I finish this project." Neither is sustainable.

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

I think about warm granite.

Janet Kellam

Retired • Ketchum, Idaho

After a college ski racing career, Janet Kellam made her way to Idaho in the 1970s and began her avalanche career in 1981. She served as the Lead Forecaster for the Sawtooth National Forest Avalanche Center from 1996 to 2001, and as its Director from then until 2010. Janet also worked as a National Avalanche School instructor. She recently retired and is spending her newfound spare time with her husband, Andy, and her new Toller Retriever puppy, Toby.



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

JK: Remember that you will unconsciously be influenced by your perception of the

snowpack that was under your feet yesterday. No matter where you are, force yourself to look at the snowpack today with new eyes. Catch yourself when you make assumptions.

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

My first job was as a licensed backcountry ski guide in 1981. I was very fortunate in the late 1970s to fall in with the likes of Alan Bard, Tom Carter, and Ned Gilette. Exploring the old CCC trails off of Mount Mansfield on three pins quickly morphed into skiing the backcountry of my stomping grounds around Ketchum and Stanley.

It quickly became apparent that learning about snow and avalanches was critical to navigate safely. In our group, being aware and self-sufficient was part of the culture. It was fascinating to discover that snow was not just about how to wax your skis. I was able to attend—and even assist on—some avalanche courses with Peter Lev, Rod Newcomb, David Beck, Ed LaChapelle, Don Bachman, and

Chris Landry. I quickly discovered how little I knew about snow, and how much I was eager to learn. In my early 20s, I didn't yet know that I had a lifetime ahead working in this community of snow and avalanche professionals.

How have you seen the industry change since?

The industry has changed significantly since the 1970s and early 80s. We've grown from a fledgling knowledge of avalanche science and mitigation applications into a very diverse field of skilled professionals. From the early days of pattern recognition and learning by trial-and-error when a pro wore many hats, the industry has developed into diverse specialties. There are stand-alone programs like forecasting for ski areas, highways, and the backcountry. There are diverse prevention and mitigation tools and methods, we have advanced mapping and engineering, and we see different branches of education, and even college degrees in snow science. We can utilize more effective and safer instability tests to help us follow the conditions.

Technology provides much better data collection and analysis, and this has allowed the development of systems that work pretty well for us. But there is always room for improvement. Sometimes technology can work against us when we get too immersed in the details and forget the big picture. We can try to cut it too close, counting on technology to make our final decision in spite of strong, basic evidence for avalanche conditions.

In spite of all our industry progress, ongoing research continues to ask questions, seek answers, and remind us we don't have a full understanding of snow and avalanches.

Who were your mentors? How did they challenge you?

I was very fortunate to spend time with a number of remarkable avalanche pros. I will never be able to thank each of them enough for their graciousness and wisdom they shared with me: Chris Landry, Doug Abromeit, Karl Birkeland, Ian McCammon, Chris Stethem, Knox Williams, Doug Fesler, Jill Fredston, Bruce Tremper, Paul Baugher, and Butch Harper. There are others, and they have all been amazing.

My mentors all put me in working positions or asked me to do something that I felt I wasn't qualified for felt over my head. In spite of some sleepless nights and anxious moments, I did fine and I learned and grew through each of those experiences. I might not have accepted or applied myself to a number of situations without some avalanche pros believing in me.

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

Our most powerful learning comes from making mistakes, and in the world of avalanches this often means our own close calls or accidents. We've all made some bad decisions and had nothing bad happen—so we may never truly register how close we came to a terrible accident or loss. Inevitably, in our profession, the "other" type of day comes. I do believe there is a greater awareness among avalanche pros as we have shifted from a tough-it-out cowboy mentality to really listening to others' difficult experiences. There is nothing as powerful as a personal loss, but I believe sometimes we can learn from others and not have to suffer the same tragedies.

Over many decades, I've had three very serious near-misses by being caught in or nearly obliterated by avalanches. Fortunately, I have escaped injury or any terrible loss from those events.

The first time I was quite young. I was skiing off of Galena Summit. I made several mistakes. First, I didn't like the early season conditions or the steepness of the slope we were headed for—but I didn't speak up. We dug a pit and examined the faceted early-season snow, and when everyone else seemed to think it was okay, I was suckered into thinking the same thing.

The next mistake was skiing with some people that I hadn't toured with. I assumed we all had the same interpretation of what "one at a time" and stopping in "safe spots" meant. We had talked about how to ski the slope, but the actions of two group members

led to three out of four people being caught in a large slide. Some of us lost gear, but no one was hurt or even fully buried. So we went through the motions of good protocol and understanding the snowpack and terrain, but we failed horribly at all of it. My take-away: Communicate, communicate, communicate. Do not make assumptions and look at the big picture. Be honest about what the data is telling you, no matter what your goal is.

My second close call happened about ten years later. I was slow on the draw to say I didn't like the conditions. I ultimately voiced my perspective halfway up a remote island peak off the Antarctic Peninsula. This was before satellite phones—we had a marine/air net radio and food for a month, but the rest of our expedition was days away. Our only rescue would be a passing Chilean freighter, if we were lucky.

So my party of two decided to turn around. As we downclimbed, a serac cut loose high above, bringing down a large wet slide. It barely missed us. By sheer luck, we were in the one protected section of a long, exposed gully. Volkswagen-sized ice blocks cascaded only a few feet beside us as wet slush poured over the rocks, scouring the gully and slope below, leaving debris 20 feet deep in the runout. I was nauseated at the reality of what might have happened.

We did communicate about conditions and made a good decision to retreat—but we should never have been there in the first place. The take-away from this close call, again, was not to make assumptions, and to be honest about the data, no matter what your goal is.

Ten years later, I had my third near-miss. While working as an avalanche forecaster at the Sawtooth Avalanche Center, I was fully buried in an avalanche eleven miles from the trailhead. I survived because of my two partners, and because in spite of relatively low avalanche danger, we never stopped using professional protocols and communication.

We carefully examined and tested the snowpack in multiple spots, chose cautious routes, and traveled one at a time to a safe spot, all while closely watching each other. At the time, I was four years into my forecasting job. I was more comfortable and confident about evaluating the snowpack and terrain, and I knew that put me at greater risk to make a poor decision.

That day, while snowmobilers were high-marking on the peaks nearby and heliskiers were skiing very similar terrain the next drainage over, we encountered an isolated windloaded slope that shattered like a pane of glass. We traversed low on the slope, one at a time in the same track. I was last. We thought we were skirting the windslab, but we weren't—we'd crossed the thinnest, most susceptible trigger point. Ultimately, it failed with the last person: me. No fresh windloading had been observed throughout the day, and we found out later that area was notorious for isolated winds.

When the wind slab and blocks stopped moving, my head was a foot and a half deep. My feet, with my skis still on, were three feet deep. I was blue and nearly unconscious. I'd disappeared out of sight as the slide ran low

into the basin, but my partners managed to locate and dig me out within five minutes.

I beat myself up for years about making a bad mistake while Doug Abromeit, my boss and mentor, repeatedly told me we had done nothing wrong. In fact, Doug emphasized, we had done everything right. He said that sometimes, we encounter incredibly variable avalanche conditions—and in spite of everything we do we still may trigger a slide, get caught, or go for a ride. That's why we have our safety protocols and training.

There is a certain humility among the older avalanche leaders who have been my heroes. It seems as if the more an avalanche professional experiences, the more they respect the snow—and the more they emphasize the uncertainty that goes along with forecasting avalanches and avalanche behavior.

How would you describe your communication and leadership styles?

I like to lead by example. I try to engage people by raising questions or asking them to do something. One of my favorite teaching openers is "There is no such thing as a stupid question."

I strongly believe that people learn by doing things themselves. I stress that everyone should be encouraged to have a voice about what they are seeing or thinking about the snowpack, the weather and the terrain. I like to point out for all of us to truly listen to others and not just be formulating a reply while someone is speaking.

I do have experience to share. If I think it could benefit someone, I'll talk about past incidents or my perspective. At the same time, I try to draw people in, asking them about their own experiences. Empathy for people and listening to their experiences can be a powerful leadership tool.

Have your leadership and communication styles changed over time?

Like most older avalanche professionals, the more I've seen and experienced, the more cautious I've become. I feel I have little to gain and so much to lose if I make a bad choice or poor decision. I don't let students get as close to the edge of making a bad mistake anymore, because I've come to believe "that edge" may be a lot closer than we realize! Still, I try to put students in a position of having a "Whoa, we almost..." moment, while still in a relatively safe learning environment.

As an instructor or co-worker I have more confidence now. I'll speak up, strongly at times, and point out conditions or observations if I feel being conservative is warranted. And conversely, I like to point out or ask specifics about data and observations if the snowpack really appears quite stable.

As part of a group, I only ski with people I am confident are solid backcountry partners and with similar goals to mine. Of course, the more aggressive recreational skiers choose not to go out with me, since I take the more conservative outlook in our faceted snowpack environment. I am ok with that. My worst fear is not being buried again; it is being the person left alone on top of the snow with my partner buried and facing the aftermath of an accident.

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

If you are passionate about an avalanche career, keep at it. It isn't an easy path, but it is

an amazing group to be a part of. I am on the retirement side of a wonderful avalanche career. I still enjoy living in the snow, paying attention to most things avalanche, and help-

ing with local avalanche concerns, but I don't miss the stressful days and nights. I do miss the interaction and time spent with all my co-workers and the broader "avalanche tribe."

Eeva Latosuo

Associate Professor of Outdoor Studies, Alaska Pacific University • Anchorage, Alaska

Born and raised in Finland, Eeva Latosuo holds an M.S. in Environmental Studies from the University of Helsinki. Her Scandinavian upbringing means she's comfortable at northern latitudes, and Eeva has called Alaska home for more than a decade. She has worked as a NOLS climbing and mountaineering instructor and as an instructor at the Alaska Avalanche School. Eeva is as an associate professor in APU's Outdoor Studies department, as well as a search-and-rescue volunteer with her avalanche rescue border collie, Sisu.



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

EL: Seek out opportunities and try things without the fear of failure. You don't need to have everything figured out on the first or second go—or to be perfect at any given time.

Courageously ask for caring feedback from people that you respect, and listen carefully when the more experienced ones talk.

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

I got hired with Vail Ski patrol in 1999. I had moved to Eagle County in the fall and blue-eyed walked into the patrol office to ask for a job. They chuckled and told me that the try-outs had been in April, so I missed the dead-

line by six months, but I was offered a job as a mountain host. To my fortune, few patrollers got injured early on, and I was an emergency hire to Patrol before Christmas. On my first season, there were six women in the crew of 60-plus patrollers—yet we had a strong female leadership with the patrol director, Julie Rust. I learned a lot about navigating in the male-dominated teams in that job.

How have you seen the industry change since?

During the 2019 A3 Pro Trainer Workshop, which I taught with two other female educators, I had an opportunity to spend time with a younger female avalanche professional, who had recently left Vail Ski Patrol due to other job opportunities. While women are still in a definite minority on Vail Ski Patrol, her professional story is a great example of times changing. She will be one of the three new female mountaineering rangers on Denali next summer. The federal government is an equal opportunity employer, but it has taken quite a long time to bring more than one woman into this team of highly-qualified mountaineering experts.

In Alaska, we have a proportionally large number of females in leadership positions in the avalanche industry. Maybe Alaska offers more level playground as such a unique and wild place for each individual regardless of gender, ethnicity, or creed.

Have your leadership and communication styles changed over time?

In the last few years, I have started calling myself lovingly "a cranky old lady." At times I communicate my thoughts more directly, as I

am less concerned about how people might receive my opinions or ideas. But I am still a rather conflict-avoidant person, as I care about the community vibes and am often emotionally affected when people don't get along. Being tuned into emotions is often described as feminine trait, and is not always seen as a positive quality for leaders. It is an interesting juxtaposition between emotional intelligence and emotional sensitivity. While acting out the emotions is not beneficial, having self-awareness and social awareness are helpful for any professional.

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

Be a Jane of All Trades, but develop at least two or three hard "technical" skills. Examples include website design, GIS, marketing, weather station maintenance, or non-profit administration.


Learn how to travel in avalanche terrain. There is no substitute for time on the mountains making decisions for yourself. And this means both competency in travel skills (e.g. skiing or riding) as well as competency in personal risk management.

This industry is really hard to build long-term careers. Most positions are seasonal, with no or minimal benefits, and often too small of a paycheck relative to the responsibilities and training requirements. Then there are plenty of applicants and stiff competition for those jobs that offer more steadiness. In addition, avalanche work requires a certain level of physical fitness and overall health becoming the crucial issue either after injury or high number of laps around the sun.


I am very fortunate that I have a teaching position with a university that provides me the stability of a year-around faculty salary. Not having to piece income for mortgage payments or retirement savings from seasonal contracts offers a certain peace of mind. This arrangement allows me to continue to work on specific avalanche contracts as a very rewarding side gig, while also offering me a unique platform to combine academics with the rest of my avalanche industry interests.

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

In order to take good care of myself, I require a minimum of two hours outside on a daily basis. Some days this involves long hikes with the dog, but more often adventurous trail runs or mountain bike rides.



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Wendy Wagner

Director, Chugach National Forest Avalanche Information Center • Girdwood, Alaska

Born and raised in Utah's Wasatch Mountains, Wendy Wagner has spent much of her life on snow. In her first career, she was a member of the US Nordic Ski Team, and is a two-time Olympian. Multi-talented Wendy also holds a master's degree in atmospheric sciences, with an emphasis in mountain weather and snow science, from the University of Utah. Her entry into the avalanche world was via the Utah Avalanche Center; she's been with the CNFAIC since the 2010-11 season. You'll often find Wendy on a snowmachine.



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

WW: Pay attention and think for yourself.

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

I started out as an entry-level forecaster with the Chugach National Forest Avalanche Center. Before that job, I cut my teeth in Utah, where I was fortunate to have the Utah Avalanche Center staff as mentors in countless ways. I was also a graduate student in atmospheric sciences with a focus on snowpack energy balance and metamorphism. Studying snow and avalanches was an all-consuming passion.

Who were your mentors? How did they challenge you?

My first mentor was Drew Hardesty. I don't believe I would have been able to break into this field without his encouragement, insights, and leadership. Drew facilitated not only learning in the mountains but also in other realms, like teaching basic avalanche awareness. He opened doors that led to other opportunities and mentors to learn from.

Other profound mentors in my life were Brett Kobernik and Jake Hutchinson, who also showed me their styles in the mountains. Brett included me in his near-surface facet monitoring studies and other unique snowpack analysis. All that pushed my understanding of the snowpack. Jake was there to guide me in formulating avalanche forecasts and in my communication style to the public. John Horel, my graduate school advisor, did everything he could to bring a ski bum up to speed in the world of academia. I rely on those skills daily!

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

The second you think you know something—that's a sign you don't.

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

Well, I can think of a few. One time I was skiing alone on a spring day in the Wasatch when I unintentionally triggered a springtime slab avalanche. It released well above me. I had absolutely no idea I had triggered it until the debris came rolling by me in the gut of the path while I was seeking out the dryer, more fun snow on the edge. I learned that a slightly refrozen surface doesn't mean it's not going to avalanche. And also, to pay attention—for real.

Say you're working in the field, and a colleague you respect proposes taking a run you don't think is appropriate, given the conditions. How would you respond?

I hope I would ask why they felt like it's ok to be on or under the slope in question. By simply asking that question, I would hope to generate a discussion that would provide some alternative options for other routes to take.

How would you describe your communication and leadership styles?

I'd say I'm easygoing and approachable. I listen and rely heavily on my staff.

Would you say those traits are typically described as "masculine" or "feminine"?

I have no idea!

Very large debris piles on Sixmile creek, near Hope, AK on December 10th. These avalanches released sometime between 2pm on 12/9 and 11am 12/10. River flows peaked on the evening of the 9th with 3+ inches of rain, temps in the 40s, and 120+mph winds at ridgetops. It appears that the river was dammed up for several hours by debris. Big chunks of debris were left high and dry down river. Photo Graham Predeger, CNFAIC

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

That's a difficult question, as many avalanche jobs do not compensate to the degree that one can make a decent living. I feel very fortunate to have a permanent avalanche job. My advice is:

1. Get a Bachelor's degree in a physical science, as many higher paying jobs require this
2. Develop a very diverse skill set, like: lots of previous time in the mountains managing avalanche issues, mitigation, forecasting, good snowmachine skills if backcountry forecasting, writing and public speaking
3. Build relationships and seek mentorship with other professionals in the field
4. Pursue interests/projects related to the field that helps grow the field as a whole, like articles, papers, etc.

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

Family time! Taking the kids snowmachining, ski touring, commercial fishing on our set-net site on Kodiak Island, mountain biking, doing the dishes, and making dinner. 🍷



FROM 'OFFICE GIRL' TO EDUCATOR:

A Journey in Avalanche Education

BY BROOKE EDWARDS

After four summers guiding in Alaska, I was curious to see what winter was about in these vast mountains. In my last year of graduate school, I treated myself to a mid winter break by booking a Level 1 Avalanche Course in Alaska. While I knew there were courses on offer in the lower 48, the reputation of Jill Fredston and Doug Fesler had already spread like wildfire that their Alaska Mountain Safety School was offering top-notch avalanche education. I flew in late at night, gathered the keys to my friend's Toyota Tacoma stashed for me at the airport and began the drive up to Hatcher Pass for my first ever winter experience in Alaska. New to skinning and backcountry skiing in general, I gathered my gear together nervously in the parking lot, donned my headlamp and began skinning by starlight into the Independence Mine building full of already sleeping students and instructors. My heart navigated the way as the outlines of the peaks shone above me as if to illuminate my first steps along what's become a passionate career.

My instructors, Nancy Pfeiffer, Jill Fredston, Blaine Smith, and Scott Raynor, blew my mind as we ventured out onto steep slopes, our arms linked together to leap up and butt bomb the slope. I was terrified, while others around me laughed at our new slope test. It was the winter of 2000 and I knew what that I would live here in Alaska. Raynor had newly purchased Valdez Heli Ski Guides from Doug Coombs and offered me a position as "the office girl" for the following season when I would be done with graduate school. I had no idea what I was in for.

That next winter arrived and by then I had secured my own hippie shack in a Girdwood bog, committing to a seasonal life in the mountains of Alaska. My cockiness about my skiing ability soon dissipated into the void as I ventured into the incredibly steep and intimidating world of Valdez. I shared a 1970s trailer with Don Sharaf and spent my days eagerly picking the brains of Kent McBride, Mark Newcomb, Rob Hess, Jeff Zell and above all, Kirsten Kremer. In this incredibly intimidating world, Kremer took me under her wing and showed me the way. Don was superbly patient with my ignorant questions regarding snow and mountains. My first experiences ever in the world of heli-skiing were being handed a radio by Mark or Don and told to tail guide. I'll never forget that feeling of standing alone at the top of some of the steepest lines of my life, gripping the radio and holding my breath; fully aware that if anything were to happen... I was the first responder. With only a level 1 avy certificate, I would stand there shaking, unable to see any of the skiers who had disappeared beyond my view in just two or three short turns. I would repeat the rescue sequence over and over in my hand praying that I'd never get the call. I never did, just the booming voice of Big Don over the radio encouraging me to drop in and manage my sluff.

Almost 20 years later, with a Pro 2 from Don Sharaf freshly added to my resume, I board the plane from Jackson to Seattle, Seattle to Tokyo, Tokyo to Sapporo where I would rejoin my team of guides and my ski season as an avalanche forecaster and backcountry guide for Whiteroom Adventures in Hokkaido. They had hired me the year prior and had assigned me the role of avalanche forecaster for our guide team. I again revisited that terrified girl standing quaking at the top of those steep Chugach lines; only this time it was an emotional terror. What on Earth had I put on my resume that made them believe I could actually be a forecaster for a guide operation? After a decade and a half working in and around the heli industry yet never getting the opportunity to guide, I had finally decided to get my ski guiding experience elsewhere.

After my experiences in Alaska, I had fully expected to be at the bottom of the totem pole; the new girl with tons to learn. Instead, I was handed the keys to the castle and asked to develop a program of forecasting that would help put Whiteroom Tours ahead of the cowboy culture of ski guiding that had been prevalent for years in Japan.

I worked with Ronan Maguire, an Irishman living in New Zealand who was functioning as lead forecaster for an Australian company in Japan. I stepped off the plane my first year

and a few hours later taught a 4-day Canadian Level 2 Rec Avalanche Class by myself. Ronan came with me on the field days, showing me where to go and how to navigate on the left side of the road with Japanese street signs. I was off and running; nervous but excited. I drew on all my years as the wallflower in heli-ski guide meetings, learning and watching, quietly being mentored by more folks than I can mention.

I marveled at how lucky I had been to miss getting off the wait list for the Level 3 all those years, only to be dropped onto the rigorous and informative Pro split, new in our American avalanche education tradition. Armed that first year with the confidence of putting all my skills to the test in the Pro 1 Bridge, I dove in headfirst to leading guide meetings and writing forecasts. I had a team of male guides from all over the world who listened, supported and mentored me. Again, I was dumbfounded, but steadily gained the experience I needed to feel confident in my avalanche education and skill set. I committed to a second year, feeling optimistic that finally I had found a workplace that believed in me enough to believe in myself.

I ran into Sarah Carpenter at the end of that first season in Japan in a 7-11. We laughed and hugged and I demanded that she put me first on the list of the Pro 2 with AAI for that

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Brooke demonstrating how to calibrate hand hardness to her Rec 1 students for Alaska Avalanche School.

following year. She joked that it would be months before it was listed or even scheduled for that matter, but she'd be happy to take my money now. I practically Venmo'd her the money on the spot. Sarah honored her 7-11 promise and wrote me an email as soon as the Jackson Pro 2 dates were listed. I called Ronan and asked for my Japan season to start a little later so I could add this valuable education to my list. He agreed and I crossed my fin-

gers and hoped for Don. I won! I got two Dons and a Bill Anderson (plus a bonus Lynne Wolfe field day).

Laid up all fall from an invasive surgery to remove a massive non-cancerous tumor, I took to studying for my Pro 2 with an intensity and devotion I've never before had. With a season of forecasting under my belt, I was armed with questions and hungry for more knowledge to make me more effective at my

work. I wanted to feel confident (yet humble) at ski guiding instead of that young girl with quaking knees atop Dimond in Valdez. For my technical report, I chose the hard path of investigating a dear friend's death. It helped me enormously and I believe I presented it to my course mates with resounding empathy that indeed, it could have been any of us making those same human factor mistakes on any given day. We've all gotten away with so very much.

Where my Pro 1 had given me the technical tools to be able to confidently speak the jargon and do the protocols to be an effective forecaster and ski guide, the Pro 2 took me to an entirely different level of integration. I was floored with how engaging it was. My colleagues had studied hard themselves and brought numerous tales of experience to the table, where we all explored our own vulnerabilities and learning in an open minded and open-hearted context. I reveled in the learning, soaking up each conversation and logging it into my own learnings. I left that course with more passion and excitement for avalanche education than I'd ever experienced before. I was once again that hopeful optimistic girl skinning by starlight under unknown peaks into the mystery of the avalanche education world.

With the blessings of Don, Don, and Bill, I stepped off the plane in Sapporo this year with the resounding confidence to apply my newly found learning and begin to mentor others on the path. It was an incredible season where we created a team of forecasters who would rotate mentoring newer guides into how to look at weather, interpret snowpack and begin to capture this in succinct and pertinent writing.

Without my Pro Track Education, I think I would still be stuck in "office girl" land... learning tons from behind the scenes and rogue tail guiding opportunities but never speaking up with the confidence that I could lead clients, much less other guides. My Pro 2 and the community of educators who chose to believe in me, specifically Don Sharaf, Ronan Maguire, and Kirsten Kremer, enabled me to put aside my imposter syndrome, step up to the plate and confidently walk into the room knowing full well that I deserve to be here. ●



Photo Ralph Kristopher

Brooke Edwards just recently started a new job as the Alaska Avalanche School Staffing Director and finished her training as a Pro-trainer with A3 to be able to teach Professional level courses. She just taught her first Pro 1 Bridge Exam with Blaine Smith coming full circle from him being her first L1 instructor. She is also pursuing certification as a ski guide on the AMGA track.

