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the AVALANCHE REVIEW

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A3 STATEMENT OF PURPOSE

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

A3 STAFF AND BOARD

the AVALANCHE REVIEW

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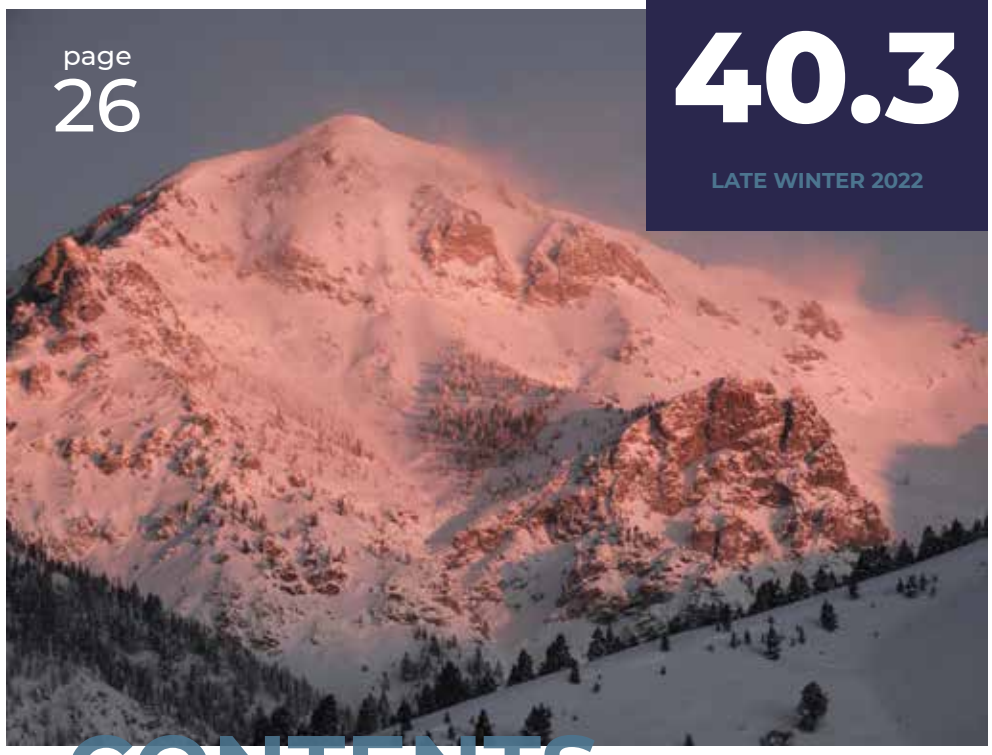
LATE WINTER 2022



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51 LAST LAP

▲ One perk of being up early to look for avalanches is that you also get to look where they aren't. This peak in the Boulder Mountains north of Ketchum often produces monsters, but it has been quiet this year.

BEN VANDENBOS

ON THE COVER

Four Turns by Cy Whitling

CY WHITLING swings ski poles and paintbrushes in Idaho. He likes skiing with his dog more than his dog likes skiing with him.


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NO NAME BOWL, DECEMBER 12, 2021. MARK WHITE

FROM THE EDITOR

HEART OF THE WINTER

Heart of the winter—we're intent on snow, following the storm tracks, tracking drought layers as they are buried, driving through whiteouts and on ice, stripping skins, and clearing storm boards. Early mornings and a thermos of coffee bring the truly winter-specific senses of pastel mornings and sibilant skiing through surface hoar. I'll set the joys of coaching a team through their first AM form against the more austere pleasures of breaking trail up a smooth ridge with a treasured partner. Enjoy the blessings of the season, friends, as the sun rolls higher in the sky.

The February TAR is broadly themed as the science issue every volume. Generally I will trawl the topics and speakers lists for the SAWs, then pursue the ones that interest me, expecting that they will interest you as well. This year I had help from the very capable eye of Colin Johnson of Winnipeg, who came to TAR via a timely referral from Don Sharaf, after they were both students on a mapping course in BC:

Hi Lynne,
Don and I just finished an avalanche mapping course and I am hoping to get more involved with the academic/research side of the avalanche business. Is the Review *looking for any journal reviewers to go through submissions?*

I'm a keen reader and have sifted through my share of reports and studies from my engineering work and current job as a meteorological technician. If you have any ideas or suggestions where I could help please let me know.

Thank you,
—Colin

Hi Colin,
Pleased to meet you electronically. A reference from Don is a powerful referral for sure.