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EAST VAIL RIDER DEMOGRAPHICS AND SKILLS

HEADS UP PASSHOLDERS: in recent search practices we have found considerable signal interference from some season passes with RFID chips.

BY KELLI ROHRIG

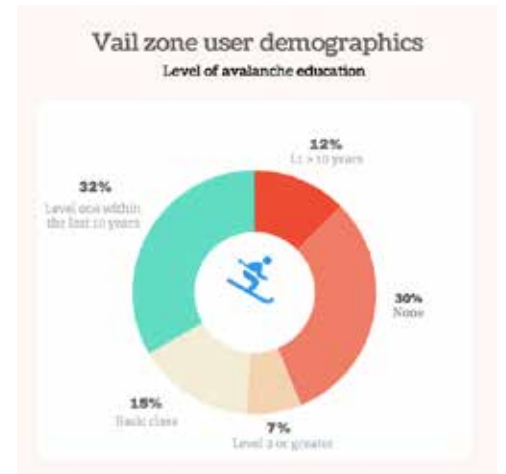
I grew up in Colorado's Vail/Summit County zone and have been venturing into the backcountry since the late 1980s when I was in high school. Back then, we barely had a clue and made every rookie blunder possible. This included skiing East Vail, which has since become one of the deadliest backcountry zones in America, responsible for seven avalanche deaths, all sans rescue gear. It took being buried to my waist on Vail Pass to begin my evolution from a reckless 20-year-old to a prudent snow-safety instructor.

I moved to Big Sky, Montana, in the late 90s where I coached the junior freeride team returning to Vail full time in 2010. Upon returning, I was curious to see whether East Vail safety protocols had evolved since I left. Specifically, I wondered whether riders were now better equipped and better educated. I also questioned who was driving the growth in popularity. Back in my rookie days, which was at least a decade after the original East Vail explorers, 20 people skiing East Vail qualified as a busy day; three decades later, that number had grown to as many as 300 daily users. I decided to survey as many people as possible,



asking them about everything from what lines they skied to what formal avalanche courses they'd taken and whether they'd triggered or been caught in any avalanches.

Due to work and play commitments, it took three years to reach my goal of surveying at least 90 participants. I moved around the research area trying to capture riders descending both standard runs and more aggressive lines in the zone. I always armed myself with chocolate for bribes and/or rewards. These



were the questions I asked those willing to participate:

What level of avalanche education, if any, do you have?

Do you have any medical training?

Do you carry avalanche rescue gear, including an airbag?

Have you triggered or been caught in an avalanche in East Vail?

I also asked individuals what descent they were planning to ride so that I could pair it with the avalanche danger. Unfortunately, many weren't keen on divulging that information. As a result of multiple unpleasant interactions, I gave up on that aspect of the survey.

I was surprised that all but four people I crossed paths with had avalanche rescue gear.

I was also happy to learn that a fair number of parties had some degree of formal avalanche education (48 of 95), with a smattering of riders (14 of 95) having taken informal seminars or attended presentations. Although not stellar statistics, a sizable number had some basic medical training with a few boasting higher education (16 of 95 had taken WFR/OEC or EMT courses).

Then came the most surprising results. Of the 95 riders surveyed, only nine had done mock searches in that year. Many, including experienced users, were unaware that beacons may succumb to signal drift or "broken" antennae over time. A significant number did not know that a variety of electronics may cause interference. Thirty-one of the interviewees were still using outdated double-antennae transceivers.

My final questions, and by far the most interesting results, related to triggering or being caught in an avalanche. Consistent with the lack of accidents that are reported to forecasting centers, many people were hesitant to answer or avoided answering entirely, even though the survey was anonymous. Fifty-two of the 95 riders interviewed said they'd triggered an avalanche (this ranged from small sluffs to large slabs). Of those 52, 24 had been caught, a whopping 25 percent of all those in-



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SURVEY RESULTS

Total contacts: 95

Triggered a slide: 52

Caught in a slide: 24

Completed Level 1 avalanche course: 30

L1 taken > 10 years: 11

Attended basic avalanche safety seminar: 14

Completed Level 2: 7

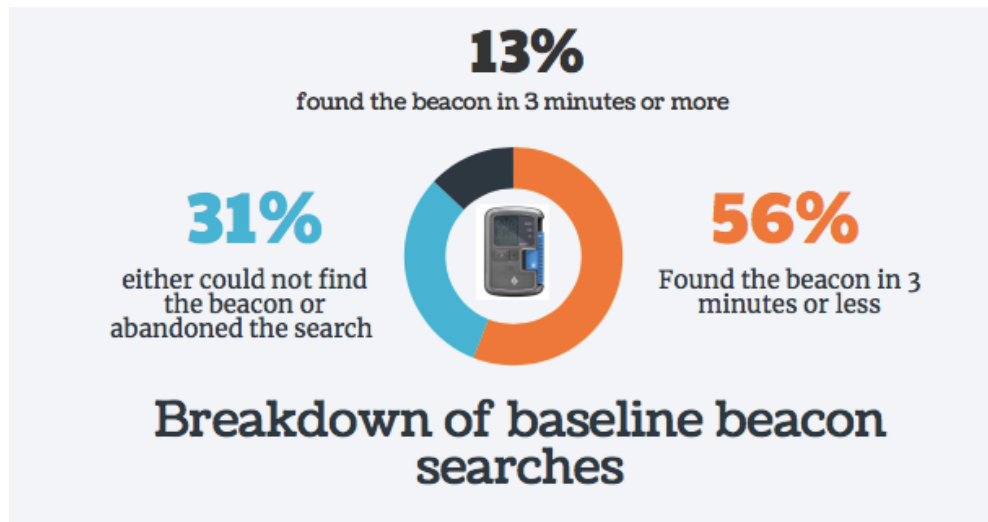
Trained in CPR: 14

Trained in 1st Aid: 12

Trained in WFR/OEC: 15

EMT: 1

Completed a search this season: 9



interviewed. One was a full burial, one was a solo rider who self-rescued, and multiple people said they'd been "knocked down" or "carried."

These results further piqued my interest, so I was inspired to continue researching. Due to the low number of riders who had done a practice search or checked the operation of their transceiver, I focused my next project on beacon use.

As a "freelance" avalanche educator, I've had the opportunity to work all over Colorado for different avalanche schools and outfitters. Due to permitting and logistics, some outfitters have a fairly limited venue for teaching rescue protocols and digging the ever-controversial snow pit. Fortunately, my primary employer has been around since the '70s, so they've secured an expansive choice of terrain options and permits. I used to balk at using the lower elevation "rookie" terrain for teaching, but in recent years, I've been proven wrong. Through a long evolution that I won't bore you with, I started exploring the neophyte zone for rescue classes and day two of both Level 1 and Level 2 classes.

With expansive terrain dotted with plenty of hilly undulations, tree stands and very few members of the public, our teaching area allows for endless rescue scenarios. Rather than setting up a 15-meter run into the practice burial, oftentimes dodging the general public and curious onlookers, which was standard protocol with most of the outfitters I've worked for, we have an unlimited area to create rescue drills. This has given us the freedom to run more creative training.

Two years ago it occurred to my co-worker and me that our students were comprehending the finer nuances of searches faster with our move to the new venue. Having additional terrain and thus the ability to start farther away from the buried transceiver, which allows students to attain the signal versus starting the search within signal range, has been a turning point. Graduating into more complex terrain, such as convexities that decrease the range of the buried transceiver, has further increased the students' comprehension of big-picture searches. In addition, enhanced working space has allowed for wider search margins, the ability to add more students on a group search, and ultimately has given the process a more realistic feel.

We hypothesized that more terrain has granted the students a better understanding

of the search process by requiring them to obtain the search signal, compelled them to understand signal deflection from undulating terrain and allowed students more space to understand gear mishaps. An additional benefit has been students' being obliged to be more vocal with their search teams due to a bigger working area.

To put this theory to a test, I embarked on a public rescue research mission last winter—following up on my prior demographics survey. I set up near East Vail's highly used backcountry access gate from the Vail ski resort, where users tend to be moderately to highly skilled skiers and snowboarders; the same user often exits the gate multiple times a day. To cover all directions from the gate, I set up two rescue scenarios, both in the direction of rider traffic so participants could ride into the scene. I hoped that being able to ride into the search, in the direction of travel, would encourage users to participate since it would add negligible time to their descent. Both schemes had at least a 40-meter run-in, and the transceivers were buried in a shallow hole below a convexity.

I used the international 10-minute benchmark for locating, probing, and digging out an avalanche victim (with the average backcountry burial depth being just over 1 meter/3.2 feet). I allowed searchers three minutes to locate, not probe, the transceiver. The general professional standard is to locate, and probe, two beacons in five minutes and three in seven minutes.

The results may lie in the "ignorance is bliss" mindset, as they weren't stellar. Due to real-world constraints, my research was limited to a few hours a day over the course of four days. My journalist cohort, Devon O'Neil of Backcountry Magazine, attended three of these days and interviewed willing parties while I set up and ran scenarios. Of the 33 gate users we contacted, only 16 agreed to participate in a search. Of the 16, two were ski patrol, two were former students who happened to be in the area, and all but one of the 16 had formal avalanche education.

Those unwilling to participate offered the following responses:

- "I'm good, I don't need to do a search."
- "Ski time is ski time, not education time."
- "I don't have time, I need to get to work."
- "I just don't want to do it."

Two of the 16 searchers found the trans-

ceiver after three minutes and five were either unable to find the beacon after a long effort or gave up in frustration. One user actively discouraged and left his partners who wanted to do the search; another tried and failed with an older beacon that no longer had a viable search range. Two recent Level 1 graduates had their two-way radios mounted directly over their chest-harnessed beacons, which has the potential to cause interference (they said their instructor had not explained potential electronic interference). Another searcher, who was well over the three-minute mark, was most likely steered off course due to his cell phone being within 30 centimeters of his transceiver.

Finally, I had the opportunity to work with an internationally employed photographer during my research. We buried a beacon under his standard backcountry photo pack. My updated transceiver had a search jump of 15 meters; the photographer's beacon was erratic, bounding between 15 and 30 meters, and his search time increased significantly.

The takeaways? **As instructors, we need to be setting our students up for success. As professionals, there is no excuse for a substandard beacon/rescue scenario. As a recreational skier, make sure you understand how to acquire a signal, follow the signal and be a useful partner or rescuer.** ■



Photo Liam Doran

Kelli Rohrig grew up in a third generation skiing family. Life on snow has been a constant, minus a very short and unusual foray into politics. Her on-snow career has included Nordic, Alpine, and Freeride coaching, mechanized and self propelled guiding, snow shoveling, and educating. Lately, she's been focused on heuristics in the backcountry and potential climate change effects on the snowpack. Kelli also runs a non-profit called The Glide Project that works with youth and avalanche education.

WILL THE SLOPE SLIDE?

Preliminary measurements of the spatial variability of crack-face friction

BY RON SIMENHOIS, KARL BIRKELAND, KELLY ELDER, GAVIN GUNDERSON, ETHAN GREENE

INTRODUCTION:

Dry slab avalanches start with a crack in a buried weak snowpack layer. As the crack advances, the weak-layer collapses, losing its volume. The overlying slab then progressively loses support and comes into contact with the bed surface as the crack-faces close. Finally, the gravitational force pulling the slab down-slope must overcome the crack-face friction for an avalanche to occur. The last step is a crucial step for dry slab avalanche release, but thus far, it has received only modest experimental attention.

A common method to mitigate avalanche danger in the field uses slope angle measurements to reduce exposure to slopes capable of producing a down-slope motion of the slab after a weak-layer fracture. In reality, determining whether a slope is steep enough to avalanche is not so simple. Whether an avalanche will start sliding or not does not depend solely on slope steepness. From an avalanche release perspective, it depends on the relationship between crack-face friction and the gravitational force pulling the slab downslope. This friction is controlled by several factors, including properties of the interface between the bed surface and the bottom of the slab.

Previous studies found that persistent weak layers tend to produce lower crack-face friction than non-persistent weak layers (van Herwijnen and Heierli, 2009; Simenhois et al., 2012). Simenhois et al. (2012) also found a negative correlation between slab hardness and crack-face friction. While these results suggest that crack-face friction depends on snow properties; to our knowledge, the number of measurements is still relatively limited, and many questions, including how crack-face friction varies across a slope, remain unanswered.

We collaborated with the Colorado Mountain College Avalanche Science program to collect spatial variability measurements of crack-face friction. We asked Gavin Gunderson, a student in the program, to help us collect field measurements as part of his work-experience portion of the program. In this article, we present preliminary data on the spatial variations of crack-face friction across two slopes.

METHODS:

Over the winter of 2018-19, we collected two datasets of 16 measurements (11 and five respectively) on Ball Mountain and Fremont Pass, near Leadville Colorado (Figure 1). In each pit, we used a Sony HX80 Compact Camera to record videos of the sliding motion of modified propagation saw tests (PST). Our modified PST differs from a standard PST (Gauthier and Jamieson, 2008, Greene et al. 2010) by having block length longer than 1m, and by having the upslope and downslope faces of the blocks perpendicular to the slope

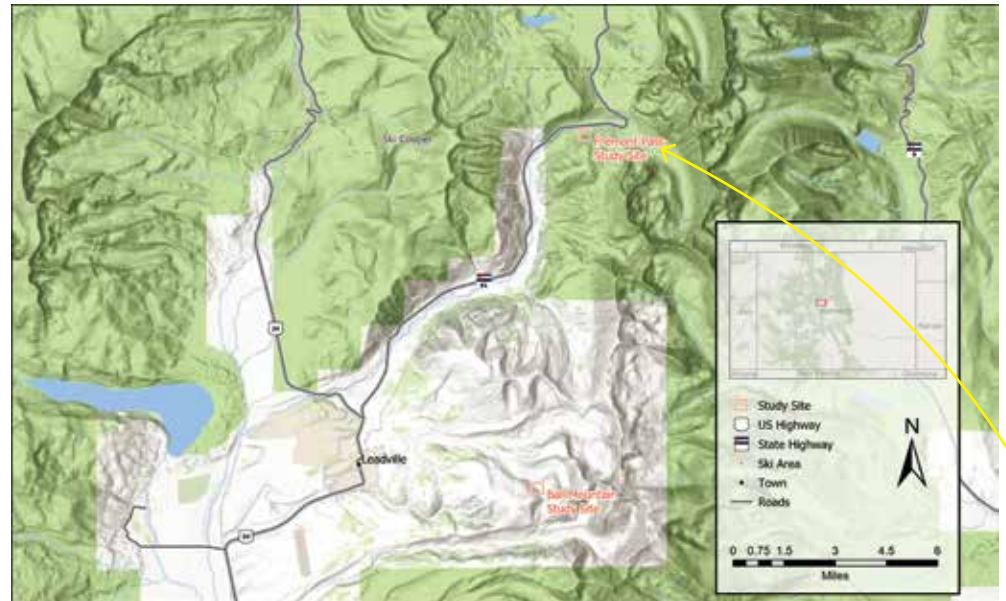


Figure 1: Area map of our study plots. Both our test slopes were below treeline on north-northwest and north-northeast aspects near Leadville, Colorado.



Figure 2: Ball Mountain test site at 11760 ft above sea level, on a north-northeast slope. We measured crack-face friction in 11 pits. The distance between the pairs in each row is approximately 10 m, and the distance between the rows is about 10 m.

PST Fremont Data Pit	Gavin Gunderson	Stability:	HS180 PF25	Layer Notes
Sawatch	Sat Feb 2 11:00 2019	Air Temperature:		109-118: Problematic layer
CO	Co-ord: 13S 396901E 4357172N	Sky Cover:		
Elevation: 11047 ft	Slope Angle: 33°	Precipitation:		
Aspect: 330°	Wind Loading:	Wind:		
Specifics:				

Depth (ft)	Crystal Form	Crystal Size	Moisture	P (kg/m³)	Stability tests
180	V	1	D	198	
170	#	0.5	D		
160	□	1	D	240	
150					
140	#	0.5	D		
130					
120	□	1-1.5	D	280	
110	⊙	0.3	D		
100	□	1	D	312	
90	#	0.3-0.5	D		
80					
70					

Fremont Pass (site 2) data pit.



Figure 3: Pit setup with a tilted camera in the slope direction to capture the slab sliding motion in the x-axis. The red markers on the top of the PST-like block are 1 m apart for size calibration. The black rectangles are used by the tracking software as a reference point to measure motion for every video frame.

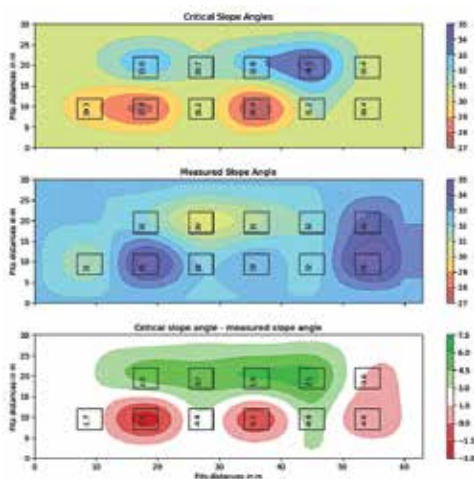


Figure 4: Graphical representation of our Ball Mountain measurements. The upper chart shows the critical slope angle across the slope. Pit locations and actual measured values are in the rectangles. We initiated the boundaries with average values and used a linear spline interpolation to generate the contour lines in all three charts. The center chart shows the bed-surface steepness across the slope. The bottom graph represents potential sliding and none sliding areas. Red areas are zones where the slope is steep enough to slide, and the green regions are zones where the slope is not steep enough to slide.

(Figure 3). We made sure that in each dataset, all modified PST cuts were on the same weak layer. In addition to a sliding block video, in each pit, we also collected bed surface inclination, weak-layer properties, and slab properties. We collected snowpack properties from one data pit for each measurement set.

We placed black rectangle markers on the slab and markers on the top of the block for size reference (Figure 3). We assume Coulomb friction between the slab and the bed surface after the weak-layer collapse. We measured the acceleration in the downslope direction using a Lucas-Kanade method computes optical flow (Lucas and Kanade, 1981). The errors of our video measurements were less than 1 mm. We omitted videos (or part videos) where the slab motion in a non-slope direction exceeded 5% of the overall motion. We applied Newton's second law of motion to calculate the friction force that limits the downslope motion of the slab block (Herwijnen and Heierli, 2009).

DATA AND RESULTS:

We measured crack-face friction in 11 dif-

ferent pits on Ball Mountain on 10 February 2019 (Figure 2). The Ball Mountain site was at 11,760 ft above sea level on north-northeast facing slope with bed surface angles between 30° and 35° with an average of 32.5°. The weak layer at the site was 2 mm, 4F hardness, FC grains with a 1mm, 4F, hard slab and a 2mm, 1F hard, FC bed surface. The weak-layer depth ranged between 0.43 m (17") and 0.59 m (23") below the snow surface, with an average of 0.52 m (20.5").

Our critical slope angle (the slope steepness where a slab above a propagating weak-layer crack will slide) measurements varied between 27° and 34° with an average of 30.5° and up to 6° difference within 10 m distance. We subtracted the actual slope angle from the critical slope angle to determine in what areas in our study slope are capable of producing initial sliding after a slab release. We found variations between 2° below minimum sliding angle and 7.5° above than the minimum slope angle for a slab to slide within 10m (~30 ft.) distance (Figure 4).

Our second test site was on Fremont Pass, where we measured crack-face friction in five different pits on 2-3 February 2019. The Fremont Pass site is at 11,050 ft above sea level, on a north-northwest facing slope with bed surface slope angles between 31° and 35° and an average of 33°. The weak-layer was 1-1.5 mm, 4F hardness, FC grains, with 0.3-0.5 mm, 1F hardness, wind-packed slab above, and 0.3 mm, K hardness, and a MFC bed surface. The weak-layer depth ranged between 0.53m (21") and 0.65m (25.5") below the snow surface, with an average of 0.58m (23").

Our critical slope angle measurements varied between 29° and 36° with an average of 31.5° and up to 6.5° difference within a distance of 10 m. Subtracting the actual slope angle from the critical slope angle shows variations between 4.5° below the minimum slope angle for sliding to 1° steeper than the minimum sliding angle within 10 m (~30 ft.) distance.

SUMMARY, CONCLUSIONS, AND LIMITATIONS:

We presented two unique datasets showing the spatial variability of crack-face friction. Our data suggest that a critical slope angle for avalanche release might vary sizably across

a slope. In fact, in some places, we measured an up to 6° change in the critical slope angle (25% of kinetic friction coefficient). On both of our study slopes, the variability in the critical slope angle exceeded the variability in the actual slope angle along the bed surface. The spatial variability of crack-face friction is in line with the spatial variability of almost every other snowpack property we can measure.

Our results suggest that managing the avalanche hazard with terrain and slope angle may be a bit more complicated than previously thought. Further, we already know that different snowpack properties tend to have different crack-face friction (van Herwijnen et al. 2016). We encourage folks to adjust their slope angle travel guidelines by carefully paying attention to the slope angles of recent avalanche occurrences.

Our measurements have a few sources of potential errors. The direction of motion was not always only in the down-slope direction, although this should have little effect on the results. Slope measurements were within an error of +/- one degree, and we estimated our distance measurements to be within a 2% error. We estimate our overall critical slope angle errors to be within +/- one degree. Thus, these results should be interpreted with caution and should be considered preliminary.

ACKNOWLEDGMENTS:

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THE 2019 AVALANCHE CYCLE IN COLORADO

An Engineer's Perspective

STORY AND PHOTOS BY CHRIS WILBUR

Avalanche professionals working on land-use planning, mapping, and avalanche defenses must quantify the runouts, extents and flow parameters for long-return period avalanches. Such events are, by definition, rare. They might not occur during our careers. Yet in March of 2019, we witnessed an unprecedented avalanche cycle in Colorado. The series of storms and large avalanches provides us with a unique opportunity to do a reality check on our understanding of these rare events. It also allows us to review the indirect assessment methods that we rely upon. As we begin to reflect, collect data, analyze and discuss our experiences and opinions, several common topics come up.

RETURN PERIODS

What were the average return periods (annual exceedance probabilities) of these large, long-running and destructive avalanches? The data are still coming in, so answers to this question are speculative. That said, based on timber destruction and a review of historic records, it appears that there were dozens of 100-year avalanches. There were probably a few 300-year avalanches too. Not all paths ran big, so the distribution of return periods covers a wide spectrum, but the spectrum was shifted towards lower frequency events compared to most years.

Colorado's documented avalanche history suggests that the 2019 avalanche sizes and runouts, as well as transportation impacts and infrastructure damages, have not been seen since 1906 or earlier. The extent of forest destruction also suggests that many avalanche paths expanded their lateral and distal trim lines into areas not reached in more than a century. Statewide, the big avalanche cycles of 1962, 1986, 1995, and 2003 were clearly exceeded. Newspaper accounts and dendrochronology take the record back farther and include big avalanche cycles in 1891, 1899, and 1906. In the San Juan Mountains of southwest Colorado, the avalanches of 1906 and previous years appear more similar in scale and extent to the March 2019 avalanches than subsequent big avalanche years. Application of dendrochronology methods promises to shed more light on return periods as new data are collected and studied.

RELEASE CHARACTERISTICS

The release characteristics of the March 2019 avalanches exhibited two important characteristics. First, a nearly perfect sequence of weather events created a strong mid- to upper-snowpack structure on top of our usual basal facets. This oversimplified two-layer stratigraphy was mostly able to support gradual loading from December through February. Then the weight of the March storms with SWE increases ranging from 3 to 7 inches in a few days overstressed the strong snowpack. Storm slabs built up over 10-12 days

had included up to 12-inches of SWE. The slab releases were unusually dense and strong enabling fracture propagations that extended long distances and probably transmitted fractures deep into the older snow. The result was impressive fracture lines crossing terrain features that usually confine release widths. Many avalanches had crowns extending thousands of feet with some over a mile long. The second unusual characteristic was that avalanches ran on all aspects. Our prevailing westerly winds and snow structure tend to favor releases on the E-NE segments of the compass. In 2019, all aspects were represented with some impressive west- and south-facing avalanches.

FLOW REGIMES

Most of the large avalanches were dry and cold enough to become highly fluidized. In other words, the flow was granular with no free water and plenty of air space between particles, so internal friction was low. The combination of large release volumes and low friction resulted in long runouts and very tall fluidized or saltation layers, as evidenced by damage to surviving large conifers in the paths. The unusually high saltation layers snapped large healthy trees near ground level and uprooted other trees, leaving behind craters.

DAMAGE AND THE D-SCALE

The real indicator of an unusual avalanche season is the extent of damage inflicted. The Colorado Avalanche Information Center (CAIC) reported that ten homes or cabins were damaged or destroyed in six counties (Hinsdale, San Juan, Ouray, Gunnison, Summit, and Pitkin). Two structures were occupied, yet there were no residential avalanche fatalities. Utilities, including major electric and gas infrastructure, were damaged in five counties. Transportation routes were severely impacted. Fortunately, there were no fatalities, even in full vehicle burials on Highway 91 south of Copper Mountain.

We had the opportunity to apply the high end of the D-scale in 2019. The destructive size or D-scale was developed in Canada and is widely used along with the relative or R-scale, developed in the United States, to describe avalanche sizes. Both the D-scale and R-scale use five size categories. The CAIC reported over 80 D4 avalanches. There were at least three D5s, including the Highlands Ridge (Conundrum Creek) and Garrett Peak in Pitkin County, and the Copper Creek in Hinsdale County. It is likely that more D5s will be discovered away from civilization.

The D-scale was developed to use easily observable criteria including mass, path length, and destructive potential. The de-



icebreaker



women's and men's 260 Tech Top

Layer up naturally this season with icebreaker merino.



Several large avalanches occurred in remote areas like this one on Elk Creek in the Weminuche Wilderness in southwest Colorado.



This concrete splitting wedge avalanche diversion structure designed by Art Mears saved this home in the Conundrum Creek valley south of Aspen.

scription category is subjective, but the easiest to envision and is the essence of the D-scale. The path length was intended by the authors as an observable substitute for maximum (terminal) velocity. In the engineering world, impact pressure is an important parameter, but it must be calculated using velocity squared and density. Since density has a narrow range and velocity is squared, impact pressures are largely determined by velocities. Assuming a density range of 200–300 kg/m³ suggests that D5 avalanches have maximum velocities of about 60–70 m/s (130–160 mph) and D4s have velocities of about 40–50 m/s (90–110 mph). Many of the March 2019 avalanches were between these velocities and some were probably closer to D5 than D4.

The mass column of the D-scale is also important, since it influences the extent and runout limits. Along with terrain, release mass and entrainment are important factors in determining avalanche damage potential. This connection between total mass and destructive potential is very apparent in applying dynamics models.

Forest destruction is another category on the D-scale. A D5 avalanche can destroy 40 hectares (100 acres) of forest and a D4 can destroy 4 hectares (10 acres). The forest destruction in March 2019 will be useful in further quantifying the number of D4 and D5 avalanches from satellite images.

Prior to 2019, the use of D5 was pretty much unheard of in Colorado. Our avalanche starting zones tend to be limited by ridges and other terrain features. Furthermore, the D-scale descriptors of “largest avalanches known” and “could destroy a village” discourage the use of D5 anywhere in the U.S. outside of Alaska and possibly on large volcanoes of the Pacific Northwest. The identification of at least three D5 avalanches further confirms that March 2019 was a truly historic avalanche period.

CLIMATE CHANGE

The causal factors that led to the big Colorado avalanches of 2019 are complex and cannot be directly tied to a changing climate. However, we have observed and measured warmer winter storms with higher rain-snow elevations

over the past two decades. Avalanche practitioners have observed and predict greater overall snowpack stability as a result of warming. Interestingly, practitioners are predicting more avalanches from upper elevation zones and fewer at low elevations. The snowpack structure and loading that Colorado experienced in 2019 were not inconsistent with climatic trends of warmer and wetter air masses colliding with our mountains. Looking forward, it will be interesting to see how climate change affects avalanches in Colorado and elsewhere.

DATA AND OPPORTUNITIES

The 2019 avalanches in Colorado provide us with an incredible opportunity to improve our understanding of rare events. Today we have tools and resources that were unimaginable the last time an avalanche cycle this big occurred. We have weather instruments, satellite images, UAVs (drones), dynamics models, LiDAR, Google Earth, and more. In just one or two generations, we have gone from sparse data to data overload. This is a good problem to have, but it will take time to analyze and digest all of the information. Ultimately, we will learn a great deal from the 2019 Colorado avalanche cycle.

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Chris Wilbur is an avalanche defense engineer based in Durango, Colorado. He is fascinated with the engineering behavior of highly variable complex natural materials, as well as the dynamic response of structures to avalanche loads.





Climbing back out after performing a crown profile on No Name Bowl, triggered remotely from the ridge on December 1, 2019. The crown was over 1000 feet wide, took out the whole bowl down to the facets at the ground, snapped an island of fairly large pines, and moved them 100 yards downslope to the flats. Photo Mark White

OF TROGLODYTES AND TECHNOLOGY

BY DICK DORWORTH

I glide into the eighth decade of life on earth and the seventh of climbing and riding up and skiing down its snow-covered hills and mountains with the intention to continue doing so more attentively than tentatively. Personal intention and attention are things we can control, or at least influence, unlike the weather and the snowpack and the intentions and attentions of our fellow skiers and other citizens of the planet. Like every person past the age of innocence, I am continually reminded of both change and constancy in the things of life and in the intentions and attentions of its peoples, and the world of skiing and skiers is, it seems to me, a microcosm of the larger world.

Years ago, Bob Beattie, one of the best friends American skiing has ever had, passed on to me a universal truism that I always try to keep in mind, especially if a situation or premise seems opaque, contradictory, or just feels wrong. He said, “The basics never change.” Those four words have helped me more than words can describe, though sometimes the basics seem buried in an avalanche of modernity and have to be dug out and revived in order to be more fully appreciated, and their corollaries certainly describe some constant verities and directions: “*If it looks dangerous it probably is;*” “*Why would something appear too good to be true if it wasn’t?*”; “*If it feels bad, it is;*” “*If you wouldn’t do it if the camera weren’t there and you do it anyway, perhaps your lens is not as well-ground and polished as the camera’s;*” and the Kris Kristofferson koan so well known to people of my generation and bent of mind: “*Freedom’s just another word for nothin’ left to lose.*”

Such ruminations about the basics come naturally to one who counts himself basically fortunate to still be carving tracks seven decades down the slope, still contemplating and observing that in skiing as elsewhere sorting out the basics among the changes is a constant practice, as necessary as weeding and watering the garden. A list of recommended gear for the well-prepared, modern, backcountry skier prompts some reflections and observations.

The modern backcountry skier is encouraged to carry the following: backpack (\$150), helmet (\$100), skins (\$100), saw (\$20 to \$50), probe (\$30), stove (\$50 to \$150), cook kit (\$15 to \$60), water bottle (\$15) (thermos (\$30) optional), compass (\$15 to \$70), map (\$20), whistle (\$3), two-way radio (\$35 to \$100), phone (satellite if possible) (\$50 a week to rent, \$1500 to own), shovel (\$30 to \$70), Avalung (\$130) or ABS Airbag (\$800), snow study kit (\$70 to \$120), heart rate monitor (\$60 to \$650), first aid kit (\$20 to \$150), transceiver (\$200 to \$500), bivouac bag (\$150), tool kit (\$45 to \$75), GPS (\$300), goggles (\$30 to \$180), colored ribbon and orange chalk—for the helicopter in case of rescue—(ribbon and chalk are inexpensive but you can’t afford the helicopter), headlamp (\$30 to \$100), extra clothes, food and the knowledge and training of at least a Level I Avalanche course (\$200 to \$500) and a First Aid Wilderness First Responder course (\$650) as well as the latest local avalanche advisory (prices included as caveat emptor for prospective backcountry skiers as well as caveat for those ‘earn your turns’ back-to-the-basics Brahmins who sniff at the effete, less organic, lift-riding, alpine skier elitists who generally have far fewer avalanche concerns). These and other things are used in one of the three categories of avalanche gear: avalanche avoidance, avalanche survival, and search and rescue.

These items and the admonition “be prepared to spend the night out” are among the modern prerequisites for a day trip into the local mountains. For an overnight tour or longer a tent, pad, sleeping bag and more food seem to be necessary. The majority of the items mentioned are tools of security, not toys of recreation.

The life of skiing is recreation, and while backcountry skiing may well be among the most dangerous of outdoor activities (including climbing, hang gliding and BASE jumping), the question arises: at what point do the anxieties of security diminish/destroy/deny the pleasures of recreation? The solo ski mountaineer is an anomaly in today’s backcountry in some measure because the soloist cannot rely on or, really, even consider technology as useful in a crisis, and yet for some the solo experience of the backcountry is the best recreation of all.

The expansion of the possible in skiing big lines, steeper slopes, and riskier situations has gone hand-in-hand with the technology of security. (It also goes hand in hand with the democratization of abilities that the technology of wider skis and stiffer boots has introduced to skiing.) It seems to me that both metaphorically and experientially the combined physical and psychic weight of all that security both changes and interferes with the joy and freedom of a well-executed turn, and this interference extends to many other situations in life.

It is true that the only sure way to stay out of an avalanche is to ski slopes less than 30-degree steepness, and that gets old and tame and not very exciting. It is (equally?) true as well that having and using all the most modern avalanche technology and scientific knowledge and analysis does not guarantee that the slope

IT IS WORTH QUESTIONING WHETHER PERSONAL SKILLS OF SURVIVAL ARE BEING REPLACED BY TECHNOLOGICAL FIXES OF SECURITY.

analyzed as safe will not slide. There are no guarantees, only risk assessment.

Two recent conversations are relevant. I was describing to a highly experienced and competent backcountry skier an incident in Switzerland nearly 40 years ago when I shut down a film shoot involving the day's work for 10 people simply because I didn't like the look of the bowl we were set up to ski, which slid on its own two days later, substantiating my sense of its instability. It was a huge slide. My friend said, "Didn't you dig a pit?" I replied, "No. We didn't know enough about the science of digging pits to understand avalanche danger." What I didn't say to my friend, for whom the techniques and technology of backcountry security are intrinsic to the experience, is that had we known such things and had the shovels to dig a pit, the results might have confused more than clarified what was, for me, a straightforward issue. Pits are treasures of useful information for the knowledgeable digger, but spatial variability in the snowpack is as real as the differences between every snowflake that has ever fallen or ever will. If we had dug a pit and the results indicated stability, there would have been enormous peer and professional pressure to keep the show going, to ski the slope and get the shot.

While peer approval confers its own kind of security, it is basically as riven with a sort of spatial variability that makes the most trembling snowpack look like Gibraltar. Peer pressure, like the illusion of security in what is in essence a dangerous activity, tends to distract both mind and heart from the basics of survival.

Before continuing, I wish to make it clear that this *in no way* is a call to not dig pits, study the daily avalanche reports, carry the tools of rescue, or acquire as much knowledge as possible about the proper use of those tools and the contingencies of disaster, all of which have and will continue to save people's lives in the backcountry. It is only to point out that they change the backcountry skiing experience in more ways than extra weight and expense. For some people they tend to make risk assessment a technological issue and instill an unwarranted confidence that, it can be argued, costs as many (or more) lives than it saves.

I mean, a great deal of backcountry skiing was accomplished before snow science, transceivers, and the other gear was developed and used, and, while modern skiing in all ways is of a far higher standard with a greater range of possibilities, it is worth questioning whether personal skills of survival are being replaced by technological fixes of security. It is an issue that I think deserves more attention than it gets. One leading avalanche professional commented on the subject, "I'm the sort to embrace technology to give me an edge. Having an edge is all it takes to stay alive sometimes." The question is this: **does embracing technology both give an edge and tend to push one over it?**

Of the three categories of avalanche gear, the first—avoidance—is by far the most significant, important, and useful. I know many people who have survived avalanches unscathed, a few who have survived with varying levels of damage, and all too many who did not survive. That said, in my view the

only attitude and intention to take into the backcountry is that if you are caught in an avalanche you are completely fucked. Fucked. Fucked. Even if you escape grave physical harm, there still will exist emotional and invisible damage.

Using the gear in and of all three avalanche technology categories requires proper use of human faculties prior to and with at least as much proficiency as with the technology. At the (considerable) risk of appearing to indulge in what a devoutly Christian ski mountaineer in a decidedly un-Christian (or, at least, un-Christ-like) comment about a piece I wrote in *Mountain Gazette* a few years ago about other changes in our world of mountains as another "Troglydytian rant," there is, it seems to me, a tendency among devotees of the technological to relegate to Purgatory or even lower realms the pure, organic, Caveman's, basic judgment of the kind that knows in the bone that security and survival are not the same thing. The security of wearing a transceiver in an avalanche is insurance that one's companions will be able to find and dig out the transceiver, but it does not mean that with the transceiver is attached to will survive.

The second conversation was with a friend who is one of America's best avalanche authorities. I had been expressing my admitted lack of knowledge tinged with skepticism about the relative merits of the Avalung and, more important, the subtle shift in a sense of security and thinking about the consequences of risk its bearer will take into the mountains. I know

that a (very) few skiers have survived avalanches because they had one, but I was questioning the premise that most skiers caught in an avalanche will have the time, presence of mind and ability to grab the air tube, place it in his or her mouth and keep it there while the avalanche runs its bumpy course and finally buries the Avalung-equipped skier. My friend agreed that it could be a problem but that a skier about to ski a slope that might slide will have the mouthpiece handy in case it becomes necessary. My friend prefers the ABS airbag system that will help keep the avalanched skier or at least the airbag on the surface, partly because the ABS rip cord is more accessible and easier to engage than the Avalung mouthpiece. An avalanche pro I know says "...almost every time I put the Avalung mouthpiece in at the top of a run I hear a voice: 'Can't hurt. Could help a lot.'"

I agree.

However, as I carve tracks into the eighth decade I hope to continue my basic Troglydyte ways of never skiing a slope that I even suspect might slide, whether skiing alone or with a partner or partners. And though I make sure my backcountry partners carry shovels and know how to use their transceivers, I shy away from seeking a security I do not feel in a bag of air or a mouthpiece that any avalanche worth a collapsing snow crystal might rip out of my mouth as quickly, easily and irrevocably as, say, the SEC's most recent failure to adhere and pay attention to the basics and protect the American economy. ●

South Monitor Bowl, triggered from the ridgeline on Thanksgiving Day, 2019. Photo Mark White





Avalanche fracture lines on the north face of Mt. Buckindy in the North Cascades of Washington State, April 8, 2011. Photo John Scurlock

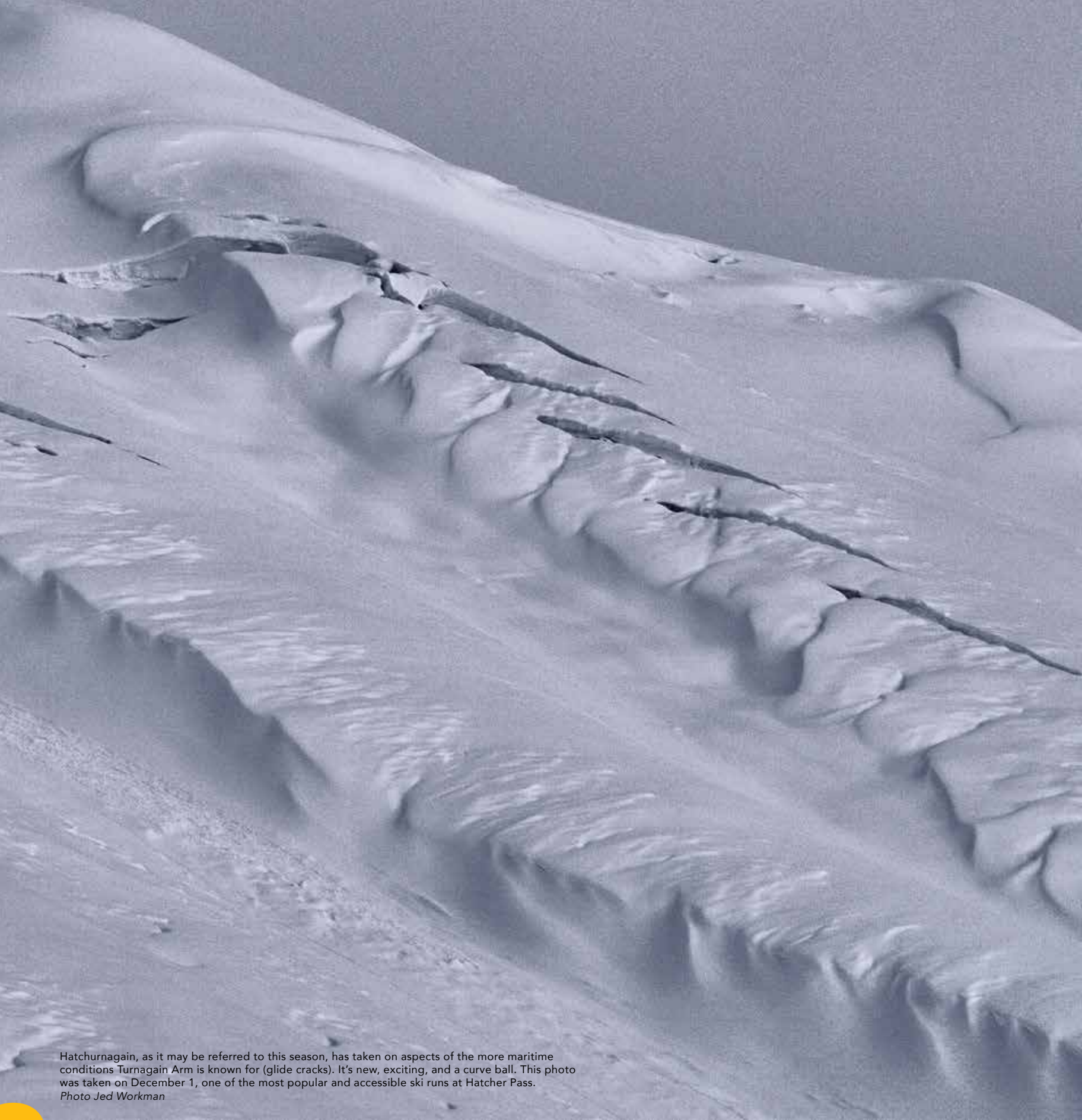
PROBABILITY &

Hello friends of *The Avalanche Review*,

I am doing a mini-theme about Probability and Likelihood for the Feb TAR. I have a few papers which treat the topic well, albeit more from a theoretical starting point, but want to include other perspectives.

Do you use the [CONCEPTUAL MODEL OF AVALANCHE HAZARD \(CMAH\)](#) and its criteria? How do you bring it home to real-life decision-making? What kind of success have you had? What makes it work inside your head when you are making up run lists? Do Sensitivity/ Distribution/ and Uncertainty cover it adequately for you? Or do you have other tips and tricks?

Thanks,
Lynne



Hatchurnagain, as it may be referred to this season, has taken on aspects of the more maritime conditions Turnagain Arm is known for (glide cracks). It's new, exciting, and a curve ball. This photo was taken on December 1, one of the most popular and accessible ski runs at Hatcher Pass.
Photo Jed Workman

LIKELIHOOD

In common conversations in the English language, we tend to use the words likelihood, chance, and probability interchangeably. If you ask a data scientist or statistician, they have more specific meanings for probability and likelihood. Probability is a chance of an event; often a model specifies a general density distribution of probabilities for means.

Likelihood is the measure of how likely any particular estimation of the mean would be.

Intergovernmental Panel on Climate Change uses a nine-step likelihood scale with numeric values for probabilities as follows :

- **Virtually certain:** 99 to 100% probability
- **Extremely likely:** Over 95%
- **Very likely:** Above 90%
- **Likely:** Above 66%
- **More likely than not:** 50% and above
- **About as likely as not:** 33–66%
- **Unlikely:** 0–33%
- **Very unlikely:** 0–10%
- **Extremely unlikely:** Zero to five per cent

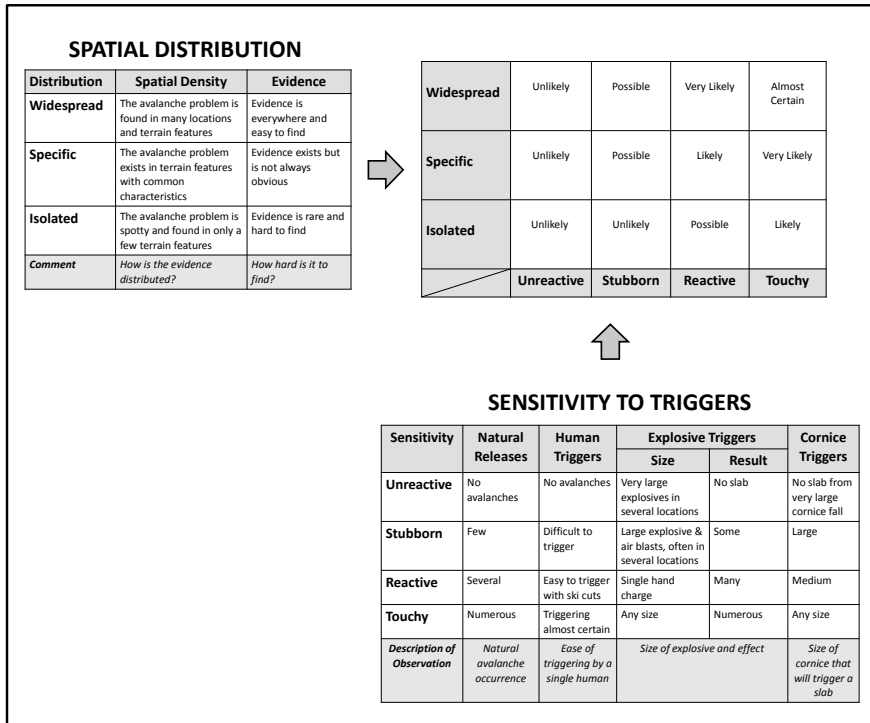
An attempt to match up IPCC percentage values to CMAH could be in the ballpark of:
Almost certain: Above 95% probability
Very likely: Above 90% probability
Likely: Above 66%—Difficult! Maybe 50-66%
Possible: 50-33%
Unlikely: Below 33%

Messy, huh?

—Eeva Latosuo

CONCEPTUAL MODEL OF AVALANCHE HAZARD

LIKELIHOOD OF AVALANCHE(S)



AVALANCHE SIZE

Destructive Size	Avalanche Destructive Potential	Typical Mass	Typical Impact Pressure	Typical Path Length
1	Relatively harmless to people	<10 t	1 kPa	10 m
2	Could bury, injure or kill a person	10 ² t	10 kPa	100 m
3	Could bury and destroy a car, damage a truck, destroy a wood frame house, or break a few trees	10 ³ t	100 kPa	1000 m
4	Could destroy a railway car, large truck, several buildings, or a forest area of approximately 4 hectares	10 ⁴ t	500 kPa	2000 m
5	Largest snow avalanche known. Could destroy a village or a forest area of approximately 40 hectares	10 ⁵ t	1000 kPa	3000 m

We're not getting away from probability anytime soon. In fact it's been here since the beginning. **The etymology of the word HAZARD traces back to the Persian and Turkish words for dice.** Some accounts suggest it carried forward into Arabic, meaning chance or luck. When adopted around 1300 into English, hazard was an Old French word for a specific game of dice.