*Every so often I do get articles that need a technical review, but what I could use more than anything is a TAR (*The Avalanche Review*) scout. If you happen to be on the Canadian continuing education classes or any of the US SAW events and see a topic that would be of interest to TAR readers, then let me know. You could also (while including me) pursue the author(s) and request that they convert presentation into an article. Baseline for my technical content is that the material/ information influences practice, rather than just being theoretical or deep background.*

How does that sound?
lw

Thanks Colin for your consistent attendance at the online SAW lineup, and for the comprehensive and helpful spreadsheet that emerged. SAW reports, starting page 40, expand on Colin's recommendations and entice us with many fascinating stories; I only have room for a few. You can find links to all the SAW recordings at http://theavalanchereview.org/. Any of you who want to be "TAR scouts" like Colin, please keep an eye open for stories you think other TAR readers might appreciate.

As I worked through the material, a new sub-theme began to emerge from the science stories. Many of our authors are musing on current patterns in weather and human behavior, weaving that awareness into targeted avalanche forecasting, refined weak layer tracking. So our Snow Science section evolved into a **Patterns and Stories** section, where we examine how our stories adapt to new technologies and expanded access, to shorter winters where intense storms alternate with blocking highs. Start with Ben VandenBos on page 26, then move through Matt Primomo's look at Deep Persistent Slabs in the Pacific Northwest, Don Sharaf's Crusts and Facets examination, and an interesting view of how planting trees affected avalanche terrain in BC, and when you're done, recall how each pattern has been traced by its author.

Under the Rescue and Accidents header, Bruce Edgerly and Jim Conway detail how to implement and instruct group searching technique using lanes. I used this on a recent rescue seminar and applaud the emphasis on how focused leadership and communication maintain lane discipline and promote resource efficiency. Ethan Greene and Spencer Logan share their research into Colorado victim demographics, which, with some further research, can help tailor forecasts and education to reach vulnerable populations (read: *how to help the old guys add more margin to their decisions.*)

Stepping away from the editor's desk at New Years in the Tetons. Where's Lucky Dog? *(Hint: he's wearing a red jacket.)* PETER THURSTON

Also in this issue you will find an introduction to the tenets of our new and first A3 strategic plan, which was built on input from you, our membership. We are proud of our role in the avalanche community, which is so much more than just an industry. We look forward to supporting you in many ways in the years to come.

Interspersed with the science you'll find less technical treats such as a moving essay from Christy NaMee Eriksen of Juneau, whose extended avalanche metaphor fits her story in a way that our community can viscerally understand. Accompanying photos from Tom Mattice and Mike Janes illustrate impacts of Juneau's urban avalanche problem. Thanks, Mike, for sending TAR her story.

There's more, friends, but I have pro homework to grade, skins to trim, and skis to wax. Gotta get this lovely issue of *The Avalanche Review* off to the printer. Enjoy and let me know what you think about this collection of patterns and stories.

—LYNNE

Eric Parker

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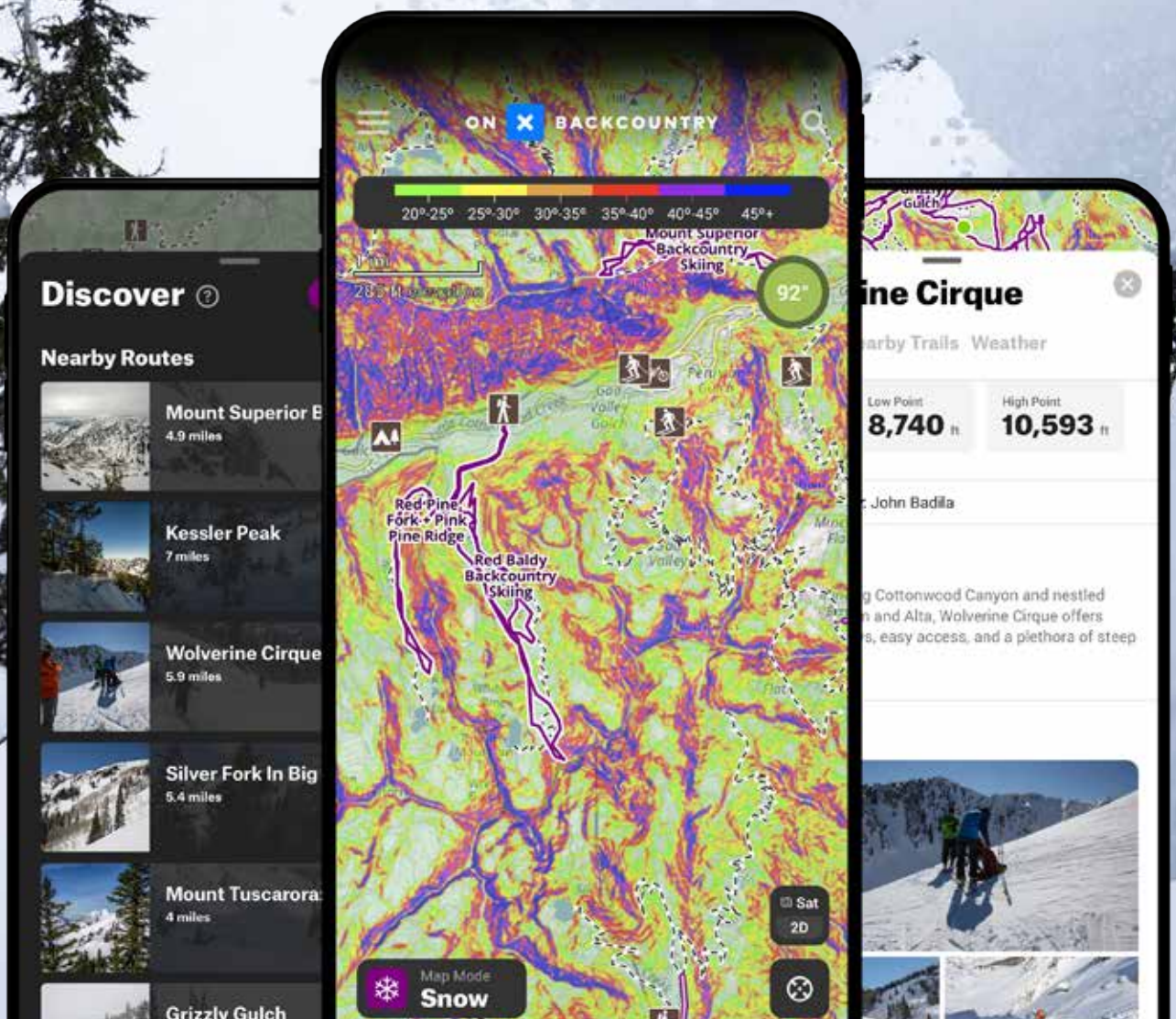