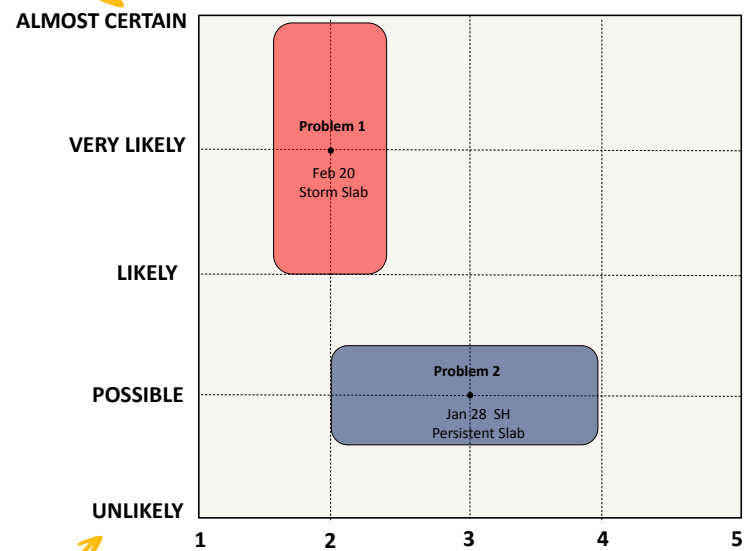
The risk components of vulnerability and exposure are more clear-cut when considering a potential numerical value and hence less opportunity for widely varying (high uncertainty) contribution to the risk equation; i.e. fairly narrowly defined in terms of vulnerable to size X or not, exposed to path Y or not. Hazard contributes the wide range or degrees of potential risk.

A while back I came across an article from NATURE (volume 461, October 2009) about Risk School that argued for the need to teach schoolchildren frequencies and probabilities to help them prepare for the complexity and uncertainty of the modern world, and help them make sound decisions throughout their lives. If teaching statistics at a young age helps to refine intuition, then we in the avalanche world need to use our own likelihoods accurately in our forecasts and decisions.

Steve Conger is a former editor of *The Avalanche Review*. He lives in Golden, BC, where he teaches in the CAA Pro track and consults as Snow Knowledge Inc.



AVALANCHE HAZARD CHART



Link the Hazard Chart to a rating system

GRANT STATHAM



Grant Statham lives in Canmore and works for Parks Canada in Banff as an avalanche forecaster and rescue specialist. He's been working with avalanches since 1986. He was the chair of the 2014 ISSW in Banff and is the first author of both the Avalanche Terrain Exposure Scale and Conceptual Model of Avalanche Hazard.

Good questions. I have always thought that assessing probability or likelihood is the holy grail of avalanche prediction. The hardest part. The business pitch. The crux. Whatever you want to call it, it's the most important and hardest question of the day. Will it happen or not?

I guess I could say I look at it in two different ways: in the office and in the field. The scales of the assessment are very different.

OFFICE TECHNIQUE—Because likelihood is such a subjective assessment with very little to no rational guidance, I try to back up a few steps and consider the inputs that contribute to the likelihood. Rather than choose a likelihood assessment out thin air, I'd rather look at whatever evidence is available. Using the Conceptual Model this leads me to consider both Sensitivity to Triggers and Spatial Distribution—both of which use evidence to reach a conclusion. Sensitivity uses evidence of avalanche activity and triggers to determine how sensitive the snowpack is. Spatial

Distribution considers how the evidence is distributed and how easily it can be found to determine how widespread (or not) the problem is. The combination of these two factors gives me my Likelihood (CM table below).

So using the CMAH, don't just randomly choose a Likelihood; back up and assess the Spatial Distribution and Sensitivity to Triggers based on evidence—that will give you the Likelihood.

FIELD TECHNIQUE (HERE AND NOW)—When I am in the field, my worst-case scenario is to find myself on top of a slope, having waited to make the decision at the last minute based on digging in the slope. I almost never do this, and try to collect observations and evidence throughout the day, making my decisions about likelihood well before I face-to-face with the spot (too much pressure).

It is essential for me that I know the layering and its strength in the snow. So if I don't already know that, then I will have to dig in a few places and test.

My assessments of likelihood are based on my observations or suspicions about avalanche activity, combined with the snowpack structure (layers and strength). When I make an assessment in the field, it is often a risk decision and considers how I will be exposed to the terrain. Left side of the slope? Regroup on the bench? Hours climbing in the runout zone? This way I can weight my options for different degrees of likelihood against different ways of using the terrain. Ultimately that is how I would choose my line. And at the end of all of this, if something doesn't feel right and I cannot rationally explain it—I bail. I rely on my intuition for retreat, but not for pushing harder.

If I could dream up the most useful avalanche research to be done today, it would be to develop better tools and methods for avalanche forecasters and guides to determine likelihood or probability of avalanches occurring. It seems to me the field is wide open.

Great topic to explore for TAR!

BRUCE TREMPER



Bruce Tremper was the Director of the Utah Avalanche Center for 29 years and retired four years ago.

As one of the co-authors of the Conceptual Model of Avalanche Hazard (CMAH), I always caution students hearing about it for the first time- it's a complex topic with layers that unfold over time. It took me many years as a professional avalanche worker to ask myself the now-obvious question: the terms avalanche hazard, danger, and risk: what do they really mean?

If someone had asked me to list the components of avalanche hazard or risk 42 years ago, during my first couple years of doing avalanche control at Bridger Bowl, I probably would have answered, "Give me a pack full of bombs and I'll show you the avalanche hazard." In perhaps an additional ten years, only after I took over as the Director of the Utah Avalanche Center, did I finally start to wonder about the components of avalanche hazard and risk. We would have spirited discussions over the difference between Moderate and High hazard. How should we systematically agree on the hazard rating?

I started filling up my notebook with a myriad of parameters and relationships that make something hazardous or risky. At first, I concentrated just on the probability of an avalanche, since that's how the official avalanche hazard scale defined the various levels. I boiled down probability to a couple of observable variables: 1) sensitivity to triggers and 2) how widespread it was (distribution). It's always a **combination** between these two variables that determine probability; they conveniently fit onto a 2-D diagram with sensitivity on one axis and distribution on the other.

But I quickly realized that hazard is more than just probability; the size and the character of the avalanche is equally important because a shallow, soft slab is a whole different animal than a stiff, deep slab. Consequence is important. Now evidently we had reinvented the wheel—the standard probability-consequence diagram used in hazard calculations in almost all other fields. Hmm. I could have saved a lot of time by doing some background research first, but hey, what's the fun in that?

In both North America and Europe, other avalanche professionals were informally having the same discussions. For instance, the Europeans developed the Bavarian matrix a number of years ago as a systematic way to determine avalanche hazard (now revised and called the EAWS Matrix). In North America, Grant Statham from Canada wisely decided to gather up a North American committee to formalize the components of avalanche hazard and the avalanche danger definitions. And the rest is history, as they say. It turned out to be a much more involved and complex project than we realized but the CMAH was finally published in a peer review journal last year, and can be downloaded for free at <https://link.springer.com/article/10.1007/s11069-017-3070-5>.

As Grant Statham concluded in his 2018 ISSW paper in Innsbruck, Austria, "*Risk-based systems explain how avalanche practitioners have been doing their work for years. Avalanche hazard evaluation illustrates the commonalities between forecasters and guides working in different domains, while avalanche risk control methods highlight the different, and specialized techniques that are unique to each particular operation.*"

Does the CMAH successfully predict avalanche hazard? There's been several good studies in presented at the Innsbruck ISSW, with slightly different results. Encouragingly, Logan and Greene (2018), analyzed Colorado data and found that both avalanche frequency and avalanche size consistently increased with higher forecasted danger ratings—just the way it's supposed to work. In another study, they also found that the probability of fatalities increases exponentially for each degree of danger rating between levels 2, 3 and 4 (where there was enough data to provide a probability calculation). This is good confirmation on the usefulness of danger ratings in general. On the other hand, Schweizer, et al (2018), analyzed Swiss data and found that, although avalanche frequency similarly increased with danger rating, avalanche size was independent of danger rating. So they suggested that the definitions for the avalanche danger scale may need to be revisited. "More studies are needed," as they say.

Also, several studies have found inconsistencies between individual forecasters and forecast operations on their choice of the overall avalanche danger rating, (e.g. Clark and Haegeli 2018, Techel, et al 2018) It seems that using systematic ways to calculate avalanche hazard is simple in theory but even if we monitor the same information sources, we often come up with completely different conclusions. Sounds like the latest news cycle, doesn't it?

Confirmation bias, as well as other biases, are an extremely powerful forces. We all see what we believe. Despite having these new, systematic tools, we are all human, after all. Human biases continue to affect human judgments and decisions.

As avalanche forecasters, we have our beliefs and theories, of course. But I always think about how every year Ed LaChapelle would come back to visit Alta and his first question to the local avalanche workers was "What are the avalanches doing?" He would never ask about our theories or beliefs. It's about the avalanches. Are people triggering avalanches and if so, how sensitive are they. Are they triggered by ski cuts, easy explosive triggers or stubborn explosive triggers? How deep? How wide? Remote triggers? What's the weak layer? These are all easy questions to answer and they are "low entropy information" (Ed LaChapelle), "Class 1 information" (Dave McClung) or "bull's eye" information (Doug Fesler/Jill Fredston).

Early mentors like Ron Perla and Doug Fesler/Jill Fredston used to simplify everything down to: **1) Is the terrain capable of producing an avalanche? 2) Could the snow slide? 3) What will happen if it does?** These are basic concepts of hazard and risk: Is there a hazard? What's the likelihood? What are the consequences? In addition, Fesler and Fredston would always ask what's the uncertainty? This is exactly the framework formalized in the CMAH.

I think one of the coolest, practical applications of the CMAH occurs every time I do a snow profile. I can estimate the Likelihood of Avalanches (the vertical axis) with the results of stability tests and estimate the avalanche size (the horizontal axis) with the mass of the snow above the weak layer. Finally, I can document the size and shape of the eclipse plot in the middle of the diagram based on the variability of my snow profiles.

So how do I come up with my own personal run list for the day? I always start with the avalanche forecast and I pay close attention to the forecast danger rating by aspect and elevation. Next, I carefully review recent avalanches and the important, recent observations, especially those from trusted observers who take photos and submit profiles. Then, I make a Ulysses Contract with myself to avoid all avalanche terrain with a Level 3 or higher danger rating. The remaining terrain is still guilty until proven innocent.

My wife, Susi, wrote a brief Forward in the latest edition of my book *Staying Alive in Avalanche Terrain*. She said that when we first started dating 27 years ago, she discovered very quickly that I was "Scaredy-cat cautious. Slow, methodical, and deliberately cautious." If anything, through the years I've become even more so. So in general, I never venture onto

or beneath slopes steeper than 30 degrees, unless I'm very, very, very close to 100 percent certain that it's not going to slide. While traveling, I do the usual routine observations and tests: where are avalanches? what slopes are getting tracked up? I jump on lots of test slopes, push my ski pole into the snow dozens of time, dig one or more, quick snow profiles on representative slopes. Snow—guilty until proven innocent.

In summary, I think the concepts in the CMAH form the backbone of all my decisions around hazard and risk. It all boils down to probability, consequence, uncertainty, exposure and vulnerability and I think the CMAH has been a very important framework to understand and teach avalanche hazard and risk.

Yes, we have much work remaining:

1) come up with improved algorithms and decision trees to aid forecasters in choosing danger ratings based on evidence

2) find ways to reduce forecaster biases

3) Dare I say it—revisit the presentation and definitions of the avalanche danger scale to better communicate the exponential increase in hazard,

4) get rid of the word "Considerable"

5) Work with marketing, advertising, communication and technology experts on better solutions to effectively communicate avalanche hazard and risk

Like Grant Statham said, **Risk-based systems explain how avalanche practitioners have been doing their work for years.** Perhaps the best outcome of the CMAH is that it gives both professionals and recreationists a shared vocabulary and system to discuss real-life, critical decisions in avalanche terrain.

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KAREN BOCKEL



Karen Bockel grew up first and then learned to ski. She patrolled first in Telluride where she made friends with depth hoar, then in Jackson, where she teaches for AAI. She also works in the Alps as an IFMGA mountain guide.



It is a fascinating subject that falls right into my obsession with how we use words and how we communicate. I often let my pro avalanche course or guide training students know that I am into 'precision communication'... which they makes them afraid, as it should 😊.

In the world of probability and our use of it, I have long been curious how and why we are in general not very good with statistics (Kahneman & Twersky, Prospect Theory), and how and why we have such an interesting use of words of probability (Sherman Kent, Words of estimative probability) and how weather forecasters use things like "a 30% chance of precipitation".

Example:

Ski partner: *I feel good about this slope.*

Me: *How so?*

SP: *Silence*

Me: *Do you think it's possible to make an avalanche on this run?*

SP: *Huff, well, it's always 'possible' to make an avalanche...*

Me (ok, that didn't work): *How likely is it that we make an avalanche on this run?*

SP: *I told you, I feel good about it!*

...to be continued

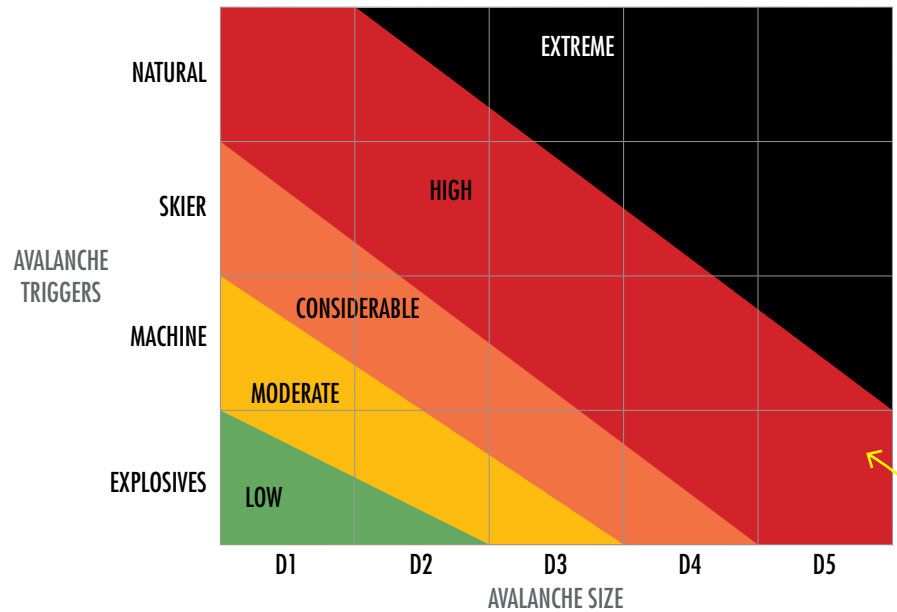
In terms of teaching the framework of CMAH to students and encouraging them to use it to make their own forecasts, I usually start by presenting the usual suspects of CMAH with type of avalanche problem and location. I get into the descriptions of the sensitivity of triggering an avalanche and the spatial distribution. Then, I tell them, ok, great, you can stop thinking for a minute now, and just pluck the right word of probability from the table of how sensitivity and distribution combine. Then you have your general likelihood. I have trained myself fairly well to talk about avalanche problems in terms of their likelihood. We have a stubborn persistent slab. Does it serve us, though? Does unlikely, for example, mean to you a chance between 5% and 25%? Or between 0.5% and 30%? And possible? Or probable? Middle of the range, for you, or actually two different things: much less than 50% for possible, and more than 50% for probable? Very likely, almost certain - does that change our perception of the problem?

And then, of course, statistics are part of the game: when we are forecasting for some spatial range, our range, our mountain, or our drainage, we apply a certain (ha!

how about the use of this word?!) likelihood, but once we reduce that scale, i.e. standing atop of a particular slope, the likelihood component of risk assessment seems less practical than digging back into spatial distribution (does this slope fall into the isolated, for example, terrain categorization where we expect to find our avalanche problem—yes/no binary answer here) and to a much lesser degree the estimated sensitivity of triggering, stubborn, for example, which we agreed on based on prior analysis, observations, and information from others.

In the moment, then, in the terrain that is, I have come to find that likelihood or probability doesn't serve much of a purpose—we can't use a thought process based on probabilities, it's just too complicated. Instead, when we need to make a go / no go decision we resort to simpler questions with simpler answers, which tend to be yes / no answers. Yep, we skip the question of likelihood. We answer these questions instead: Is the avalanche problem present in this terrain? Can a single skier trigger it? Is the slope steep enough to slide? Could the avalanche hurt/bury me? And, maybe, can I get away with it? As we tend to recognize and maybe overemphasize trends much more than probabilities, if a problem has become more stubborn (and therefore less likely) we'll answer with the trend in mind, as in 'can I get away with it NOW?'

DANGER RATINGS BASED ON TRIGGERS AND CONSEQUENCES



With my recent Pro 1 course with a widespread persistent problem, we had multiple of these top-of-the-slope scenarios and the following student-made answers:

Avalanche problem present? *yes (and even no sometimes)*

Can a single skier trigger it? *yes*

Steep enough to slide? *yes (and sometimes barely)*

Could the avalanche hurt me? *yes*

Can I get away with it now? *probably not (= no)*

Result: *slope not skied*

Going back to the initial scenario:

Me: *Feeling good must line up with an 'unlikely' likelihood of avalanches. Give'r then.*

... but does it help? Does using **likelihood** even serve us in our forecasting strategy? It sure makes the graphs practical and pretty and our definitions of the ratings of the NADS fit well. But maybe it is a false comfort. **Would we be better off removing likelihood and instead using sensitivity in terms of triggers (natural—single skier—snomo/multiple skiers—large explosives) and consequence in our rating definitions?** The more I learn about decision-making, the less confident I am in my ability to make decisions well or to even control them, and having complicated components certainly doesn't help.

MIKE RICHARDSON



Mike Richardson is a software developer based in Seattle, WA. His interests include real life happy dogs and research in the public interest.

When Lynne asked me to write about **likelihood**, I thought long and hard about what it really meant, and what it meant to me.

For me, resolving uncertainty really is at the absolute center of how I make decisions when preparing to travel in avalanche terrain.

Even before I travel in avalanche terrain, I begin collecting information about the terrain, weather, snowpack, and people with whom I will travel. This process often lasts an entire winter, and likelihood is something that remains murky and difficult to define precisely until I have worked through my thoughts and feelings about

uncertainty. With respect to space and time, it's possible to spend most of a winter caught between the waves of uncertainty and the rocks of likelihood.

I have long believed that it's important to make conservative decisions when your uncertainty is high, regardless of any other factors. It doesn't even matter if you're uncertain only because you're traveling with someone new: palpable uncertainty is a sign that you lack the information required to make sound decisions about likelihood. So you're unwilling to bet on the unknown? Take a step back and think again.

Likelihood is a tool we use to try to resolve uncertainty

in one direction or another. Maybe I feel very uncertain, but are avalanches really likely? Framed like this, it's easy to see why I believe working with likelihood can create a dangerous foothold for rationalization. We must be very careful with likelihood until we have thoroughly evaluated the reasons behind our uncertainty.

THE LIKELIHOOD SCALE IN AVALANCHE FORECASTING

BY SCOTT THUMLERT, GRANT STATHAM, BRUCE JAMIESON

Two years ago, nine of us gathered before breakfast to plan for the day of helicopter skiing ahead. We aimed to talk about the weather, flying conditions, avalanche hazard, and the run list, except there was an argument about the avalanche hazard forecast. Specifically, what likelihood term we should use to assess the persistent slab problem for the day: “possible” or “unlikely.”

The argument wasn’t serious and only resulted in two angry guides and seven frustrated guides wondering how we wasted so much time. Later, I asked the angry guides what they thought the terms “possible” and “unlikely” meant in terms of probability. Guide one said, “Unlikely is about 5%.” Guide two said, “Possible is about 5%”. Their interpretations of “possible” and “unlikely” were exactly the same! The argument was pointless.

The Conceptual Model of Avalanche Hazard (CMAH) (Statham et al., 2018) has been widely adopted in North America as a systematic, risk-based workflow for avalanche forecasting, and in my humble opinion, is a huge achievement for our industry. Now that the model has been in use for several years, we have the opportunity to explore how it is working in the field and look at how well modern risk terminology works for avalanche forecasting. Based on the above story, and many similar ones, a few of us have been wondering what the words used to describe *Likelihood of Avalanche(s)* actually mean to practitioners as probabilities.

AVALANCHE PRACTITIONER SURVEY

We asked avalanche practitioners from around the world (75 responses) to put a percentage number beside each of the likelihood words from the CMAH (unlikely, possible, likely, very likely, and almost certain) for what they interpreted the words to mean about the probability of avalanches. Figure 1 shows the results.

We observe distinct median values that are similar to forecasting experts in other industries (e.g. Beyth-Marom et al., 1982; Clarke et al., 1992; Reagan et al., 1989). However, we also observe a very large range in probabilities associated with the likelihood terms, and perhaps most importantly, we observe large overlap between categories with average practitioner estimates for “possible” ranging from 2–55% and “unlikely” from 0–35%. This is alarming and it’s not hard to imagine a communication problem developing if one practitioner thinks 5% for “possible” and another uses 35% for “unlikely.”

DISCUSSION OF SURVEY

While this large range and overlap is startling and potentially challenging to work with, it is not altogether surprising. There is a depth of research that has consistently found verbal descriptions of uncertainty, such as “unlikely,” are interpreted differently by different people and also differ widely for the same people in different contexts (e.g. Nakao et al., 1983; Theil, 2002; Morgan, 2017). Are there reasons specific to our industry for the large range and overlap in estimates from avalanche practitioners?

1. Likelihood of Avalanche(s), as defined in the CMAH, results from a combination of “sensitivity to triggers” and “spatial distribution” and has not yet been explicitly defined in terms of numerical probability ranges, meaning avalanche practitioners do not yet have training or guidance on what probabilities we should use for forecasting avalanches.
2. Natural and human-triggered avalanches are rare (e.g. Schweizer et al., 2019), so the experienced-based probabilities from practitioners are likely lower than what many people commonly associate with the likelihood words. Hence, some practitioners provided probabilities for actual human triggered and natural releases (low values), whereas some provided the more common numbers associated with likelihood words (higher values), which contributed to the large range.
3. The reference definition for Likelihood of Avalanche(s) in the CMAH is dependent on the forecast’s spatial scale. It states “*Likelihood of Avalanche(s) is the chance of an avalanche releasing within a specific location and time period, regardless of avalanche size.*” The likelihood of a single wind slab releasing within the entire North Columbia region will be much higher than the likelihood of a single wind slab releasing on Mt. Rundle.

Discrepancy between interpretations of likelihood expressions has been shown to create communication problems (Fischer and Jungermann, 1996). It can reduce forecasting accuracy (e.g. Rapoport et al., 1990) and ultimately compromise decision making (Friedman et al., 2018). In a classic example, in 1961 during the Cold War, John F. Kennedy asked his Joint Chiefs of Staff to evaluate the planned Bay of Pigs invasion. They assessed the probability of success to be about 30% and communicated that as, “The plan has a fair chance of success.” Kennedy interpreted “fair chance” as favorable odds and approved the operation, which ended in stunning defeat. The Joint Chiefs later reported, “*We thought that other people would think ‘fair chance’ would*

Even if avalanche forecasting is probabilistic and includes uncertainty, it should be grounded in clear definitions, and uncertainty should not stem from nebulous terms but the nature of the problem.

—Jürg Schweizer (Schweizer et al., 2019)

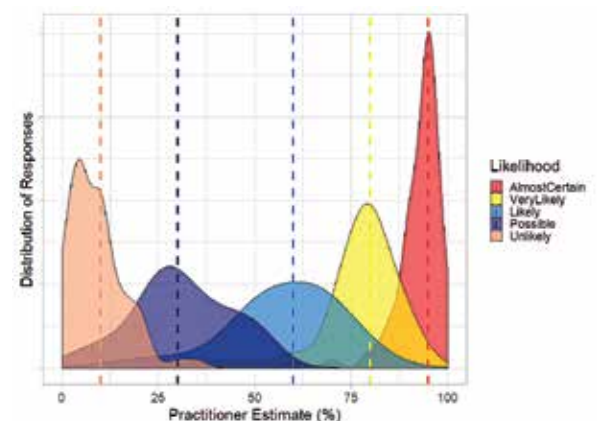


Figure 1: Probability interpretations from professional avalanche workers associated with words used to forecast the Likelihood of Avalanche(s) (CMAH), with median values shown as dashed lines.

Term	Avalanche Practitioners	IPCC*	Intelligence**	Evidence-based***
Very unlikely	NA	0–10%	5–20%	9v18%
Unlikely	0–55 % (10%)	0–33%	20–45%	18–42%
Possible	0–66% (30%)	NA	NA	NA
Even chance	NA	33–66%	45–55%	42–58%
Likely	5–100% (60%)	66–100%	55–80%	58–78%
Very likely	20–100 % (80%)	90–100%	80–95%	78–91%
Almost certain	50–100% (95%)	99–100%	95–99%	91–100%

* from IPCC (Intergovernmental Panel on Climate Change) guidance note, 2010.

** from Intelligence Community Directive 203, 2015.

*** from Wintle et al, 2019.

Table 1: Interpretations of probability associated with likelihood terms from avalanche practitioners compared with published guidelines from other sources. Note, not all terms published in other sources are included in table. Ranges in probabilities are provided with medians in brackets.

Chance	Probability	Frequency description*
Strong chance	> 30%	On average, 30 or more out of every 100 potential paths in the region release the given avalanche problem type.
Good chance	10-30%	On average, 10-30 out of every 100 potential paths in the region release the given avalanche problem type.
Fair chance	3-10%	On average, 3-10 out of every 100 potential paths in the region release the given avalanche problem type.
Small chance	1-3%	On average, 1-3 out of every 100 potential paths in the region release the given avalanche problem type.
Slight chance	< 1%	On average, at most one out of every 100 potential paths in the region release the given avalanche problem type.

*Frequency description not very useful when forecasting for a single path or areas with few paths (use probability ranges or chance terms).

Table 2: Proposed scale describing the Likelihood of Avalanches.

mean ‘not too good.’” The varying interpretations of “fair chance” was the key misunderstanding of the entire project (Wyden, 1979).

Other industries have been working on this problem and have developed strategies we can learn from and potentially adopt. For example, the Intergovernmental Panel on Climate Change (IPCC) has been desperately trying to figure out how to communicate the risks of climate change to the public and policy makers (e.g. Budescu et al., 2014); meteorologists have been promoting the use and communication of probabilistic weather forecasts (e.g. Fundel et al., 2019); and the intelligence industry has developed standards for expressing uncertainty and confidence in judgments (e.g. IDC 203, 2015).

Table 1 shows some comparisons of this study to the guidelines developed by other industries, which also discovered similar wide range and overlap of probability interpretations for likelihood words, so subsequently developed the guidelines shown in Table 1 with the intention of improving communication in their respective communities.

STRATEGIES

Can we incorporate strategies developed by other industries to help with risk communication and forecasting for avalanches? First, we have to make some underlying assumptions:

1. Natural or human-triggered avalanches are relatively rare. Jamieson et al. (2009) estimated the odds of a human triggering a potentially fatal avalanche at considerable danger, skiing one start zone, and “without skilled route selection” between 1:100 and 1:1,000. These odds change by orders of magnitude with varying levels of avalanche hazard. Further, accident data show the risk from natural avalanches is about 10% of the risk from human triggering (Tremper, 2008). Translating these rough odds of encountering a dangerous avalanche into probabilities equates to 0.1-1% for human triggering and 0.01-0.1% for natural releases at considerable danger. For comparison, let’s compare the results from this survey to the North American Public Avalanche Danger Scale (Statham et al., 2010a): “Natural avalanches possible (*practitioner estimate* = 30%); human-triggered avalanches likely (*practitioner estimate* = 60%).”
2. Associating probability numbers with likelihood terms improves risk communication (e.g. Budescu et al., 2009; Budescu et al., 2012). Further, explicitly combining the term with the intended numerical range is more effective than having a separate descriptive table (Wintle et al., 2019). Writing “good chance (10-30%) of avalanche release” is more effective than having a separate table describing the 10-30% range for “good chance.”

3. Using frequency statements greatly improves understanding of probabilities and ensures the reference scales are defined (Gigerenzer and Edwards, 2003). For example, a frequency statement for a “20% chance of avalanches” could be translated to “20 out of every 100 avalanche paths.”

Using these assumptions, we propose some ideas for development of the Likelihood of Avalanche(s) scale used to forecast avalanches. It is critical to understand these ideas are provided with the intention of improving risk communication for field decisions, and not to transition avalanche forecasting to numerical calculations.

Limitation statement: these concepts should be interpreted only as ideas for future development and we present them only with the intention of providing an example of what another scale could look like, and to inspire debate, conversation, and further research.

Here are three ideas that have potential to improve risk communication for avalanche work:

1. Consider this definition for *Likelihood of Avalanches*. Please read carefully:

Consider ANY avalanche path in the forecast region where the specified avalanche problem type is expected to exist. Likelihood of Avalanches is the chance of those avalanche paths releasing within the forecast time period, regardless of avalanche size.

For example, PERSISTENT SLABS—BTL (below 1,900 m) on ALL ASPECTS, what is the chance of those paths releasing naturally or from human triggering?

This definition includes the relevant spatial scale: any potential avalanche path. It automatically adjusts to whatever spatial scale is forecasted for. It also allows the translation of probability into frequency descriptions. For example, “Persistent Slabs—Good Chance (10-30%) to size D3” would translate to, “On average 10-30 out every 100 potential paths will release deep slab avalanches.”

2. **Associating numerical probability ranges for each word in the scale that are more closely aligned with the underlying rates of avalanche release probability.**

These probability ranges will be much lower than the results of the survey and what is presented in Table 1, and more similar to other natural hazards (e.g. Porter and Morgenstern, 2013). We propose numerical ratings that increase by a half order of magnitude in Table 2. As better data emerge for natural and human-triggered avalanche release rates, these probability ratings can and should evolve.

3. **Using chance terms to describe the probability of avalanches as these words are more intuitively associated with lower probabilities.**

LIKELIHOOD OF AVALANCHES	AVALANCHE SIZE				
	D1	D2	D3	D4	D5
STRONG (>30%)	1 or 2	3	4	5	5
GOOD (10 TO 30%)	1	2 or 3	3 or 4	4	5
FAIR (3 TO 10%)	1	1 or 2	3	4	4
SMALL (1 TO 3%)	1	1	2	3	4
SLIGHT (<1%)	1	1	1	2	3

Figure 2: Guidance for combining Likelihood of Avalanches with avalanche size to assign avalanche hazard ratings (after Muller et al., 2016a; Clark and Haegeli, 2018).

As evidenced in the survey results and literature, likelihood words are already commonly interpreted with underlying probabilities that are much higher than actual avalanche releases. Thus, we need words that can be easily associated with these lower probabilities for use by people working in the field. For example, it is not intuitive for most people to use the word “likely” with a probability of less than 50% (Mauboussin and Mauboussin, 2018). Suggestions are provided in Table 2.

APPLICATION

Table 2 offers forecasters a very different way of evaluating the Likelihood of Avalanches based on estimates of either avalanche frequencies or probability. When forecasters are evaluating a particular avalanche problem, they might (for example) imagine 100 avalanche paths typical to their area that could produce this type of avalanche and then estimate how many of these paths they think will release, both naturally and with human triggers. While the frequency estimate works for areas with many paths, it's not so useful when evaluating single paths or areas with only a few paths. In these cases, the subjective probability estimates or the chance terms are more appropriate.

INTEGRATION WITH FORECASTING

How would this Likelihood of Avalanches scale combine with avalanche size to produce a hazard rating? Figure 2 shows a potential method to be used as a suggestion or starting point for the hazard rating (after Muller et al., 2016a; Clark and Haegeli, 2018). It should be adjusted by expert judgment as deemed appropriate. More specifically, expert judgment is very much required to combine the various avalanche problem types that may be present in the snowpack into the hazard rating.

FUTURE RESEARCH

The important paper by Schweizer et al. (2018) attempts to establish the relationship between

avalanche occurrence and the avalanche danger level. We strongly encourage future studies like this with robust avalanche occurrence datasets to better define probabilities of avalanche release at various hazard levels. 🍷

Scott Thumlert, Alpine Solutions and Canadian Mountain Holidays (sthumlert@avalancheservices.ca)
Grant Statham, Parks Canada and Alpine Specialists
Bruce Jamieson, Snowline Associates Ltd.

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THINKING IN BETS

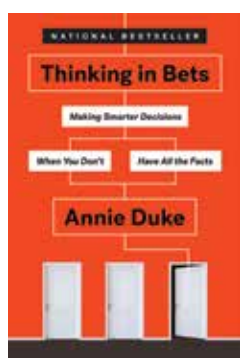
BY JENNA MALONE

In my work teaching avalanche courses, I've met many students who want to treat personal forecasting like chess. They seek a formula for deciding when a slope is safe to ski. After all, our access to snow data is greater than ever, and my students with analytic professions (engineers, pilots) are used to an equation where information plus effort equals success.

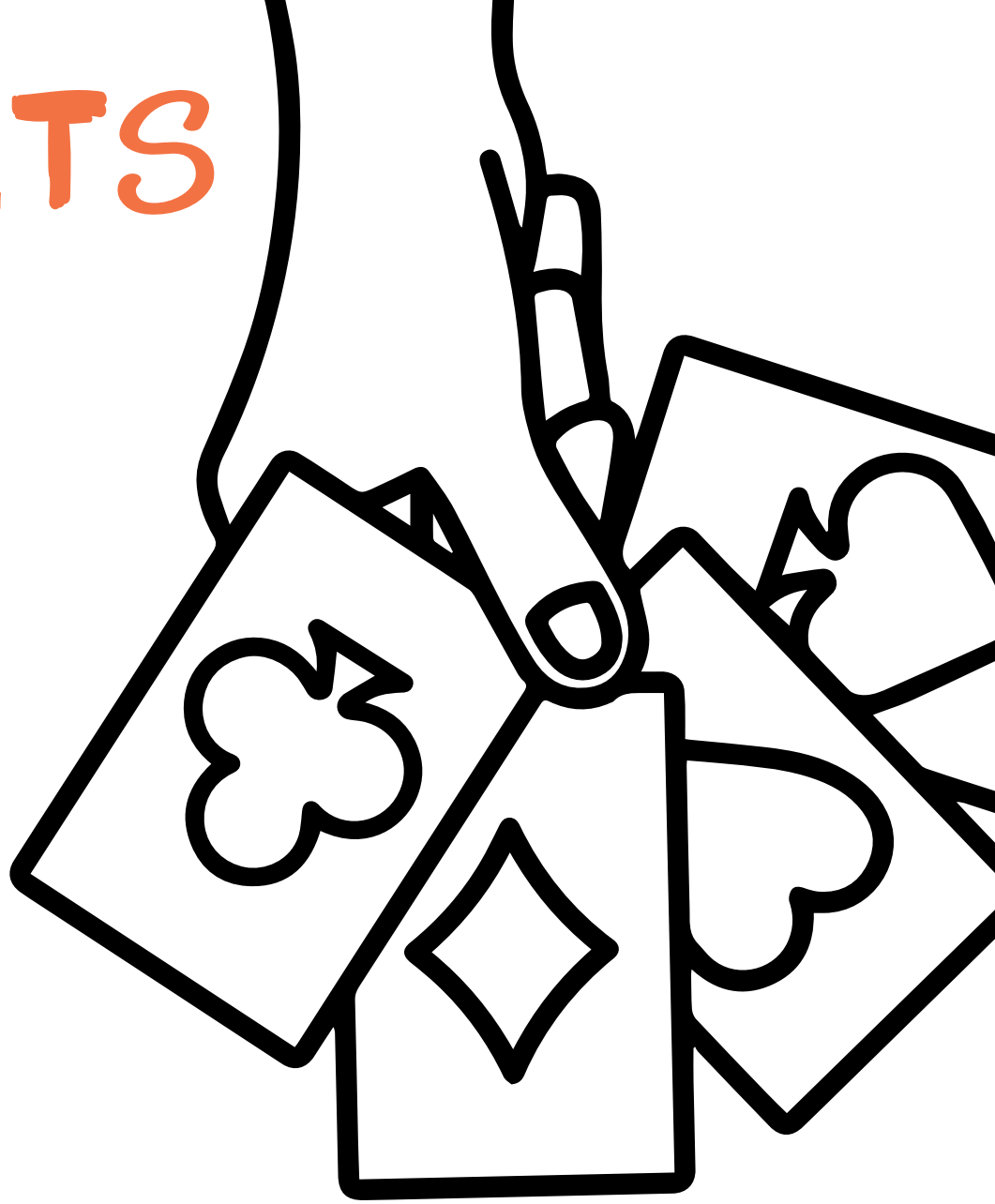
In *Thinking in Bets*, Annie Duke, a poker champion and former behavioral scientist, examines some of our common errors in decision-making. Duke describes chess as a game with “no hidden information and very little luck. The pieces are there for both players to see. If you lose, it's because there were better moves you could have made but didn't.” Poker, on the other hand, is rife with hidden information, luck, uncertainty. Avalanche forecasting shares this with poker. One attendee of the ISSW in Banff in 2014 remarked that “‘uncertainty’ was the single most common word of the conference... followed closely by ‘beer.’” Those of us who've worked in snow for some time know that uncertainty abounds. Or, we think we do. Duke found that experts in a field fall prey to the same decision-making errors as rookies, and people with more training can have bigger blind spots.

It turns out the better you are with numbers, the better you are at spinning those numbers to conform to and support your beliefs.

—Annie Duke, *Thinking in Bets: Making Smarter Decisions When You Don't Have All the Facts*



(quotation courtesy of Rob Coppelillo)



Duke points out that “decisions are bets on the future.” Every decision has an inherent amount of uncertainty. Too often we give ourselves credit for making the right call when we ski a slope and don't trigger an avalanche, and ignore any role that luck played. Conversely, when things don't go our way, we blame bad luck, or forces outside of our control. Duke calls this “resulting,” wherein we judge the quality of a call by its outcome.

The fundamental problem, she finds, is that we live in an ambiguous world, where there is much we don't know. In combination with this, she says, we like to think we're awesome. Social psychologists have identified an evolutionary drive for this: when we appear more confident, we can attract a better mate. Confidence leads to increased happiness, and better health... unless, of course, we get killed in an avalanche because of it.

Imagine you're driving, and you decide to run a string of red lights. Maybe it's the middle of the night and you're in a deserted part of town; no one hits you. Even during the day in a busy intersection, you might get away with it. This is terrible decision-making with excellent luck, an example easy to recognize. But data shows that we don't. In a study of multi vehicle car accidents, 91% of the drivers blamed the other driver. Notable explanations on insurance forms illustrate this further, “The telephone pole was approaching. I was attempting to swerve out of its way when it struck my car.” We are masters of self-decep-

tion. The problem, Duke says, is that we form beliefs easily, and then cling to them, because they fit our narrative of wanting to be awesome, wanting to be right.

We've all heard the description of traveling through avalanche terrain as a wicked learning environment. Ignoring data that argues against our beliefs is motivated reasoning, or self-serving bias, familiar terms.

Duke describes the debunked research from the 60s declaring fat evil, causing a redesign of the USDA Food Pyramid, and leading to the food industry replacing fat with sugar and starch in thousands of foods. In one generation, obesity prevalence tripled, and rates of diabetes increased. For decades before that, cardiovascular disease had been declining. Rates of heart disease stopped declining and leveled off, in spite of more widespread use of medications and surgery. We later learned that the 60s research was funded primarily by the sugar industry, and published before our current laws regarding financial disclosures or conflict of interest. We can't interview the three now deceased Harvard researchers who published the now debunked study about their blind spot regarding their bias in favor of sugar. We might think, these were researchers at Harvard, highly educated physicians and scientists, they would recognize such bias in themselves. Just as we might think, “I'm an experienced backcountry skier/ ski patrolter/ avalanche educator/ guide, I can recognize changing conditions or data that argues

against my morning forecast, I wouldn't have such a blind spot." Wrong.

In 2012, a trio of psychologists studied the blind spot bias, and found that subjects with a higher level of cognitive sophistication (in our case, a higher level of avalanche training and experience), are significantly BETTER at twisting data to fit the previously held belief, leading to headlines like: "New Study Shows Why Most People Think They're Better Than Everyone Else," and "Why Smart People Are Stupid," in *Business Insider* and *The New Yorker*, respectively, in response to the blind spot study.

So, that's the bad news. How do we fix it?

Duke recommends starting with framing our decisions as bets, which accepts some degree of uncertainty. How sure are we? The noted use of the word 'uncertainty' in recent ISSWs, along with a 'confidence' rating in recent forecasting models, both signal a trend in this direction. Acknowledging uncertainty allows for open dialogue and (this is key) embracing skepticism.

Colin Powell recently spoke in the Wasatch Speaker Series in Salt Lake City. He talked about advising four US Presidents, and the importance of dissent. "Ad-

vice that always agrees with you isn't worth much." Duke suggests forming a truth-seeking group, which she calls a buddy system for adults. Many of us are lucky enough to have this in our regular touring partners. They will hold us accountable, and, ideally, call us on our blind spots. Duke points out that the US State Department created a formal channel for dissent following the Vietnam War, and that the term Devil's Advocate comes from the Catholic church's practice in the 18th century when considering a person for sainthood. One person, the Devils' Advocate (*advocatus diaboli*), would be assigned the role of arguing against conferring sainthood. As professionals, operationalize skepticism in morning guide or patrol meetings. Encourage and depersonalize it. "True skepticism is consistent with good manners, civil discourse, and friendly communication," says Duke.

Perform a premortem. A postmortem investigates the cause of death. A premortem is a look at ways in which the future can go wrong. We've become skilled at this in medicine, for better or for worse, due to malpractice suits in his country. As a Physician Assistant, when deciding whether or not to order a test or scan, I picture myself on the witness stand, defending my decision after things have gone badly. This makes me proceed with caution and question my beliefs. Instead of visualizing success, we should visualize failure. Gabriele Oettingen, professor of psychology at NYU and author of *Rethinking Positive Thinking*, has over twenty years of research in this area, and found that people who envision obstacles in the way of their goals are con-

sistently more likely to achieve success. This is also called backcasting, wherein we picture a future version of ourselves and have a conversation about where we went wrong. Many of us have done this if we've ever stood atop a slope and pictured what the headline would look like if we were to die in an avalanche. We imagine the accident investigation and what mistakes it finds, we imagine how disappointed our family and friends would be.

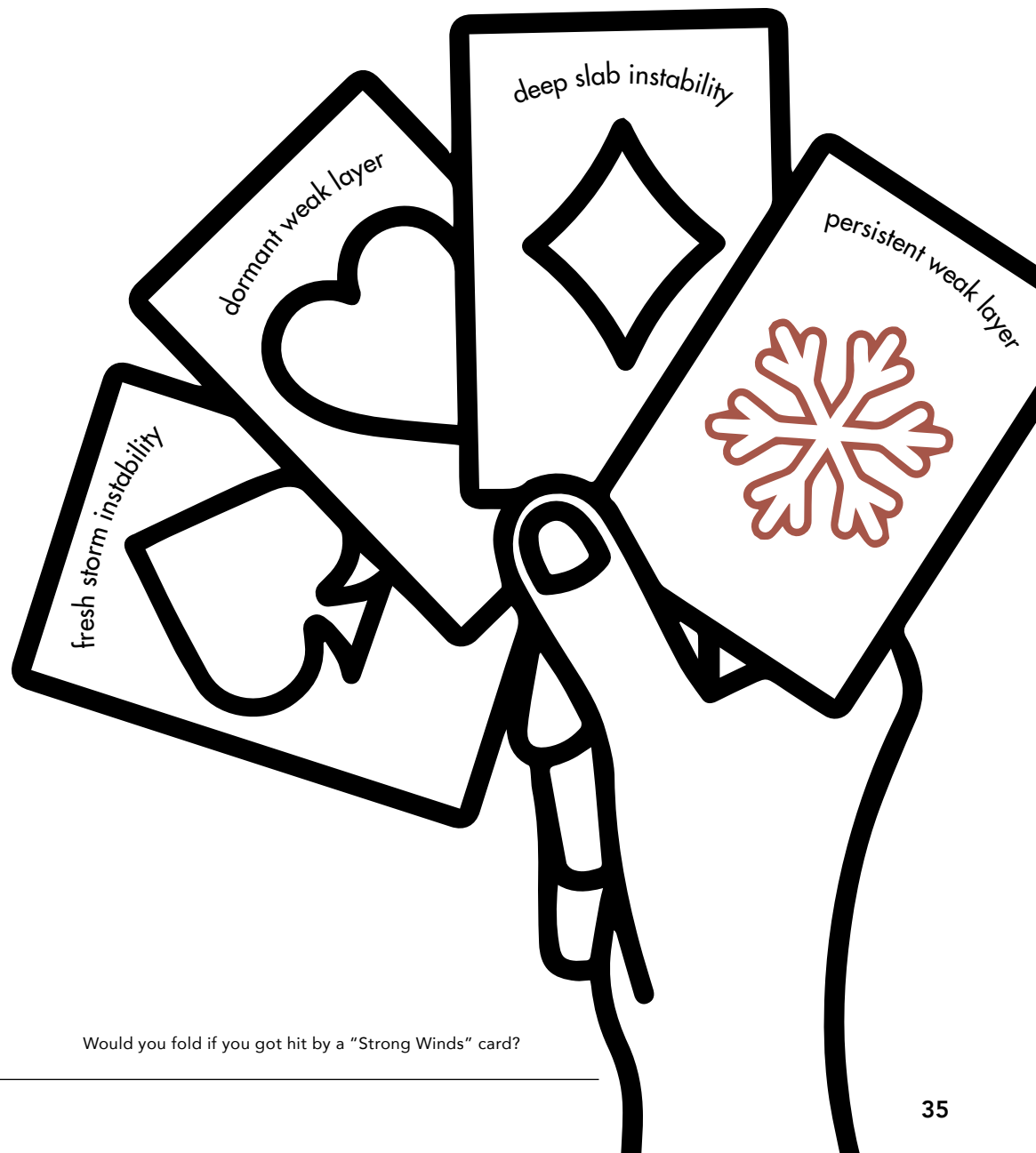
Do the work. While forecasting, like poker, has inherent uncertainty, skilled players (skiers) will fare better. For the recreationists, understand the avalanche problems. Prior to reading the forecast each day, I tell my students, create your own. Read and understand the Conceptual Model of Avalanche Hazard, and keep your terrain choices simple. For the pros, recognize the objective data put together by Drew Hardesty in his essay *Expert Intuition*. When looking at avalanche fatalities by avalanche problem from 1940 to 2015, almost 70% were due to persistent slab or deep slab. We are not good at betting and winning with this problem. Are we trying to outsmart the snowpack? Check your blind spot.

Each avalanche problem has inherent uncertainty. Deep slab is a bad hand. Don Sharaf once told me that if a ski partner tells you he's good at predicting deep slab instability, run. Or, as Hardesty put it, "When the game is rigged, choose not to play." A slightly better deal might give us a persistent weak layer, perhaps one that's been buried and dormant for some time. We're still relying on some luck.

Where's the thin spot? Have the winds and PI increased enough that we're teetering on the edge of collapse? Or will we skate by with our middle-of-the-road pair of sixes? A good hand to have on a given ski day is new snow instability. We can easily predict it and have tools for managing it with ski cuts and good travel habits. This might be three Aces.

Perfect timing on a smooth corn run with no underlying instability is a royal flush, with little uncertainty as long as we time our travel correctly.

These strategies won't instantly fix decision-making blind spots, or stop motivated reasoning, but can help. They'll also help us review others' accidents with greater compassion so that we can learn from them. Duke points out that the goal is to change our course by a few degrees, so that our lifelong trajectory is altered in favor of better decision-making. And, I would add, so that our life's trajectory is long. ●



Would you fold if you got hit by a "Strong Winds" card?

ARE WE ALL COMMUNICATING THE SAME

Words of Estimative Probability and the Language of the North American Public Avalanche Danger Scale.

BY JIMMY TART AND KEN THOMPSON

WEPs

= Words of Estimative Probability

NAPADS

= North American Public Avalanche Danger Scale

This all started with a conversation with a coworker. After completing our avalanche mitigation routes, it was routine for our supervisor to ask over the radio if we were done and ready to open the area. A common response among our mitigation teams was “I feel good about it” and then we would call our area clear to open. One morning after opening our area, my coworker and I got into a discussion about how vague that response actually was and how “feeling good” for one person might hide a different risk tolerance and level of uncertainty that another person might have.