FROM THE EXECUTIVE DIRECTOR

Dear TAR Readers,

One of our organization's most notable accomplishments in 2021 was the development of our first-ever strategic plan. Shaped by thoughtful input from the A3 community and developed over multiple months, the strategic plan will be our North Star as we navigate the next three years and beyond. The A3 Board of Directors formally adopted this strategic plan at their general board meeting on November 30—and I'm excited to share a high-level overview of it with you now.

I want to extend a heartfelt thank-you to everyone who participated in the research-gathering phase of the strategic plan; this outline wouldn't have come to be without you. I also want to extend sincere thanks to A3's Strategic Planning Committee: Eeva Latosuo, Erica Engle, Erich Peitzsch, Ethan Greene, Halsted Morris, Jake Hutchinson, Kate Koons, Scott Savage and Simon Trautman. Each of these folks devoted many hours to bringing this plan to fruition.

Supporting avalanche professionals has been at the core of A3's work since our founding in 1986—and that core value will not change. In fact, A3 is recommitting to our mission of supporting the avalanche workers who keep us safe, informed, and educated. The following focus areas were developed with that mission in mind. Each focus area contains specific goals and objectives that will help us tackle the opportunities and the challenges that will move A3 forward.

As always, we appreciate your feedback as an A3 member, and I look forward to your input as we begin implementation.

Best,

Jayne Thompson Nolan
Executive Director
Jayne@avalanche.org

Three of the four A3 staff members managed to be in the same place at the same time this fall at WYSAW. Left to right, Jen Reddy, Jayne Thompson Nolan, Lynne Wolfe.

A3 STRATEGIC PLAN:

MISSION:
Promote and increase professionalism, expertise, and knowledge within the avalanche industry for the benefit of all who work, travel, or play in avalanche country.

VALUES:

Community—We are dedicated to cultivating positive connections between individuals and organizations within the avalanche industry. We respect all avalanche industry disciplines and geographic regions and encourage inclusion of those new to our community.

Collaboration—We seek to develop and strengthen partnerships with organizations and individuals, both within and outside of the avalanche industry because collaboration is vital to our success.

Innovation—We believe in supporting projects that develop knowledge, techniques, and equipment that improve avalanche safety.

Transparency—We work in an ethical way that creates openness and trust between members, donors, sponsors and partners.

FOCUS AREAS:

1. Membership

A3 is committed to serving our growing membership. In the next three years, we will:

- Expand membership benefits (monetary and otherwise)
- Improve the user experience for members on the A3 website
- Launch a Resilience Program to build a mental health resources list on the A3 website and provide grants for mental health services to Pro and Affiliate A3 members.

2. Education

A3 is committed to both the continuing professional development of our members and ensuring sustainable oversight of avalanche education standards in the U.S. In the next three years, A3 will:

- Expand our current professional webinar series
- Explore mentorship programs and partnerships
- Offer additional scholarships for continued education for A3 members

Professional Avalanche Education

Starting this spring, A3 will re-evaluate and revamp our Professional Education Program, including:

- Re-evaluate all current curriculum recommendations and standards
- Reassess the current role of the Industry Advisory Group (IAG) and determine utilization of IAG moving forward
- Re-evaluate our Pro-Training workshop curriculum and course outcomes
- Track, report, and market A3 Pro-Program and Pro Providers
- Finalize structure and process for Avalanche Search and Rescue within Pro Programs
- Re-evaluate income structures that support A3 Pro Program operations

Recreational Avalanche Education

A3 is committed to improving our role in recreational avalanche education, including:

- More clearly define A3's role in recreational avalanche education oversight
- Re-evaluate income structures that support A3 Rec Program operations
- Update curriculum guidelines for education requirements for Rec Courses
- Execute a feasibility assessment of expanded Rec Program and creating an ongoing audit process for A3 approved Rec-Providers
- Re-establish policies and procedures for A3 providers moving forward

3. Outreach

In the next three years, A3 will continue to improve our outreach efforts. This will include clarifying A3's role in the avalanche community, expanded story-telling, updating our logo use policy and brand standards, better marketing of A3 education providers, ongoing support of Snow and Avalanche Workshops, and development of communications specific to the motorized community.

In the coming years, A3 will also continue to prioritize TAR, as well as work to provide other valuable publications, including *The Snowy Torrents* and SWAG (which will include regular reviews and updates).

4. Technology & Research

A3 will reassess all currently used IT solutions, identify future needs, and plan for necessary technological upgrades. A3 will expand our support of member-led research and reassess our research awards cycle to provide the most benefit for A3 members conducting research.

In addition to general technology, A3 will also expand our partnership with the National Avalanche Center (NAC) to build upon Avalanche.org. This will include, but not be limited to:

- Update the public-facing website
- Implement a data access plan for public avalanche forecast data
- Build and deploy a centralized public observation and occurrence platform
- Implement Phase II of the Weather Platform update
- Explore a long-term plan for an accident database with CAIC

5. Inclusion

A3 will build on our past commitments to diversity, equity, and inclusion within our organization. A3 is also committed to partnering with other organizations to maximize our impact in this space. This element will include:

- Expanded resources for underrepresented communities within our membership
- A more inclusive environment for newcomers to the avalanche community
- Consultations with professional DEI trainers
- Recruitment of diverse applicant pools for future staff and board positions

6. Sustainability

Organizational sustainability will be a top priority for A3 moving forward. From diversifying revenue to developing an annual fundraising plan, and completing an organizational financial assessment, A3 is committed to making sure that we can move into the future sustainably. Moving forward, A3 will publish an annual report on all operations and finances each year to keep members apprised of our financial sustainability and impact.

7. Capacity

In the next three years, A3 will expand staff capacity to meet the needs of our programs. We will complete annual assessments of all programs to map out improvements. A3 will also expand our board engagement and continue to build upon our current strategic plan. To ensure progress, the strategic plan will be reviewed quarterly by the A3 board of directors.

A3 SPECIAL SERVICE AWARD:
Art Mears

BY HALSTED "HACKSAW" MORRIS

ART COTTON AT CSAW 2016

The Special Service Award recognizes specific and outstanding achievement in the service of North American snow avalanche activity.

The following individuals have nominated Art Mears for American Avalanche Association Special Service Award; Knox Williams, Don Bachman, Denny Hogan, Chris Landry, Janet Kellum, Bruce Smith, and Chris Wilbur.

ART MEARS

Art is a professional engineer and geologist with degrees in civil engineering (B.S. 1969) and geology (M.S. 1972) from the University of Colorado. Since 1972 he has worked exclusively as a consulting engineer and geologist in the fields of snow and rock avalanche mechanics, debris-flow and mountain-torrent dynamics, rockfall, and associated structural-defense and land-use problems. His primary consulting emphasis during the past 36 years has been avalanche-control engineering. This engineering specialty includes delineation of avalanche-hazard areas for zoning and mountain construction and design avalanche-control facilities. He has worked as a consultant on avalanche forecasting and hazard-evaluation for several state transportation departments in the United States. His consulting work has taken him to various snow climates in North and South America, Europe, Asia, and New Zealand. He has worked as a research consultant on avalanche dynamics for the U.S. Geological Survey, U.S. Forest Service, and Colorado Department of Transportation.

Art was also a principal and guest lecturer instructor for over thirty years at the National Avalanche School. He specialized in the subjects of structural defensive structures, avalanche dynamics, and avalanche mapping and zoning. His work in the avalanche mapping and zoning field is still being used throughout the western United States; particularly in the Sun Valley, Idaho area.

Art is well-known for his meticulous field research. He worked as a consultant for CDOT on many projects, but one was to study and document the many storms to hit SW Colorado and the highways impacted. He was very detailed in his records to get all of the information correct. Denny Hogan relates that he would be sure ask if my measurements submitted were estimated or measured, as he preferred we MEASURE them to be accurate! Art could also remember the length of highway centerline covered, having measured the distance after each storm cycle, as well as the dates of each of these big avalanche events that hit the highways. If there was a storm cycle in SW Colorado highways, Art Mears was there to help document it. The end result of all his work for CDOT was the Avalanche Hazard Index for Colorado Highways. The final report came out in October 1995 and was a useful study to measure the avalanche hazard to traffic on the highways.