The language that we were using, and possibly misusing, to try to describe our feelings employed single words or terms that are known as “Words of Estimative Probability.” Used to convey the likelihood of an event’s occurrence, some more common of examples of Words of Estimative Probability (WEPs) appear in the “Likelihood of Avalanches” section of the North American Public Avalanche Danger Scale (NAPADS): certain, very likely, possible, and unlikely. I had a suspicion that the numerical probabilities that we attach to them and our corresponding risk assessments were not uniform among professional avalanche workers or recreational winter backcountry users or even humans in general, so I designed a survey to investigate how much in agreement we might be regarding their meanings. Quantifying the words of estimative probabilities from the danger scale can give us data to further refine our personal and public risk communication.

My study consisted of **five questions** regarding the perceived probabilities of each of the following words from the Likelihood of Triggering section of the North American Public Avalanche Danger Scale; “certain”, “very likely”, “likely”, “possible” and “unlikely.” I also



After 16 years of ski patrolling, Jimmy Tart now is a guide for Park City Powder Cats. He teaches pro avalanche courses for the Silverton Avalanche School, is the Snow Safety Director for Majestic Heli Ski in the Chugach Mountains of Alaska, and guides for Ski Arpa in the Central Andes of Chile during the northern summer.



Ken Thompson has nine years of professional avalanche mitigation experience, three of those as an avalanche forecaster. Originally from Maine, he earned

a degree in physics, and later stumbled into snow science. When he is not tracking PWLs or fixing weather stations, he enjoys swimming in cold, salty water.

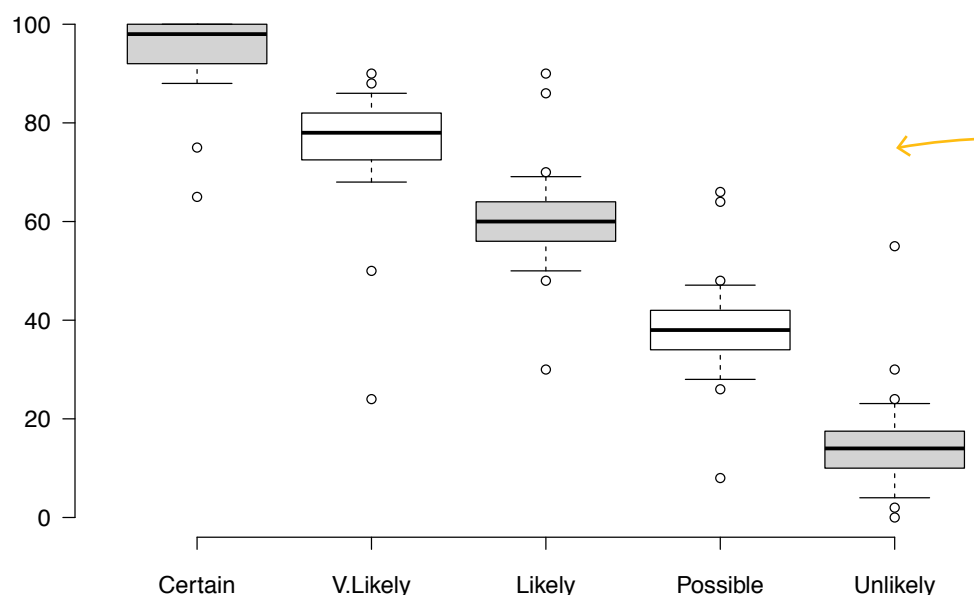


Figure 1 shows the distribution of responses to the survey questions about the words of estimate probability. First, the middle-quartile responses are distributed in an orderly, step-like manner. The WEP “certain”, which came first in the questions as noted had a nice tight range of middle quartile responses with 77% of the respondents ascribing it a value of between 95% and 100%, and 90% ascribing it a value of between 88% and 100%. Outside the middle quartiles is where things get interesting. A meaningful number of respondents define a value one step, sometimes more, different from the majority of respondents. Virtually the entire range of middle quartile responses for “possible” lines up with the first quartile range of responses for “likely” and the fourth quartile of “unlikely” and the fourth quartile responses of “possible” match the range of the first three quartiles of “very likely.”



From the photographer, Ben VandenBos, who is a forecaster at the Sawtooth Avalanche Center: "What does certainty look like to you? The avalanches pictured here failed as part of a narrowly focused, very dense deep slab cycle that occurred in the Boulder and Smoky Mountains of Central Idaho in the spring of 2019. As a personal project, I attempted to document as many of these slides as possible. In one small portion of this area, just 17 square miles of terrain, I observed over 50 deep slabs, whose combined crown length spanned over 10 miles. Very large avalanches certain? I think so. Forecastable? Well, that's another story."

included three questions to establish the respondents' profession and experience with statistics and probability. The distribution of the questionnaire was intended to reach not just avalanche professionals and recreational backcountry avalanche terrain users, but also segments of the professional world that involve risk management and that have embraced probabilistic thinking. Doctors, nurses, securities traders, pilots and firefighters were all targeted in the initial distribution.

Survey responses showed that while humans seem to think similarly about the probability attached to the word "certain," as the scale descends toward "unlikely" the range of responses increases and the distribution of answers widens regardless of profession or level of training. Furthermore and most interesting, professional avalanche workers don't have a more uniform distribution of responses than do recreationalists, medical professionals or people with formal training in statistics and probabilities.

One hypothesis was that professional avalanche workers are in better agreement about how to define these words than recreational users. The results of the survey do not suggest that particular user group is consistently in better agreement about how to define these words.

All in all, the data seems to show that there is potential to improve the communication of risk through a better understanding of how we collectively define the words of estimative probability in the NAPADS. Because the use

of these and other WEPs is common in avalanche risk communication amongst both professional and recreational avalanche risk communication, tightening the ranges and overlaps in the perceived values of the WEPs might be a good way to reduce avalanche accident numbers while also highlighting the limitations of WEPs.

WHAT TO DO WITH THIS?

Currently in North America, the accepted tool for the job of communicating the backcountry avalanche hazards and risks is the NAPADS, where we find an assessment about the likelihood of avalanches using words of estimative probability. Looking outside our industry for solutions to the question of how to communicate risk could help guide us to a refinement of the NAPADS. Further understanding about what is being said and what is being heard, combined with some understanding about the limitations inherent in words of estimative probability could allow people to refine their personal risk analysis algorithm to reduce the number of avalanche accidents.

SUMMARY

The whole goal of this project is to nudge decision-makers in the winter backcountry to make better decisions by framing the Words of Estimative Probability used in the North American Public Avalanche Danger Scale in terms of numerical probabilities produced by

...tightening the ranges and overlaps in the perceived values of the WEPs might be a good way to reduce avalanche accident numbers while also highlighting the limitations of WEPs.

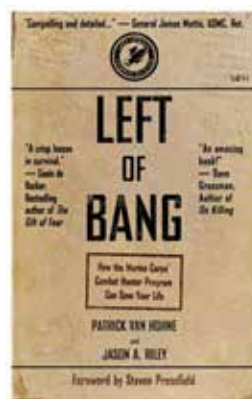
an analysis of the survey data. Although the numerical probability for the likelihood of triggering an avalanche on any given slope would be realistically impossible to ever state to any degree of accuracy, simply understanding our perceived values of the Words of Estimative Probability would allow the North American Public Avalanche Danger Scale to more clearly give decision-makers better tools with which to make decisions regarding terrain and timing. ●

LEFT OF WHOOMP

BY JAKE HUTCHINSON

...the preparation for an attack leaves behind cues a trained observer can pick up on to provide an early warning. Training Marines to make those observations was one of the goals of the program. In the lexicon of Combat Hunter, the purpose was to get Marines Left of Bang.

—*Left of Bang*, Patrick Van Horne & Jason A. Riley



On March 24, 2019, six experienced backcountry skiers were skiing in Cardiac Bowl in the Wasatch Mountains Big Cottonwood Canyon. On their first descent, they observed cracking and sluffing in the new snow as precipitation intensity increased during the day. They choose to follow the 'traditional' skin track route back to the ridge. As they broke trail, they observed widespread cracking in the storm slab. As the person breaking trail approached the summit, they triggered a small sluff in the storm snow. As this small avalanche gained momentum and mass, it triggered a larger sympathetic storm slab approximately 200 feet above the lead skier, that encompassed the entire bowl. All six skiers were caught and carried in the slide with two partial burials and one person sustaining a knee injury. Thankfully the party was able to self-extricate and request rescue assistance to evacuate the injured. This accident and many with similar circumstances (obvious clues, improper mitigations) have often intrigued me. Why do experienced and inexperienced people continue to make what in hindsight seem like obvious and easily avoidable mistakes? (Full accident report can be found here: <https://utahavalanchecenter.org/avalanche/46366>)

As I crawled down a completely unrelated rabbit hole this summer, studying failure and mindset in the sports performance world, a friend turned me onto the book *Left of Bang*. This book is based on the Marine Corps Combat Hunter Program, a program to help young Marines identify threats in a world where the enemy no longer wears a traditional uniform and relies on increasingly deceptive tactics to inflict casualties. As I read, and then listened, and read again, I began to see some obvious parallels between patrolling an Afghan market place and working or playing in avalanche terrain. Leave it to a Marine to take a book about identifying and reacting to threats in a non-traditional combat theatre to stretch a few lines, connect some dots, and bring it back home to the mountains. But as I sat reading this book, I couldn't help but make one connection after another, linking the need for expert intuition and experience between traveling and working in avalanche terrain and going on patrol in hostile territory.

As an educator, I have spent a lot of time teaching the pre-mortem: using checklists, identifying the avalanche problem, understanding and assigning open and closed terrain. We teach tools to assessment and quantify the conditions under our feet, we explain bullseye clues and give them values in flags and fruit, we warn others of our inevitable human folly and the traps it will likely lead us into, like the Sirens calling sailors to their demise. More recently, we have placed much emphasis on the tour or day post-mortem, whether it was a casual ski tour or an active mitigation day, encouraging honest assessment of how and when we may have been over-exposed and how to mitigate it in the future. But it seems as if we have missed or assumed people were going outside with proper situational awareness.

By now, we're all familiar with the early Heuristics work of Ian McCammon and the research on heuristic traps he presented at Penticton in 2002. In fact, I would be shocked if any avalanche course at any level didn't at least touch on the subject briefly, it has become such a staple for helping us understand some of the reasons that otherwise reasonable, intelligent people seem to make questionable decisions. By Ian's own admission, his research was meant as a starting point not the finish line, but unfortunately until recently no one has truly picked up the torch.

Like going on patrol in a combat zone, traveling, working, and recreating in snow-covered mountains is a highly complex undertaking, where no two situations are entirely alike and often the clues and cues about what is going on can be deceptive and even conflict with one another. The ability to recognize cues and instigate proper mitigations is critical to both avoiding an ambush and staying out of avalanche involvements. The US Marine Corps recognized the need for, and challenge of, imparting experiential expertise and observation into young Marines who would be leading patrols into territory where the enemy was no longer identified by uniform, and often looked no different than the local villagers. They began to look at heuristic cues as a way to help these Marines separate the harmless from the threats, moving Marines from an awareness of danger, to operational and prepared, to appropriately respond. It seemed to me that many avalanche accidents failed to properly take this step in a timely fashion, or that

LEFT: Everything that occurs before the avalanche

PROACTIVE

WHO

pre-determined mitigations were either lacking or incorrect, leading to avalanche involvements. In reviewing avalanche accidents, it seems very rare that people are completely blindsided by avalanches or unaware of the danger around them. Instead, they often identify and are aware of the danger, but fail to make proper mitigations until it's too late.

Expert intuition: The situation has provided a cue; this cue has given the expert access to information stored in memory, and the information provides the answer. Intuition is nothing more and nothing less than recognition.

Valid intuitions develop when experts have learned to recognize familiar elements in a new situation and to act in a manner that is appropriate to it.

—Thinking, Fast and Slow, D. Kahneman

Expert intuition and how it affects our decision making has been a hot topic of late and is at the foundation of the Combat Hunter Program. The problem lies in experience, how does one install the knowledge and experience of a seasoned vet into a young Marine heading out

	WHITE	YELLOW	ORANGE	RED	BLACK
MENTAL STATE	<ul style="list-style-type: none"> Unaware of environmental danger Unprepared to take action Oblivious 	<ul style="list-style-type: none"> Prepared and alert Proper Situational awareness, yet no specific threat has been identified Observing and Quantifying 	<ul style="list-style-type: none"> Alert to a specific danger or condition Still aware of surrounding environment Prepared to assess additional threats 	<ul style="list-style-type: none"> Fight or Flight Mode Complete commitment to emergency at hand Instinctual and emotional responses heightened Lowered Intellectual Response Time Distortion 	<ul style="list-style-type: none"> System Overload Denial Confusion Irrational and/or repetitive
PHYSICAL STATE	<ul style="list-style-type: none"> Relaxed Vulnerable 	<ul style="list-style-type: none"> Relaxed but prepared to react ready to shift to Orange as cues present themselves 	<ul style="list-style-type: none"> Ready to take action Rescue, escape, evade Heart and Respiratory rates increase 	<ul style="list-style-type: none"> Adrenaline Dump Fine Motor Skills Disappear No chance to lower situational state until threat is mitigated 	<ul style="list-style-type: none"> Adrenaline Overload Cramping Hyperventilation Gross Motor skills affected
COMMENTS	Ignorance is Bliss	"I may encounter avalanches today"	Ski cutting, opening a slope, rapidly changing conditions, or baseline is wrong	You are right of Whoomph! Reactive to situation	Freeze State Complete Amygdala Hijack you have become a victim

ical world, the amygdala is part of the limbic system and it manages all of the systems that keep us alive. It makes your heart beat and your lungs function, it is the primitive part of your brain that takes care of daily business without you needing to think about it. But when we are confronted with threats, the amygdala takes over and puts us in survival mode. That survival mode can take one of three basic forms; Fight, Flight or Freeze. The fight or flight response is well known and in its simplest form, means you either run from a threat (survival by avoidance) or you confront it (survival by confrontation). Each situation is different and either of these responses may be the correct or incorrect mitigation given the circumstance. The third response, Freeze, is bad. This is the amygdala hijack, your heart rate, adrenaline, and other factors conspire to make you the proverbial deer in the headlights. You are a liability, unable to function and likely have become an additional threat or condition that requires mitigation. This will be known as Condition Black.

SITUATIONAL AWARENESS STATES

Retired Marine Lt. Colonel Jeff Cooper developed a color coded system of awareness during his time in the Vietnam War to describe the psychological conditions a person could experience during any given situation. His scale used four colors, white, yellow, orange and red to describe the range from unprepared and unaware at one end, and "in the fight" at the other. The Combat Hunter program added a fifth color, black, to describe the freeze. From here I began to apply these concepts to situational awareness in avalanche terrain and will describe them as follows:

CONDITION WHITE: White represents 'Ignorance is Bliss,' where you as skier or soldier are unaware the world is dangerous and unprepared to take action if a threat presents itself. Your physical state is relaxed and vulnerable. This could be the resort skier venturing outside the boundaries, a young ski patroller, or the backcountry enthusiast with headphones in and lacking focus on the environment around them.

CONDITION YELLOW: Yellow represents optimal operational function. You are aware the

world in dangerous, you know avalanches exist and you're likely to have an idea of what type and where they exist, and you are psychologically prepared to do something. You have assigned cues that may elevate your state to Orange, but haven't seen a specific indicator yet. You are observing, assessing, and quantifying the world around you. Physical state is relaxed, yet ready to react if cues present themselves.

CONDITION ORANGE: A cue has presented itself, you are now aware of a specific threat—crossing a slope, beginning a ski cut, or opening a run come to mind, but you aren't so focused on the specific threat that you have become oblivious to the world around you, you are still prepared to assess and mitigate additional threats. Your physical state has changed, heart rate and respirations have increased due to adrenaline. You are no longer relaxed, you are ready to take actions. Rescue, escape, and avoid are on the table. This state isn't sustainable physically or mentally, but once the threat is mitigated, a return to yellow is possible. You are poised, left of Whoomph, anticipating some action.

CONDITION RED: Fight or flight time. The shit has hit the fan, you are completely committed to the emergency at hand, both physically and mentally. Your instinctual and emotional responses to stimulus have been heightened, while your intellectual responses have been



on his first patrol? How do we share hundreds of days and years of experience and observation in avalanche terrain with those with less time in the trenches? Well we can't. But we can provide some tools to help people identify cues and implement pre-determined mitigations and hopefully avoid getting Right of Whoomph.

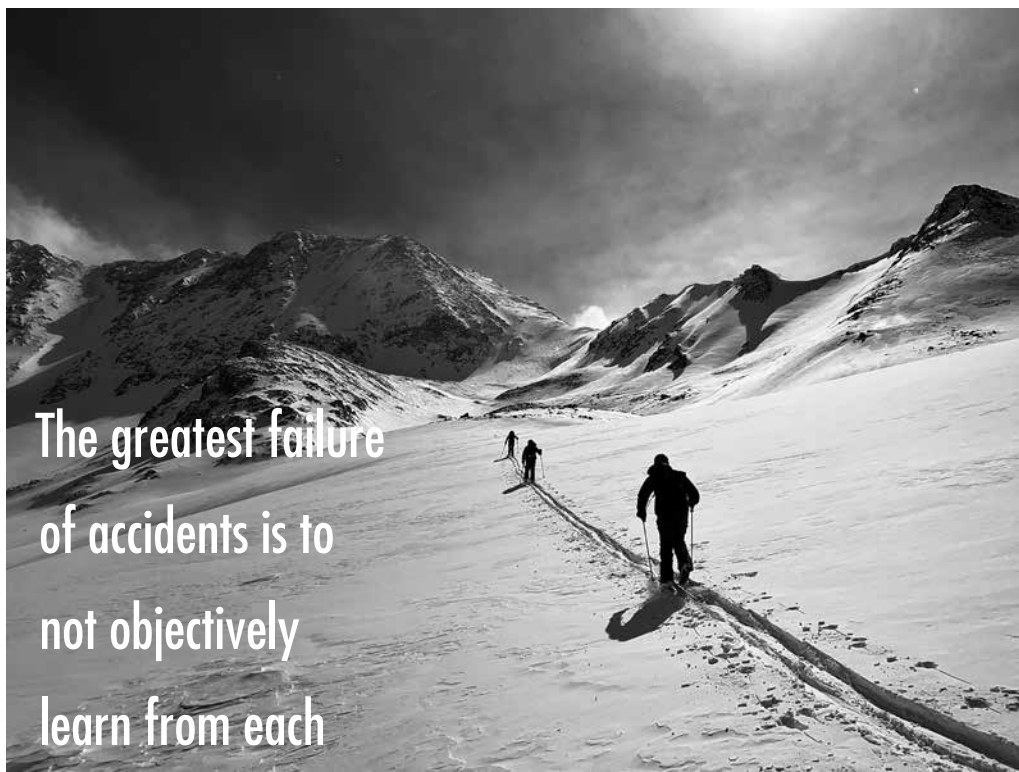
What is Left of Whoomph and how do we get and stay there? Left is pre-event, we are planning and preparing, observing and quantifying. We know the snow holds secrets, we know that steep, snow-covered slopes can and may avalanche, we are in a PROACTIVE state of readiness, looking for pre-event indicators.

Whoomph is the avalanche, the event has happened, if you stayed left, you are able to manage and mitigate whatever has occurred.

Right of Whoomph is bad, you are reactive, you must respond to a threat to life or limb. You are no longer in control of the situation, and must react to whatever the circumstance requires, whether that is to try and escape an avalanche you are caught in, or rescue a partner.

Before we dive into the situational awareness states, let's talk a little about a part of our brain called the amygdala and how it can both help and hurt us in a response to a stressful event or stimulus. Without diving too far into the med-

Most avalanche accidents don't seem to be caused by anomaly, but rather a failure to either identify the cue or to apply improper or untimely mitigation—which could be considered an anomaly itself.



The greatest failure
of accidents is to
not objectively
learn from each
and every one.

Last winter in Mayflower Gulch in Summit Co, CO, just a few weeks before shit came unglued there. Pro 1 course gathering data for their operational exercise, on a wonderfully cold Colorado bluebird day. Photo Jake Hutchinson

lowered. Time distortion is also likely to occur. The amygdala is taking over and prioritizing your resources to the systems that keep you alive. Physically you have likely experienced an adrenaline dump and your fine motor skills (think dexterity, hands and fingers) will disappear. You have no opportunity to go back down the scale until the threat is fully mitigated. You are now right of Whoomph.

CONDITION BLACK: If red is bad, black is its scarier and meaner big brother. You have experienced a complete mental and physical breakdown. Full amygdala hijack has occurred and you are overloaded. You're in denial and confused, likely irrational and may become repetitive. Physically, a total adrenaline overload has occurred, gross motor skills (walking) have deteriorated, cramping and hyperventilation may occur. Now you cannot and will not fend for yourself and will require caretaking and/or evacuation.

Operationally (whether that is avalanche work or recreational) it seems obvious that yellow is the appropriate and desired state, white has no place in avalanche terrain, and moving to orange is likely to occur, but this is a manageable state. Avoiding the red and black is critical to staying safe. So how do we appropriately add this to our already bursting tool box? A core tenet of the Combat Hunter program is to “Establish the baseline, and seek anomaly,” which is the foundation of appropriate situational awareness.

Condition Yellow represents the baseline. Being in Condition Yellow doesn't hurt. You can and probably should live there most of the time without a lot of stress. Condition Yellow is not being paranoid, it's not jumping at everything, it's just being alert. One benefit of Condition Yellow is that it actually allows you to go out and safely and happily engage with the world. It allows you to maintain your intellectual curiosity and your love of fresh air, mountains, snow, and skiing. If you travel the mountains in Condition White, you'll wind up overwhelmed, shell shocked, and possibly dead.

Condition Yellow and the baseline are established in a variety of ways and means depending on the application, but for a recreational user, the local avalanche bulletin, a knowledge of season history, pattern recognition and specific avalanche problems are the building blocks. Baseline is enhanced with partner discussion, route planning, and checklists. For the professional, this also encompasses the AM meeting, previous day's observations, and the Operational Mindset.

The next step is to identify the cues that warrant an elevation to Orange—performing a ski cut or opening a slope, specific environmental cues—cracking, collapsing etc. Rapidly changing or unexpected conditions (test result not in-line with baseline—aka anomaly), specific group dynamics or even injury. The final critical step is assigning proper mitigations to each cue—to keep you in orange and avoid red—but also to describe conditions or cues that allow you to move back to yellow.

So what about that anomaly part? Most avalanche accidents don't seem to be caused by anomaly, but rather a failure to either identify the cue or to apply improper or untimely mitigation—which could be considered an anomaly itself. A few other anomalies that come to mind include time lag, perception bias, and those well documented heuristic traps and other human factors.

How do we avoid the red and black? Well we could stay home, out of the mountains, and live in a bubble, or we could look at our training and how it's deployed. It's incredibly hard to accurately re-create the stress of an avalanche event, but by training as close to reality as possible, we maximize our ability to stay in orange. Knowing rescue gear functions upside down, backwards and sideways with your eyes closed and sirens going off is one way to mitigate the loss of fine motor skills. Until faced with a situation, no one knows how they will respond, and previous response is no guarantee you will function in the red and stay out of the black.

The goal is to make everyone an avalanche expert and make them so adept at identifying

and understanding specific avalanche conditions, they begin to do it intuitively. This looks like creating the ability to be hyper aware of the obvious threats while still analyzing the external complex world. Achieving this level of expertise requires thousands of focused hours in the mountains.

Once we understand the differences between the novice and the expert we can devise systems to help close the gap and assist novices in gaining appropriate experience. Research psychologist Gary Klein cites the following as abilities experts have that novices do not:

1. Experts see patterns that novices do not detect.
2. Experts see anomalies—events that did not happen.
3. Experts see the big picture (situational awareness)
4. Experts create opportunities and improvisations
5. Experts have the ability to predict future events using previous experience
6. Experts see differences too small for novices to detect
7. Experts know their limitations.

Finally, as we send novices out into the mountains, we must remember the ‘wicked learning environment’ where the novice will often lack direct feedback to help them assess the accuracy of their observations and conclusions, which limits the value of the experience and may assign incorrect values to the observations. Mentors can be a valuable asset here, to help the novice understand when they made good decisions, or just “got away” with a bad one.

Back to Cardiac Bowl. It is my conclusion from reading and listening to first person accounts, the group was correctly operating in Condition Yellow, aware of the specific danger for the day and how it was forecast to change. They observed and identified cues to support the baseline and appropriately moved to Orange. The mitigation (increased spacing) turned out to be incorrect due to an unexpected anomaly. The possibility of triggering an avalanche was identified, the anomaly was the size, the entire bowl sliding meant everyone was in harm's way. Luckily no one was killed or seriously injured.

How do we impart this expert knowledge into the novice for future use? It's quite simple—in the face of rapidly changing conditions and obvious clues of instability, margins must be widened and rather than spacing, the appropriate mitigation was to choose the longer, less direct, and less exposed up track. The greatest failure of accidents is to not objectively learn from each and every one.

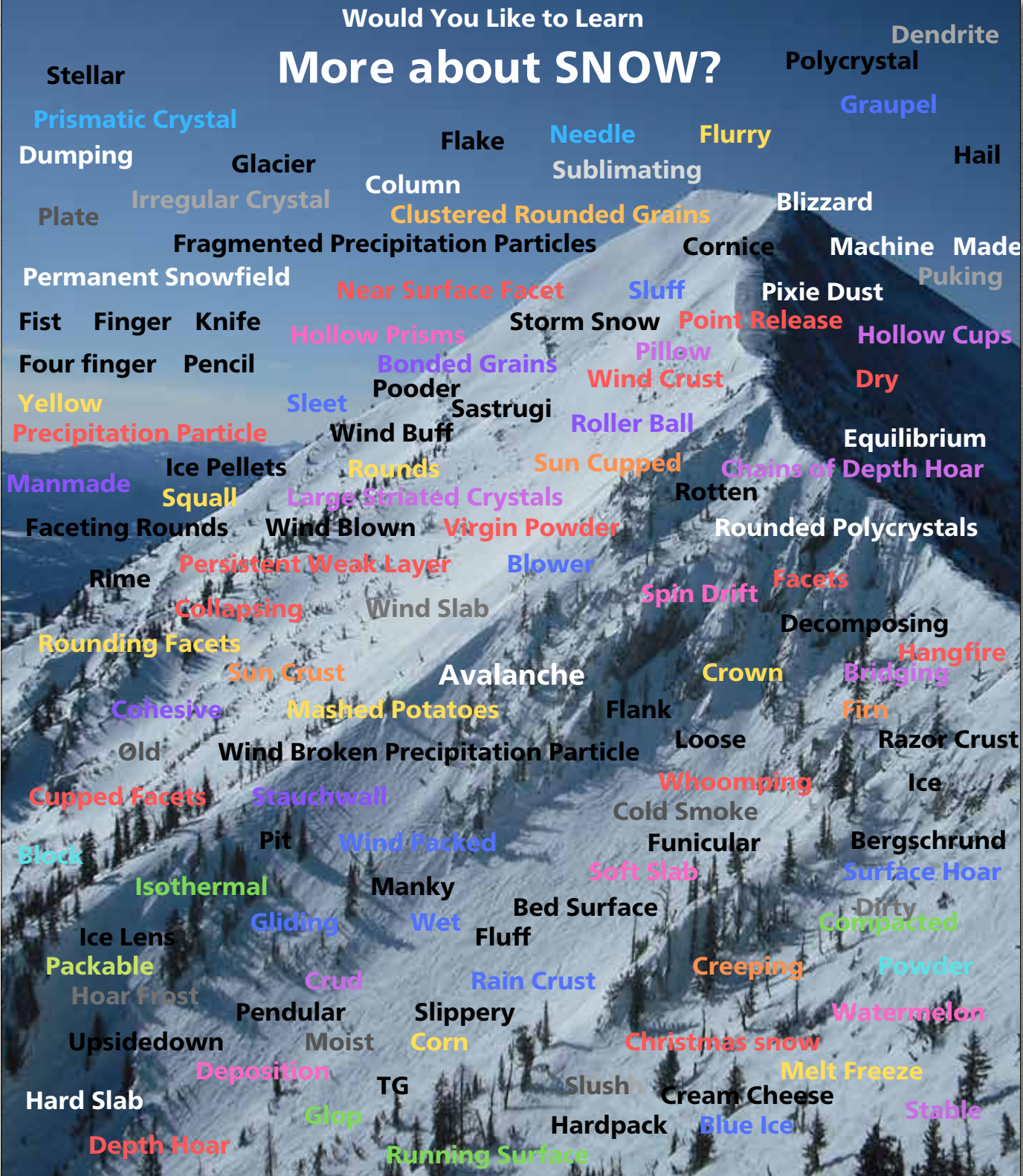
In conclusion, it's a simple process:

1. Identify the baseline
2. Identify the threats and assign cues
3. Assign mitigations for specific cues
4. Be wary of anomaly
5. Stay left of Whoomph

SOURCES:

D. Kahneman, *Thinking, Fast and Slow*
Klein, Gary, *Sources of Power: How people make decisions*
Patrick Van Horne and Jason A. Riley, *Left of Bang*
Gavin DeBecker, *The Gift of Fear*
Michael Syed, *Black Box Thinking*

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LOOKING FOR A COLLABORATOR AND IDEAS.

This poster template is a start for providing a resource to encourage people to take that next avalanche class. The idea is to celebrate avalanche knowledge and education through the words we use. I designed it hoping to engage people who might see it in the bar and add words they use or staisrtstep on the poster to open a conversation about snow and avalanches. Another poster might be about stability tests and perhaps one about heuristics. Hoping to move to video as well.

The need for some kind of sponsorship seems inevitable, but the end goal is to create an open source template that could help the avalanche education community reach that elusive one-avalanche-class demographic that seems to need a little more education.

Email: leewatson007@gmail.com with your ideas, advice, or for more information.

—Lee Watson

Snow and Avalanche Workshops

WYSAW

BY DON SHARAF

Ten percent.

That's what the average person may retain after hearing a lecture or talk two weeks later. I didn't research this, it is just what I remember Ian McCammon telling me years ago, he may have told me some other number, but that is how I remember it. This summary will be from my 10%, so if you remember 10% of this article that leaves you with 1% of some truly remarkable presentations—what an injustice!

Women Rock the House!

Over half of the presenters were women and they spoke from experience and from their research. They were presenting topics that were original and useful for practitioners. Really impressive—now we just need to get practitioner numbers to approach that ratio. Looking around the Alta Ski Patrol room it seems like women are gaining traction in the avalanche industry, but you wouldn't have known that from the staff training that AAI did in Salt Lake...

Format that works

The organizing committee decided to go with a Friday afternoon for Pro-specific presentations (ones that had direct bearing on avalanche professionals) and then a full Saturday General session (talks that applied to both recreationists and professionals). I found both sessions highly engaging and attendee feedback felt the same. Sponsorship from A3 and the TCSAR Foundation made the whole event very affordable and easy to attend. In the Pro session we limited the seating to the first floor of The Center for the Arts which allowed for easy questioning from the audience. Pro session attendance was ~100 people and General met the building's capacity of 500 people.

Recommendation for all SAW organizers—have your entire SAW professionally filmed and edited—the benefits from being able to review presentations and to share with non-attendees is enormous. Although pro filming and editing doesn't come cheap, you could build the cost into the tuition OR the video access permissions.

Problems Without Solutions.

Usually I hate talks that state how hard avalanche forecasting and decision-making is and the presenter doesn't offer tools to make it easier or better. Laura Maguire and Scott Savage fell into that category, but occasionally when people point out a problem we haven't thought of before, we are challenged, and motivated, to move forward on our own. Maguire went past her ISSW take-home of Avalanche Forecasting is hard and threw down the challenge that we are being too simplistic in our accident analysis. Her point was that accidents need to be evaluated on

a contextual basis and that viewing them through the Heuristic Traps filter is narrow in scope. Distractions also play a large part in accident formation and workflow is a broader process than we appreciate. Her take-homes were Anticipation and Adaptation were key to successful management of our complex and complicated challenges. Two words... easy. I'm hoping to think through our most stressful situations that we encounter as patrollers, guides, educators, and forecasters with a strong pre-mortem filter and then build in some margin (Seth Carbonari talk) into those moments.

Savage also gave us perspective on what we don't know. His case study of an avalanche cycle in Central Idaho pointed out the problem of 'tweeners'. Our boxing of avalanche problems into dry slabs and wet slabs is useful for forecasting and management, but doesn't address the reality that mid-winter storms with rain may not behave as we expect. His observations that large avalanches were occurring 1000' above rain-line, but were not true dry slab occurrences has me shaking in my boots. With climate change producing higher variability in Winter Weather (McKenzie Skiles WYSAW and USAW talk and Brian McInerney USAW talk), we can anticipate more of these 'tweener avalanches and will need to rely on our Norwegian Brethren to help us figure this pattern out, or short of that advice a large step back in our confidence for a while.

Solutions for Problems

Seth Carbonari's talk on Choosing and Managing Teams in High Risk Environments really resonated with me, as have his talks in the past. Seth's background in wildland firefighting and...rugby has given him many great insights that I hope to emulate in my operations. Particularly insightful were his illustration of the differences between qualifications and character and the stark difference between an investigation (assigning blame) and a facilitated learning analysis (identifying solutions). Looking at accidents, near misses, and decisions in light of context is far more useful than "resulting" (Maguire—CSAW, WYSAW and USAW and Jenna Malone—USAW).

How are we doing?

Anne St Clair did a really well researched study on how effective Public Avalanche Forecasts are at extending their message to their audience. Her graduate work was focused and poignant and suggests subtle changes in iconography can influence comprehension. It also seems that we may be missing the mark a bit for the most basic of users. I would watch for more from this team, working with Pascal Hageli, out of Simon Fraser University, in the near future for concrete advice for our messaging.

Laura McGladrey explored stress response amongst first responders and qualified levels of mental stress injury as a result of exposure to traumatic accidents (either as a responder or a bystander). Search on your browser

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for stress continuum model for more details on this tool. I found it interesting how this model could be applied to operational stress as well—looking at guides and patrollers over the course of our long and intense seasons. A good tool for seeing how your friends are doing...and so they can see how you are doing.

Hungry for more...

The presenters had far more to say than what I am chronicling here, so if you are curious or intrigued check out the videos of the general session <https://vimeo.com/user4475613> (Teton County SAR vimeo channel) and my notes <https://docs.google.com/document/d/1e4ozLiBR6ZRbKUHXY-p7ZF-CEXNsY9jeu1gjdkXop63I/edit?usp=sharing>

3 + 1 Soapbox Alert:

Challenge yourself to retain the knowledge and learnings from these SAWS. Write down three things that impacted you from each talk and one thing that remains confusing. Keep them in a notebook or on your computer and revisit them from time to time. Perhaps that 10% will help you make better decisions or even save your life.



Don Sharaf writes one article for *The Avalanche Review* each year. In his remaining time, he rests on the couch and eats popcorn. This year his favorite quote is “We don’t rise to the level of our expectations, we fall to the level of our training.” —Archilochus

Stay tuned for a new quote next year.

Liz King helped with this write-up also.

USAW

BY CHAD BRACKLESBERG

The 12th Annual Utah Snow and Avalanche Workshop (USAW) once again offered separate sessions for professionals, recreationists, and motorized users in a 2-day workshop format allowing in-depth discussions for each group. The UAC kept with the ISSW style of 15-minute presentations followed by five minutes for questions. We also used our “speakers corner” for an opportunity for people to visit with speakers to ask additional questions. With the ample space of the Mountain American Exposition Center in Sandy, we have plenty of room for workshop attendees and sponsors to all be located inside the speaker hall. Utah Food Services provided copious amounts of coffee, a great lunch, and a happy hour after the workshop each day. As always, the wonderful sponsorship of Utah ski resorts and outdoor industry helped us put on a great workshop.

The professional session on Friday was dedicated to explosive issues, how the 2018–2019 snowpack impacted avalanche mitigation work, and risk management. The recreational session on Saturday offered topics about challenges with an unconventional snowpack, a review of the 2018–2019 snowpack in rural Utah, and how to evaluate and determine your personal risk tolerance. We used stories from accidents, personal tragedies, and more technical analysis of weather and snow to provide a range of powerful learning opportunities. Over the years we have found that the personal accident accounts provide valuable



Jenna Malone tells the USAW audience how decision-making in avalanche terrain is more like poker than chess. See her article Thinking in Bets on page 34 of this issue of TAR.

lessons learned and help build a community in which there is no shame in recounting an avalanche accident. The motorized session was a two-hour session at the beginning of the open session with a theme of how we move in the mountains, including discussions around matching your riding to the avalanche conditions, decision-making, and identifying red flags. Grouping our talks into themes continues to help our attendees better understand the goal of the messaging.

Professional Session Agenda

Closed Door Explosive Handler Workshop

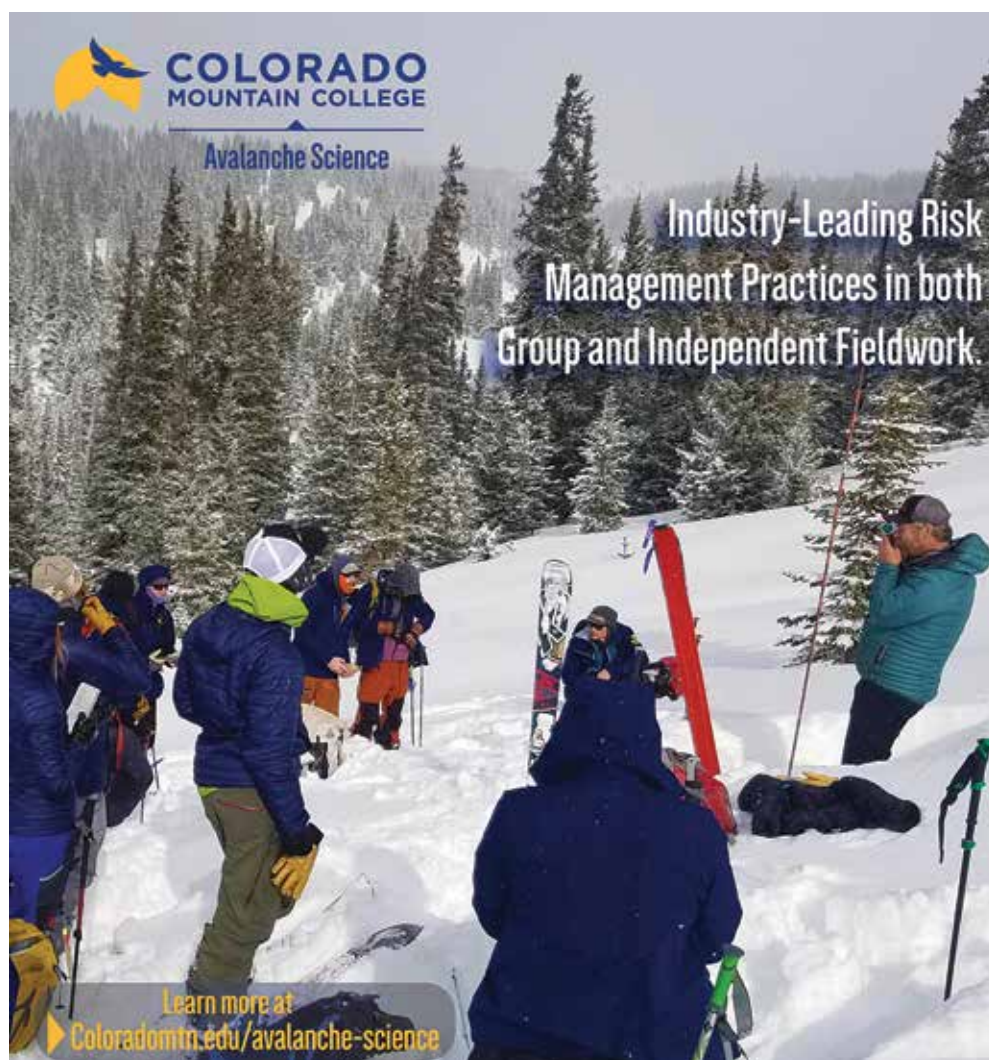
- Historical Avalanche Film: “Avalanches to Order” starring Monty Atwater and narrated by Lowell Thomas. *Doug Wewer, USFS*
- Proper Respect for Explosives. *Stephen Shelley, ATF Explosives Enforcement Officer / Bomb Technician*
- Infrasound for Snow Avalanche Monitoring. *Dr. Jeffrey Johnson, Associate Professor of Geophysics, Department of Geosciences, Boise State University*
- Helicopter Operations for Avalanche Work and Rescue. *Spencer Storm, Powderbird*
- Big Fish... Capturing the Experiences of Avalanche Workers for Future Generations. *Andrew Hennigh, PCMR*

A Curve Ball Thrown at an Intermountain Snowpack

- Utah Winter Review. *Craig Gordon and Trent Meisenheimer, UAC*
- Fat Skis, Atmospheric Rivers, and Heightened Avalanche Activity. *Brian McInerney, National Weather Service*
- Dust and drones. *Dr. McKenzie Skiles, University of Utah*
- A case study of the Feb, 2019 size 4 and 5 avalanche cycle in Provo Canyon. *John Woodruff, UDOT*

Risk Management

- When 10,000 Hours Is Not Enough. *Russ Costa, Westminster*
- Gad 2 Wind Rolls. *Eric Murakami, Snowbird*
- Close Call in Honeycomb Canyon, Solitude. *Ian Reddell, Solitude Mountain Resort*
- Near miss! Now what? *Pete Earle, Park City Powder Cats*
- Operating at the edge: human performance in extreme environments-. *Lau-*



BY DAVE REICHEL



The UAC team, from Left to Right: Chad Brackelsberg, Craig Gordon, Eric Trenbeath, Drew Hardesty, Bo Torrey, Greg Gagne, Brett Kobernik, Trent Meisenheimer, Evelyn Lees, Toby Weed, Nikki Champion, Andy Nassetta, and Mark Staples.

ra Maguire, Ohio State University, Graduate Researcher, College of Engineering Cognitive Systems Engineering Lab

- Special Operations Approach: Risk to Force/Mission. *Eric Oehlerich, 20+ year retired Navy Officer (SEAL)*

Open Session Agenda
Challenges With an Unconventional Snowpack in an Intermountain Climate:

- Atmospheric Rivers. **Brian McInerney, National Weather Service**
- So, Tell Me...How Does This All Work? *Steven Clark, UDOT*
- Confidence Versus Competence. *Dave Richards, Alta*
- Betting Your Life...Why Avalanche Forecasting is Poker, Not Chess. *Jenna Malone, Wasatch Powderbird Guides, Alta*
- Utah Winter Review. *Craig Gordon, Trent Meisenheimer, UAC*
- MOAB—Mother of all Basal Weak Layers. *Eric Trenbeath, UAC*
- The Dog Days of Winter. *Andrew VanHouten, PCMR*
- It Ain't Vegas....It's Worse. *Craig Gordon, UAC*

Decisions... Decisions. Determining Your Personal Risk Tolerance:

- Close call in Cardiac Bowl. *Mark Oliver, Claudia Wiese*
- Risk and Perception when the Danger is LOW, Particularly When It's Not. *Drew Hardesty, Russ Costa*
- Lessons from the forecast office to the field: Perspectives from a career of avalanche forecasting. *Evelyn Lees, Mark Staples, and Trent Meisenheimer, UAC*

What are the odds?

- What to Make With the Pieces Left Behind. *Melissa Gill, Lululemon*
- Beyond FACETS: Cultivating Backcountry Expertise. *Laura Maguire, Ohio State University, Graduate Researcher, College of Engineering Cognitive Systems Engineering Lab*

Motorized Session Agenda

How We Move in the Mountains:

- Having the Gear and Knowing How to Use It. *Brandon Archibald*

- Riding Within the Limits of the Avy Traffic Light. *Phatty Dyer*
- Decision Making. *Steve Martin*
- Red Flags and Exit Strategies. *Karl Love*

Chad Bracklesberg is the Executive Director of the nonprofit Utah Avalanche Center. He is responsible for communications, marketing, fundraising, strategy, and UAC business operations. Chad spent the prior 20 years in the corporate world working for large consulting companies in technology consulting, program/project management, and data center operations. Chad is active in the Utah outdoor community and is an avid backcountry skier, ski mountaineering racer, ultrarunner, and mountain biker.



Soccer dad and professional snowboarder Jeremy Jones opened the 2019 California Avalanche Workshop with a great line about “playing an avalanche pro in the movies” but acknowledged being a bit nervous in front of the 300 folks in the room. Jeremy walked the crowd through his backcountry routine with multiple photos of handwritten notes and drawings in his field books. One of Jeremy’s points that struck a chord was his call to celebrate turning around and noting if a decision to turn around hadn’t been made recently, that this could be a warning sign. The focus on turning around hearkened back to Cody Townsend’s talk on the Normalization of Deviance from the 2017 CAW. It seems interesting that two established pros recognize the value in turning around and emphasize the value in this during public presentations. After his talk Jeremy split to cheer on his kid at a soccer tournament.

Tahoe National Forest Sierra Avalanche Center Lead Forecaster Brandon Schwartz began his presentation by honoring Bob Moore as the single person most responsible for the creation of the Sierra Avalanche Center during his time with the Forest Service. After retiring, Bob went on to volunteer for many years as secretary on the SAC board; he recently stepped down in order to have more time to chase grandkids. Once applause for Bob subsided, Brandon dove into his talk which was built on Doug Krause’s TAR article *Pocket Risk Management*.

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BendSAW

BY KEVIN GROVE

Having recently accepted a position with the CAIC, Ryan Lewthwaite's final day with the Bridgeport Avalanche Center was spent at the CAW presenting *Wait There's an Avalanche Center for Snowmobilers in the Eastern Sierra?* The Bridgeport Winter Recreation Area (BWRA...and pronounced "BOORAA!" with your best Marine voice, due to its neighbors at the Mountain Warfare Training Center) is a popular sled area. The Bridgeport Avalanche Center has endeavored to provide outreach and information to the users of the BWRA.

Avalanche educators Richard Bothwell and Michael McCarthy presented on the Nickolay Dodov Foundation. Richard shared the story of outdoor enthusiasts Alex and Natalia Dodov who raised their son Nickolay to love the ocean and the mountains. Living in Bear Valley at the southernmost portion of the Sierra Avalanche Center forecast area, Nickolay grew into a serious snowboarder who pursued the activity until he was killed in an avalanche while heli-boarding in Alaska. The Nickolay Dodov Foundation is now the major provider of avalanche awareness training to youth in the Sierra. After Richard facilitated this emotionally powerful portion of the talk, Michael deployed interactive exercises the Nickolay Dodov Foundation uses in its awareness classes.

Randall Osterhuber shared *Snow Observations from Donner Summit*. Working at the Central Sierra Snow Lab has provided Randall with an incredible snow history data set for the Sierra. Drawing from his experience as a backcountry skier, longtime avalanche educator, and former SAC Board, Randall examined the data and commented on trends.

Meghan Collins, Education Program Manager at the Desert Research Institute (DRI), presented on *Stories in the Snow*. This citizen scientist program involves taking pictures of freshly-fallen snow crystals with a smartphone. The images, location, and time are then shared with DRI who work to connect the crystal type photographed with the atmospheric conditions that created it.

The good folks at the National Weather Service were represented by Zach Tolby, who works out of the Reno office and also serves on the SAC Board. Zach's talk *Weather in the Sierra—Predictability and Tools for Different Time Scales* examined the accuracy of different forecast models over different time scales.

Michael Ferrari's *Life in an Avalanche* presentation covered his exciting thirty years at Mt. Rose. After a couple seasons as a lifty, he moved over to the ski patrol and presided over major increases in the inbounds avalanche terrain at the resort. Michael regaled the crowd with stories and challenges of his time at Rose. Towards the end of his talk he graciously and deftly handled a random heckler, later explaining that after dealing with lawyers, this was nothing.

Next year, the CAW will be on October 24, back in Kings Beach with fingers crossed for another sunny après session on the shore of Lake Tahoe after a day of awesome presentations.

David Reichel works for the Sierra Avalanche Center, Lake Tahoe Community College, and guides. He started the California Avalanche Workshop.