Denny Hogan worked for a number of years on Red Mountain Pass for the CAIC while Art was doing studies there. Art was known for his great dry sense-of-humor. Things could be going to hell in a hand cart and Art would say something dry and have us all laughing at ourselves and the situation we were in. Denny recalled one time when they were trying to close the pass due to a big San Juaner and it was snowing hard for the last few hours and the south wind was howling across the summit.

"Sitting there in our CAIC/CDOT rig for a meeting of the minds: Don Bachman; myself, Gary King. We all three decide it's time to close Red Mountain Pass and begin our sweep of the road. Up drives Art Mears from the north side, "Greetings men, Blue Point just ran behind me across the road. However, the road was dry all the way up the gorge to Ironton Park. So I might just be spending the night in Silverton, you know of anybody that I might ask for a room?" The storm went on for the next 72 hrs. and the highway was closed for several days. Art always has a great sense of timing."

Knox Williams says that Art is his favorite ski touring and 14er climbing partner because he doesn't skin straight up the slopes. They usually tour and climb at a more casual pace so that they can actually have a conversation. When Art speaks, people listen.

This award goes to a true gentleman and professional who is both a researcher and field practitioner in the avalanche world. ⬢

LETTERS

To the Editor:


SHORT STACK STRATEGY

A Poker Strategy for Operating in High Consequence Avalanche Terrain

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

—Kahneman/Tversky

As a former hedge fund manager, I appreciate all approaches to improve risk assessment in the backcountry. So I read with interest Mike Austin's "Short Stack Strategy" article in 40.1.

One of his interesting stats was that, over a 5-year period, 18% of avalanche fatalities in Switzerland involved a guided group. In a note to that, he cites 14% of avalanche deaths over a 20-year period in France involved IFMGA certified French guides. I'd be interested in the nationality of the guides in the Swiss fatalities. In my admittedly limited time in Chamonix, the scuttlebutt was the Swiss and American guides were safer than the French or Italian guides. A gross generalization, for sure, but given the risks, it swayed my guide hiring practices.

I'm not sure poker is the best analogy for risk avalanche risk assessment. In poker, you are playing against other humans, and who you are playing dramatically affects the odds and the outcomes. Avalanches are purely natural phenomena—nature doesn't care if it wins or loses. And in avalanche terrain, crossing the 30-degree line dramatically alters the bet; at 45 degrees, you are "all-in."

This truth makes avalanche risk assessment easier than poker. In poker, they say if you don't know who the pigeon is at the table, it's you. In avalanche terrain, you always know that you are the pigeon. But at least in avalanche terrain, a knowledge of snow science can massively reduce your odds of "losing all your chips."

As Chris Lundy stated in his piece in 40.1, most backcountry skiers underestimate risk and start from the wrong default decision-making point. A default start of "how do I assess the odds in 30–45 degree slope situations" is the wrong way to start. You are highly unlikely to lose all your chips to the avalanche going "all-in" on you if you stay sub 30. Once you cross that line, the risk is non-linear.

Perry Boyle
Ketchum, ID

A Thank you from WYDOT Avalanche to CDOT Avalanche: The professional avalanche community at its finest

Dear CDOT,

Thank you! When we were down and scrambling you stepped up to the plate and helped us when it felt like we weren't getting help from anyone.

This fall at WYDOT Avalanche we had an incident with a piece of avalanche infrastructure, resulting in the infrastructure being inoperable for the 2021–2022 winter season.

Thankfully, no one was injured or killed during this incident. As the legendary Jackson Hole Ski Patroller and Grand Teton National Park Jenny Lake climbing ranger Renny Jackson once told me, "That's all that really matters."

We reached out to CDOT as they have one of the largest highway avalanche mitigation programs in North America. Because of the delay on a project in Colorado this fall, low and behold they had a piece of infrastructure we could borrow for the season.

This never would have happened if it weren't for the hustle of Jamie Yount, (Winter Operations Program Manager) and Brian Gorsage (Avalanche Program Manager) for CDOT. It should be noted that both gentlemen previously worked as avalanche forecasters for WYDOT.

At times in this industry, we struggle to communicate with agencies in our own valleys. Yet these individuals made incredible moves to help us out and get back up and running.

Seeing how we can work together across state boundaries and agencies made me prouder than ever to be a part of this community of avalanche professionals.

I hope this thank you inspires others in the industry to communicate more openly across not only state boundaries, but perhaps across valleys and rope lines. And remember that we are all in this to do our best to inform and protect our customers and the traveling public.

Again, I want to thank Jamie, Brian, and the countless others behind the scenes who helped us get back online this season.

Sincerely,
Brenden Cronin
WYDOT Avalanche Dept

WYOMING DEPARTMENT TRANSPORTATION AVALANCHE CONTROL

JEN REDDY INK DESIGN

METAMORPHISM

TODD GREENFIELD WILL BE MISSED

Snowbird, UT, lost a vital member of their team, Director of Snow Safety Todd Greenfield, this summer. Growing up in the Northeast, Greenfield developed a love for the outdoors at a young age and eventually made his way westward to Utah to pursue his dreams. He was a dedicated father, son and friend who began his time at Snowbird in 1996. For 16 years, Todd worked in the summer as a wildland firefighter for the Bureau of Land Management, eventually retiring from firefighting in 2019 to work at Snowbird year-round. He was a well-respected member of the Avalanche Artillery Users of North America Committee where he achieved the level of Master Gunner and then Trainer. Greenfield played a vital role in keeping Little Cottonwood Canyon—known for its bountiful snowfall and avalanche danger—accessible and safe during the winter months. He was recognized for being a hard worker and someone who brought many of those around him to tears with his sense of humor. A GoFundMe has been set up in his honor to support his family: https://gofund.me/0dd9137f. ⬢

ERIC MURAKAMI is Snow Safety Assistant Director at Snowbird.

A3 NEW HIRE

A3 is pleased to welcome Jen Reddy to our team as the new A3 Member Services Coordinator. Jen brings a wealth of avalanche knowledge and industry experience to her new role. In addition to her work at A3, Jen is currently a member of Teton County Search and Rescue, an avalanche educator with the American Avalanche Institute, a board member of the Bridger Teton Avalanche Center Foundation and the Teton Backcountry Alliance, and a founding member of the Teton Interagency Peer Support program, which is a mental health initiative for first responders. Jen is also an avid artist and her art and illustrations have been published in previous issues of *The Avalanche Review* and can be found at jenreddyink.com. ⬢

MOUNT SHASTA NEW HIRE

The U.S. Forest Service team and Mt. Shasta community would like to extend a warm welcome to Ryan Lazzeri. Ryan applied for and received a permanent 18/8 position with the USFS Mt. Shasta Avalanche Center and Climbing Rangers this past fall, 2021. Ryan cut his teeth on the other 14,000' Cascade Volcano: Mount Rainier. He spent six seasons there as an NPS climbing ranger and helicopter rescue team member. During this time he spent eight winters ski patrolling, first at Mount Bachelor, OR, and then in Telluride, CO, where he also did some part-time backcountry ski guiding. In his free time he enjoys long rock climbs in the alpine, playing music, and floating down rivers. ⬢

LOTS OF NEW FACES AT THE CAIC

The Colorado Avalanche Information Center is excited to welcome a bevy of new talent to our team.

We added a couple new positions to round out our technical team. Jake Barney serves as our new Development Manager and will manage technology and research projects. This is his first professional job in the snow world after spending a decade leading research and evaluation projects in social services. He moved to Colorado from Minnesota in order to drop out of a geography Ph.D. focused on urban housing (but where his favorite teaching assistant duties were classes in meteorology, dendrochronology, and GIS.) He has been an avid recreational user of avalanche forecasts for the last seven years, and a volunteer ski patroller at Loveland Ski Area for the last four.

Ryan Becwar is our new Information Technology Coordinator. Ryan's background is in the data science consulting space, where he worked for several years as a data engineer. He completed a M.S. in Computer Science at Colorado State University, studying techniques for efficient georeferencing in a distributed and streaming context.

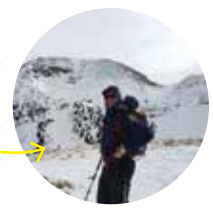
Will Barrett will be tackling forecasting operations for US Highway 50, US Highway 24, and Colorado Highways 82 and 91. Will comes to the CAIC after a long tenure with the Breckenridge ski patrol, where he started patrolling in 1989. Through the subsequent decades he rose through the ranks to become an Avalanche Forecaster, Snow Safety Director, and Assistant Director of Ski Patrol.

Ian Fowler joins the team as a weather and avalanche forecaster out of our main Boulder office. Ian grew up in the avalanche and ski mecca of England. Travels as a kid taught him about the wind slabs in Scotland and the wide-open bowls of the European Alps. He has worked in New Zealand, the Alps, Canada, Alaska, and Colorado. His varied career includes time as a ski patroller, mountain guide, and avalanche educator, earning his IFMGA Mountain Guide Certification along the way.

Our backcountry forecasting team welcomes several new people to the mix:

Austin DiVesta grew up and went to college in Colorado. After college, he started his ski patrol career at Park City Mountain where he stayed for five seasons. He worked for three years as the Assistant Patrol Director of Monarch Ski Area, where he began training his dog, Fawkes, for avalanche rescue. Austin is based in Fraser, CO for the season, and forecasts for large portions of our Northern Mountains.