Central Oregon Avalanche Center hosted the second annual Bend SAW at the COCC campus on November 9th. For the second year in a row we sold out the 250-seat venue for the full day event. There was a great deal of energy, buzz, and enthusiasm for the coming winter season and a full array of vendors. Eleven speakers covered a wide variety of topics with decision-making in a high risk/high consequence arena being a general trend throughout the talks.

Anne St. Claire summarized phase two research findings from Simon Fraser Universities avalanche research group. They are attempting to better understand the recreational users of avalanche bulletins and the efficacy of avalanche bulletins in reaching this population. The goal is to provide evidence-based solutions to help bulletins resonate more effectively with the user base.

Drew Hardesty presented an eloquent talk about forecasting and what happens when the forecast is wrong. He talked about a forecasted low hazard day last January in the Wasatch when eight victims were caught, carried and/or buried in avalanches. He discussed the cognitive bias known as anchoring where people rely too heavily on the first piece, or one piece, of information seen. The green flag may cause backcountry users to turn their brain off and go about their day on autopilot, ignoring any red flag warnings that might arise throughout the day. Knowing that sea-

soned forecasters issue thousands of forecasts throughout their career, and 100% accuracy is impossible to achieve, we must be diligent about not putting the blinders on with forecasted low hazard days.

Laura Maguire gave the keynote talk about developing backcountry expertise. Laura is completing a PhD at Ohio State Universities cognitive engineering lab where she explores research methods for studying real work in the natural laboratory. Much like Gary Klein emphasizes the positive aspect of human intuitive decision-making compared to Daniel Kahneman highlighting our flaws through short cuts, Laura is working toward understanding our ability to adapt and be resilient in conditions of uncertainty with dynamic change. She highlighted research findings studying ski patrollers, learning that, for many, their cognitive day begins well before they have boots on and are 'on the job.'

Graham Zimmerman talked about a project he worked on with Steve House. They just released a series of five alpine principles videos highlighting perfect preparation, paying attention, failing well, reflection and debriefing, and being realistic. These videos are very well done, worth a watch, and can be found here: <https://www.youtube.com/channel/UCOYnpuacr0hmFlciAgGvMYw>

Bjarne Salen rejuvenated the post-lunch crowd with amazing imagery and storytelling. He is currently capturing the exploration and adventure of Cody Townsend attempting to climb and ski the 50 classic ski descents in North America. Bjarne talked about turning around and the importance of listening to your intuition. It is great to see professional

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skiers, photographers, and videographers who are willing to talk about these topics and not just showcasing going big in the mountains.

Last, but certainly not least, Lynne Wolfe gave two awesome talks on checklists and debriefing. She talked about the importance of checklists in other industries and how critical stopping at key pause points can be to run through a checklist. AAI has developed an incredible checklist/ flow chart that is short, to the point, and a critical tool to put in your belt. In her debriefing talk, Lynne discussed a near miss she had on Taylor Mountain in January of 2012 and the key learnings that came from debriefing the day after the incident occurred. (see *Taylor Musings* in TAR 32.4) We concluded the day with an after party at the Deschutes Brewery and toasted an amazing event. Special thanks to A3 for their grant support and to Mt. Bachelor, Oregon Ski Guides, Black Diamond, and a host of other sponsors for their help in making this a great event.

Kevin Grove is an Assistant Professor of Engineering and Physics at Central Oregon Community College. He is on the board of COAC and can be found chasing after his two daughters in Bend.



NRSAW

BY LLOYD MORSETT

The SAW season concluded on November 16th this year with the ninth annual Northern Rockies Snow and Avalanche Workshop (NRSAW.) NRSAW, presented by the Friends of the Flathead Avalanche Center,

attracted over 300 professionals and recreationalists from around Montana and beyond, and the stoke was high as early winter storms and colder temperatures had our minds wandering to powder days past and future. The O'Shaunessy Cultural Arts Center in Whitefish, Montana provided the perfect venue for great presentations and thoughtful discussion from each of the incredible speakers.

Flathead Avalanche Center Director Zach Guy started the day off as MC with a unique edit to get the crowd going. Not to be outdone, Steve Kujt and the crew from ISSW 2020 brought their own video magic to get us all looking forward to Fernie, BC next October. A3 Executive Director Dan Kaveney then gave a program update to set the stage for featured presenters.

Lloyd Morsett, Snow Safety Coordinator for Whitefish Mountain Resort, took the stage with an examination of avalanche fatalities in Northwest Montana. His analysis brought to light some not-so-subtle differences in the backcountry community where he lives and a few surprises that highlight where we can do better as BC travelers, educators, and rescue professionals.

Aleph Johnston-Bloom of Chugach National Forest Avalanche Information Center in Girdwood, Alaska then presented on her research on mentors in the avalanche industry. Her insight around the conversations with professional members of the A3 and the common links in many of our personal and professional lives resonated through the audience and highlighted just how important these relationships are at every level.

Kelly Elder of the USFS Rocky Mountain Research Station gave perspective to Colorado's

historic March 2019 avalanche cycle. Knowing we have only brushed the surface of the data available through the time and space of the avalanche cycle, Kelly spoke of his tree ring studies and new relevance to these types of events.

Crowd favorite Matt W. made a career as a Special Forces helicopter pilot and training officer for Survival, Evasion Resistance and Escape. He put critical thinking skills under high stress situations into perfect context with its relevance to the avalanche world.

Henry Finn then presented his research group's work on how recreational users engage with the avalanche bulletin and its information. Undoubtedly, the discussion around Henry's presentation brought the most audience questions and many great ideas for the future of the avalanche bulletin were kicked around.

Blase Reardon, lead forecaster for the Flathead Avalanche Center, brought it all together with an open and honest discussion of several of his near misses as a backcountry user and how valuable near miss discussions are as a complement to the wicked learning environment of the backcountry.

We could not be moving into our tenth year of NRSAW without a world of behind the scenes work and financial help. Thank you to all of our sponsors including the American Avalanche Assoc., Flathead Nordic Backcountry Patrol, The Patrol Fund and many others!

Lloyd Morsett is the NRSAW Steering Committee Chair and sits on the Friends of the Flathead Avalanche Center Board of Directors. He has been a professional ski patroller for 22 years, trading the depth hoar of Colorado for the rain crusts of Montana six years ago.



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SAAW

BY KATREEN WIKSTROM JONES

The word *uncertainty* gets tossed around at avalanche workshops around the globe, but in Alaska, due to its scale, lack of resources, and poor historical data records, uncertainty always plays a slightly bigger role. At this year's South-central Alaska Avalanche Workshop (SAAW) speakers shared lessons learned and tools for our community to operate effectively in a often precarious and variable environment.

Up north we're grateful to A3 and TAS for financially supporting our Alaskan avalanche community and making our 7th SAAW possible. This year's workshop at the University of Alaska Anchorage campus was enlivened with generous food and drink donations from local businesses, including Kaladi Brothers, Great Harvest Bread Company, Moose's Tooth Pizzeria, and Girdwood Brewing.

Ken Wylie, IFMGA mountain guide and educator, opened the morning session by sharing his honest self-reflections regarding his role as an assistant backcountry ski guide involved in the 2003 avalanche accident on the Durrand Glacier in British Columbia, Canada, that killed seven people. Ken could not attend SAAW in person, but he certainly didn't fail to convey over Zoom Meetings the



Jerry Johnson introduces the SAAW audience to new insight into the familiar concepts of Positional Preference and Powder Arousal.

challenge of adding depth of learning and context to this tragic event of his youth. Through more stillness and self-reflection Ken was able to identify the personal dragons that led both him and the other guide into a terrible trap. The arrogance of one guide combined with the self-deprecation of the other emerged as the characteristics that joined in their dangerous decision-making. Ken also talked about *gut feeling*. Should we listen to it? In a very uncertain situation, our gut feeling might dig up some useful knowledge, trying to lead us in the right direction. Ken admitted that he ignored his intuition that day and lacked the social courage to reduce risk for his group.

Two years ago, there was a near miss incident at Twin Peaks in Turnagain Pass, southcentral Alaska, on a low danger day. From an established skin track, two people triggered a large avalanche that fractured on a deeply buried persistent weak layer. Heather Thamm, avalanche forecaster for Chugach National Forest Avalanche Information Center (CNFAIC) gave an intriguing presentation about the challenge forecasting LOW danger with underly-

ing persistent weak layers. She looked at several years of data to understand how many days after a large snow event makes the likelihood of persistent slab avalanches in Turnagain pass truly low. A study in Colorado (Jason Konigsberg, TAR 36.3) found it was often eight days and she found that conclusion largely held true for her forecasting region too. The Twin Peaks avalanche was truly an outlier event. Heather just completed her last season for CNFAIC and will be greatly missed.

With last winter's crazy avalanche cycle in Colorado, historical by measure, it was great to hear Jamie Yount, avalanche forecaster with the Colorado Department of Transportation, recount weeks of long hours and difficult decision-making. With mind-blowing photos and videos displaying new avalanche paths and threats to critical state infrastructure, Jamie described the enormous resources Colorado must deploy in extreme loading events. Impressive to say the least.

Likewise, in Alaska we are trying to understand how to protect critical infrastructure from the threat of avalanches in extreme weather events. Gabe Wolken (Alaska Division of Geological & Geophysical Surveys, University of Alaska Fairbanks) presented a collaborative historical avalanche mapping project currently taking place around the city of Juneau in southeast Alaska, using dendrochronology and remote sensing. Juneau is an urban area with one of the highest avalanche danger exposures in the world, yet there are basically no existing historical avalanche records and people still live in houses in the run-out zones! Gabe also spoke about the statewide avalanche mapping project that he is leading, an effort to map potential release ar-

eas and run-out extents for extreme avalanche events across Alaska.

To reduce uncertainty in avalanche modeling, understanding snow depth distribution becomes critical. Ground measurements of snow depth are then necessary to validate any estimated snow depth surfaces – so, what better crowd to engage in measuring snow depth than our local avalanche community?! I had the opportunity at SAAW this year to speak about the Community Snow Observations (CSO) project. With this citizen science project, we recruit winter backcountry travelers to help collect snow depth information in high elevation, complex terrain that is used for various snow science applications.

Kyle van Peurse, of the US National Weather Service Alaska, gave his warm and wet weather outlook for the coming winter season. His prediction is that snow events will again favor our cooler interior ranges. He also explored deficiencies in existing weather models that underestimated the “Solstice Sleeper Storm” last winter that took everyone by surprise by dumping waist deep powder in Turnagain Pass.

“What if your ski partner doesn't see you because you're skiing in the trees?” or “What if you forgot to do the beacon check and your ski partner forgot to turn on her beacon?” Alaska Avalanche School's executive director Melis Coady layered last year's U.S. avalanche fatality statistics over Evelyn Lees and Mark Staples' popular *Effectively Solo* presentation. Fourteen out of twenty-five of last year's fatalities happened to people who were either solo or effectively solo because their partner could not effect a rescue. Partners were either caught themselves, too far away, or didn't have the equipment and skill.

In the final slot, Dr. Jerry Johnson from Montana State University presented progress and findings of the White Heat Project. He talked about the concepts of *positional preference* and *powder arousal*. **Positional Preference:** Do you feel more accomplished and happier about yourself if you shredded more gnar than your friends this past weekend? Asking me? For sure. **Powder Arousal:** When you take those first two turns and the powder is unbelievably deep and gooooooood, does it arouse and tempt you to ride just a little bit further out where the slope is steeper (and you hadn't planned to go initially)? You're asking me again? Absolutely, yes. According to Jerry, statistics show that regardless of your training and experience in the backcountry, positional preference and powder arousal have shown to make you take on *more risk* in avalanche terrain during these states of mind.

We had a great lineup of speakers this year! I felt challenged both from a human behavioral perspective and from an understanding-snowpack-instability perspective. After attending SAAW I'm left with a split feeling of **excitement** for winter and all the fun activities it brings, and **fear** for my personal character flaws. However, when we make wrong decisions, we're always left with the opportunity to reflect upon them afterwards, gather more information and double-check our resources, and importantly, grow from our new insights and share our knowledge with others. We're

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then better prepared for next time a similar situation arises and we can reduce our uncertainty. I know what I'll be working on *improving* this winter, and I'll try listening to my gut feeling more too.

Katreen Wikstrom Jones is a Cryosphere Hazards Specialist at the Alaska Division of Geological & Geophysical Surveys



4SAW

BY JASPER THOMPSON AND JIM DONOVAN

Silverton Avalanche School presented the inaugural Four Corners Snow and Avalanche Workshop on October 26 2019 at Silverton Public School in Silverton Colorado. For such a small town Silverton has a high density of snow and avalanche professionals. With this success and a desire to strengthen the Snow and Avalanche Community in the Southern Rocky Mountains, 4SAW was developed to capture a large, dispersed, professional, and recreational snow community.

The San Juans have long been a location for innovation, research, and education in the world. Turn of the century avalanche defense structures still stand to protect now-closed mines. This rich history is what make Silverton, in the words of Don Bachman, 'The Center of the Avalanche Universe'.

Speakers from Colorado, Utah, New Mexico, and Arizona promoted a **central theme of "past present and future"** by highlighting a mix of snow scientists, adventurers, forecasters and educators. The audience of over

200 was a strong mix of recreational travelers and diverse professionals coming from all Four Corners States and as far as Iowa.

Storyteller and avalanche educator Michael Ackerman was the MC; he set the tone for the day as a story in mountain life which began over 100 years ago during Silverton's mining days and progressed to the historic winter of 2019.

The first speakers, Betsy Armstrong and Richard Armstrong, came to Silverton as part of the Institute of Arctic and Alpine Research's San Juan Avalanche Project in the 1970s. *A History of the San Juan Avalanche Project (SJAP) in the San Juan Mountains, Southwestern Colorado, USA* began with Richard discussing the SJAP and formative avalanche detection systems, remote avalanche control systems, and the character of continental snow. Betsy then shared a history of the avalanche-related struggles and solutions of early San Juan pioneers and miners.

Next up was Chris Wilbur of Arthur I. Mears, P.E., Inc. & Wilbur Engineering, Inc. Chris is an Avalanche Defense Engineer based in Durango who works with Art Mears on projects worldwide, including mitigation programs for DOTs, mining projects, electric transmission lines, pipelines, ski resorts and residential developments. His presentation, *Avalanches of March 2019: An Engineers Perspective* gave insight into the fundamental characteristic of avalanches and return periods as well as the destructive power from the March 2019 cycle (see page 22 of this TAR).

Students of the esteemed Sallie Barney at the Silverton Elementary School then gave an inspirational presentation, *10 Years of Snow Field Work at the Elementary Level: Silverton School*



Michael Ackerman sets the 4SAW stage for a full house at the Silverton School Gym.

Students 2009-2019. Sallie's classes have exemplified Silverton School's expeditionary learning (EL) curriculum by performing field-based projects in snow hydrology. 2nd and 3rd graders study which aspects hold the most water and how much snow is needed to produce agricultural goods. Many of these students have gone on to present their research at regional science fairs and apply their skills in the mountain environment from advanced transceiver skills to fundamental problem-solving.

Stress injury has been an overlooked aspect of life in mountain towns and austere environments. Starr Jamison shared her personal and heartfelt experience with stress injury after a 12-month time span brought the loss of three friends to avalanches as well as being hit by a car while bike touring. Starr addressed subsequent challenges by forming Survivors of Outdoor Adventure and Recovery, partnering with The Responders Alliance, and The Climbing Grief Fund. *Continuing our Adventures and Careers with a Healthy Mind: Support for Grief, Trauma and Stress Injuries* presented her thoughts and experiences of that journey.

David Lovejoy of Prescott College and Kachina Peaks Avalanche Center presented *Avalanches in Arizona*. Avalanches and Arizona are rarely thought of at the same time, but David showed us the potential that winter storms can have on Arizona's highest peaks. With back to back winter snowfall totals that range from less than 100 inches in 2006 to over 450 inches in 2005, public educating and communication challenges are huge. Solutions include a backcountry permit system, avalanche courses taught by KPAC, and a business model for underfunded forecast centers.

In 2019 Josh Jespersen, Ricke Schuler, and Isaiah Branch Boyle traversed the Sangre de Cristo range of Colorado on skis and splitboards. They presented this story at 4SAW with the ski film premiere of *The Brotherhood Escort* which paid homage to friends that Josh and Ricke lost to war and served to benefit a healthy healing process for survivors.

Ryan Howe from Telluride Ski Patrol and Telluride Mountain Guides discussed *The Fine Art of Explosive Testing and Mechanical Compaction in Ski Area Operations*, highlighting the avalanche mitigation work that ski patrollers do to get terrain open to the public. A continental and often shallow snowpack with high winds offers continually changing challenges in the complex terrain of Telluride.

Kris Sanders from The National Weather Service Grand Junction Weather Forecasting Office shared basics of mountain weather in the Four Corners region with preferred storm

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tracks and orographic effects from the desert to mountain landscape. He also shared the Winter 2020 climate outlook. This climate projection looked so-so for the San Juan winter, but we assure you that things are looking most excellent as the New Year approaches.

Jeff Deems of the National Snow and Ice Data Center then highlighted the information that LIDAR can provide regarding avalanche size and location, slab thickness, and shot placement. His research has been applied at ski area operations as well as by Western water managers to better understand water supply.

Taos New Mexico is known for its extreme terrain and less-than-dependable high-quality powder. Andy Bond, founder of The Taos Avalanche Center, shared his story of forming the first public forecast center in New Mexico and the challenges of engaging a diverse user group with often limited avalanche awareness and highly variable winters. Taos Avalanche Center closed for 2018-2019 due to drought, but is back in action for the 2020 winter with increased support from the New Mexico community and Carson National Forest.

The March 2019 avalanche cycle is a hot topic of conversation, but Jeff Davis of the Colorado Avalanche Information Center reminded us that the entire 2019 winter is an exciting story. He shared with us the intricacies and events that occurred on the Million Dollar Highway during his first year as a CAIC/CDOT Highway 550 Avalanche Forecaster.

Jake Hutchinson from A3 and American Avalanche Institute shared a new outlook on human behavior with *Left of Whoomph: How US Marine Corps Combat Hunter Program Can Help us Use Heuristics to our Advantage in the Mountain Environment*, which discussed how we to avoid complacency and increase situational awareness in preventing accidents. (See page 38 of this TAR)

4SAW was followed by an avalanche rescue training, on October 27, 2019 at Kendall Mountain Recreation Area, taught by Doug Workman of Mammut North America, highlighting the capabilities of the Barryvox S and best practices for avalanche transceiver searches.

Thank you to our supporters who made it possible: A3, Wyssen Avalanche Control, Pine Needle Mountaineering, Mammut, and Friends of the San Juans.

Jim Donovan is the Director of the Silverton Avalanche School. He also develops custom courses and teaches for both the tactical and industrial programs. He has an extensive background in emergency planning and management and natural hazards assessment, and is the Emergency Manager for San Juan County.



Jasper Thompson is a Professional Member of the A3 and the AMGA. He teaches recreational avalanche courses for SAS and was the point man on organizing the Four Corners Snow and Avalanche Workshop. He is an EMT with Silverton EMS, member of San Juan Mountain Rescue, and works with Center for Snow and Avalanche Studies monitoring research plots across Colorado.



SAWTOOTH XMAS 2019

'Twas the night before Christmas and all through our 'pack,
the weak layers were grumbling, waiting to react,
surface hoar, depth hoar, crusts, and facets too,
a thin and weak snowpack, waiting to unglue.

then a deep low in Mexico sent moisture our way,
streaming north up from Baja, fresh snow with to play,
water content was low and the powder just right,
nevermind that storm totals remained rather light

so it's off to the mountains to enjoy this great gift,
but beware of the red flags that signal a rift,
cracking, collapsing, fresh avalanches too,

be safe on this Christmas, both your partners and you

—Poem and photo by Ben VanDenBos



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CONTRIBUTORS



Renowned aerial photographer **John Scurlock** has been photographing mountains and glaciers across western North America since 2002. His ground-breaking book, *Snow & Spire: Flights to Winter in the North Cascade Range*, was published in 2011. In 2018, he completed an eleven-year project to photograph every glacier in the lower forty-eight states. He and his wife reside on Bainbridge Island.



Cy Whitling swings hammers and paintbrushes in Idaho. When he's not drawing the mountains he's playing in them. Cy likes jumping off things and analyzing any pits his dog digs. More of his work can be found @cywhitling on Instagram.



Emma Walker is a freelance writer and editor based in Boise, Idaho. Emma has written for *Outside*, *Powder*, and *The Dirtbag Diaries*, and is the editor of the *AMGA GUIDE Bulletin* and two volumes of *The Snowy Torrents*. When she's not writing, you'll find Emma on skis or a bike.



Dick Dorworth ski raced extensively from 1950 through 1965 and set the world record for speed on skis in Portillo, Chile in 1963. Dick taught and coached skiing for years, served as coach of the U.S. Ski Men's Team, and later served as Director of the Aspen Mountain Ski School. Today he skis his favorite mountains in Ketchum, Idaho in winter climbs at local crags in Bozeman, Montana in summer. He writes all year.



Scott Thumlert is a ski guide and engineer working on industrial projects with Alpine Solutions Avalanche Services. Previously, he was a post-doctoral fellow with the Simon Fraser University Avalanche Research Program and completed a PhD degree with the Applied Snow and Avalanche Research University of Calgary.



Jenna Malone moved to Jackson, Wyoming, in the 1990s and joined ski patrol at Jackson Hole Mountain Resort. She now works as a PA in Neurosurgery and Trauma at Intermountain Medical Center. She also works as a ski patroller at Alta, a guide with Powderbird, and an instructor with the American Avalanche Institute.



Jake Hutchinson is a Lead Instructor for AAI, technical consultant & instructor for the Mountain Mobility Group, and Membership Trustee for A3. Currently he spends most of his time appreciating life through the lens of a 15-month-old Malinois.

CHANGE

Snow once fallen is rarely static—
 Not like stuff stored up in your attic.
 Based on temps and structure and depth of the snow—
 It can settle and strengthen...or weaken and grow.
 Whatever thoughts you had about it last week—
 Don't matter much as the change it will seek.
 Once you've decided that all is okay—
 And you head towards your favorite slopes to play.
 Don't close your eyes or mind, not for a minute,
 Because snow changes for sure, and now you're in it.
 Continual assessment & awareness are needed out there—
 Especially if it's friends or life about which you care.
 All the tests that you do, and observations you make—
 Will enhance the decisions and routes that you take.
 But don't expect that the snow is aware of your test—
 It's surprised novice and pro and buried some of the best.
 Just keep aware that the month or the year—
 Are never a sign that you're all in the clear.
 Each day is unique to the evolving snowpack—
 And you must probe its memory to find wisdom you lack

—Mark Moore

The Change rhyme came into being through many years of observing the often fragile and ephemeral nature of the snowpack and its associated stability or lack thereof. I have been surprised many times by the internal metamorphosis of snow. Fortunately for my and others' safety, these surprises have diminished over time and been replaced by an inkling of understanding. But I still experience surprise, just a little less often.

Mark Moore is well known for his poetry from the forecaster's chair at the Northwest Avalanche Center.

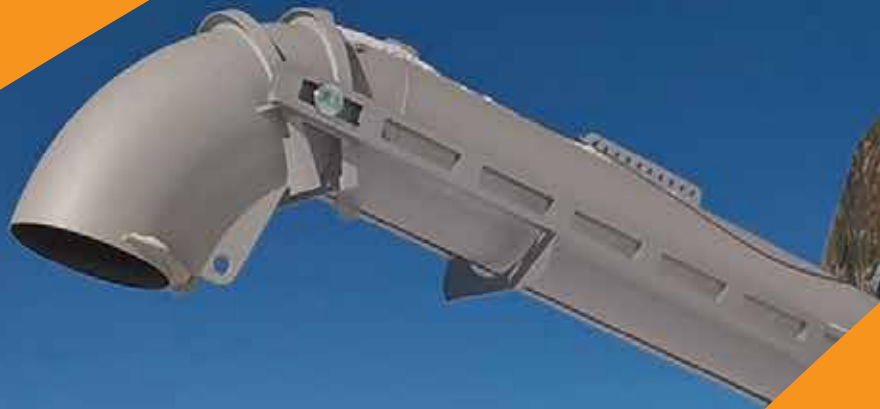
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