Jeremy Primmer grew up in Wisconsin and discovered his love for the mountains while working in Glacier National Park one summer in college. After graduating he moved to Whitefish, Montana where he worked as a ski patroller and as an intern with the Flathead Avalanche Center. Now based out of Buena Vista, Jeremy forecasts for the Sawatch Range, and Summit County and Vail areas.



Dylan Craaybeek grew up in New England spending every weekend during the winter skiing at his family cabin in Maine. After high school, he found his true love for the mountains in the Gore Range while living in the Vail area. He graduated from the Colorado Mountain College Avalanche Science Program, and since then has been teaching avalanche courses, guiding on skis and splitboards, and researching snow hydrology with the NASA SnowEx program, under the tutelage of Kelly Elder. Now based in Carbondale, Dylan forecasts for the Aspen and Grand Mesa forecast zones.

Jeremy Yanko started on skis at Silver Creek, Colorado and progressed into fulfilling his middle school "career days" with the Winter Park Ski Patrol. After graduating from Fort Lewis College he worked as a Patroller and Guide at Silverton Mountain Ski Area, spending 15 seasons in an active avalanche program. He worked for five seasons in Alaska's Chugach Mountains as a mechanized guide. He has been involved with EMS/SAR in Silverton for twelve years, and now forecasts for the San Juan Mountains.

We are fortunate to have such an experienced and diverse set of professionals join our team and help keep watch over the people and transportation corridors of Colorado. ⬢

The American Avalanche Institute and Colorado Mountain School Join Forces

Colorado Mountain School, the largest provider of avalanche safety education for recreational backcountry travelers, announced today their alliance with The American Avalanche Institute, the nation's largest provider of professional avalanche education. With this alliance, ownership and management of the American Avalanche Institute will transition to Katy and Russell Hunter, current owners of Colorado Mountain School.

Katy and Russell Hunter, CMS owners.

Don Sharaf, Don and Sarah Carpenter, and Rod Newcomb, in Avalanche Bowl, Teton Pass, digging AAI's annual Thanksgiving pit.

"I am beyond excited for the opportunities that aligning these two companies creates," said Russell Hunter, Owner/CEO of Colorado Mountain School and now The American Avalanche Institute. "I feel honored and grateful for the opportunity to carry on the legacy of AAI!"

Founded by Rod Newcomb in 1974 in Jackson, Wyoming, The American Avalanche Institute translates snow science and decision-making research into relevant tools and practices for winter mountain travelers. For the past 47 years, the organization has remained committed to educating backcountry enthusiasts and serving the winter sports community through education and training, and AAI is committed to growing and engaging with the ranks of backcountry on-snow travelers and alpinists alike.

Sarah and Don Carpenter, along with Don Sharaf, have owned and operated the company since 2009, progressing Newcomb's legacy through the expansion of industry-renowned avalanche curriculum and student experience. All three previous owners will remain in leadership roles through this transition and beyond to continue evolving the avalanche curriculum and legacy of which they have been such a huge part.

"AAI is the oldest avalanche education school in the country, and our goal has always been to maintain and grow the organization's legacy," said Sarah Carpenter, former AAI co-owner and current lead avalanche course instructor. "To be able to continue to grow this organization's presence is a huge moment, and to have additional support for AAI to reach more people in our area and throughout the Rocky Mountains is fantastic. We're thrilled."

Founded in 1981 in Estes Park, Colorado Mountain School is the state's largest mountain guide company, an accredited guide service of the American Mountain Guides Association, and the country's leading course provider for American Institute for Avalanche Research and Education (AIARE). The move marks a milestone for both companies as they work towards their shared vision for shaping the future of avalanche education, together.

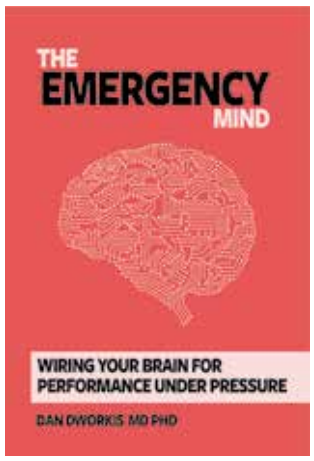
Moving into the 2021–22 season the two organizations will continue to operate separately, offering programs as they have in the past. Colorado Mountain School will teach the AIARE curriculum, while American Avalanche Institute courses will continue to follow their own curriculum. With almost 70 years of combined experience in avalanche education, both organizations are excited to share best practices and institutional knowledge, ultimately to the benefit of the students and backcountry community. Joining forces is a huge step forward in sharing the power of the mountains with adventurers and professionals who want to learn, work and explore safely.

To learn more about CMS, visit coloradomountainschool.com. To learn more about AAI, visit americanavalancheinstitute.com.

BOOK REVIEWS

The Emergency Mind by Dan Dworkis

BY LINDSEY FELL



I posit that emergency medicine and the work around avalanches are cognitively akin: human factor, communication, and sound decision-making skills are in both fields necessary for effective and safe practice. They require risk assessment in an often time-sensitive and dynamic environment. In his book, *The Emergency Mind* (Sangfroid Press, 2021), Dan Dworkis writes about "training to bring your skills to bear when the heat is on, and wiring your brain to perform at your best during times of crisis." Five, well-organized sections delve into the ideas of how to align our performance with our potential while working under pressure.

His first section discusses the concept of applying knowledge under pressure: finding calm in the storm, becoming a student of Sangfroid, the acceptance of "suboptimal," the technique of graduated pressure application, and the importance of training our "tired moves."

His next section delves into handling uncertainty and imperfection: the practice of wabi-sabi, the awareness of fallibility and cognitive bias, finding comfort in uncertainty, seeking wisdom from those around us, and making "Plan B" a regular part of our plans.

Learning how to support our critical decisions is the next: how to move efficiently between decisions, learning to ask better questions, eliminating unnecessary opportunities for failure, deciding when and when not to make decisions, and recognizing the rate limiting step in a decision-making process are covered.

A discussion on core values follows: the ideas of not wasting our moments of suffering, accepting that we are humans and not robots, praxis versus theory, and learning to rapidly accept reality are his central themes.

Finally, Dworkis addresses the actuality that with decision processes come competing forces. Chapters on the establishment of core values, seeing the forest for the leaf, finding our foci of control, combining action and analysis, and the ideas of algorithmic versus creative thinking challenge and inform us.

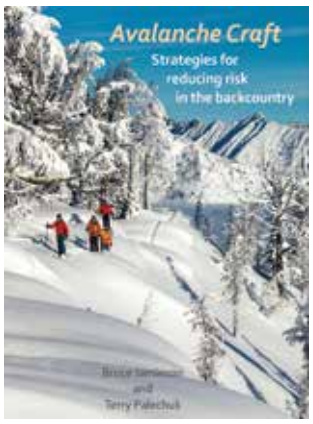
While most of us have certainly encountered some or many of these concepts, there will likely be many new concepts for the reader to contemplate and put into practice. This book is a treasure trove of information dedicated to decision making. It is clear the Dworkis has genuinely quested into the topic with an open mind, creatively combining cross-cultural and professional practices, allowing the reader to approach this topic with new perspective.

In the avalanche world, continued discussion about the human factor — our awareness of why we make the decisions that we do and how our brain works—may be improving, but the fact remains that we continue to make mistakes. We still have room to grow. As a former snow safety technician and now 4th year medical student, I've found this melding of perspective to be particularly valuable. My book is a work of origami from the many dog-eared pages and several readings. To echo the parting words of Dworkis, "from one student of human performance under pressure to another, I hope you enjoy." ⬢

Before medical school, **LINDSEY FELL** haunted the Greater Yellowstone Ecosystem as a NOLS instructor, ski patroller, and assistant snow safety director at Grand Targhee. Now she is applying into an emergency medicine residency and working with her local mountain rescue group. You'll find her staring deep into her mug of java—contemplating the finer points of why and how we make decisions.

Avalanche Craft

by Bruce Jamieson & Terry Palechuk



BY RON PERLA

Bruce Jamieson has 40 years of experience and still counting. He and his associates have authored numerous publications, some specialized for land use planning, some intended for the backcountry enthusiast. His Canadian team also produced a video collection to support and extend their publications. See their webpage snowline.ca to view their publications and videos.

Before us today is the 2021 first edition release of *Avalanche Craft*: *Strategies for reducing risk in the backcountry* by Bruce Jamieson and Terry Palechuk, who adds another 30 years experience. Shouldn't we absorb as well as we can their collective 70 years experience? And what is unique about *Avalanche Craft*?

At least for now the authors decided to release *Avalanche Craft* only as an electronic publication (eBook.) If you prefer to wait for *Avalanche Craft* to be possibly released in paperback, please don't. Try the eBook. I believe you will agree it's the wave of the future. Here's why. One of its unique features is a large number of supplementary web links that we can quickly access. For example, we can click on links to bring up the relevant video for the topic of interest. Importantly, not just the videos and tutorials produced by the Canadian team, but also tutorials from Colorado, Montana and elsewhere. Why read an endless description of a snowpack test, for example, when one video equals thousands of words? *Avalanche Craft* allows us to enter search terms to quickly reach a topic. We can click on select charts to bring up a printable page or pages. Instead of telling us to see page or appendix so and so, *Avalanche Craft* inserts the link which jumps to and back from that page or appendix.

Do you own some of the classic avalanche paperbacks like *Staying Alive in Avalanche Terrain*? I bet most of them have grey-toned rather than color figures. *Avalanche Craft* is lit up in multicolors. Publishing an eBook in color will not significantly increase its price, which is already low compared to paperback.

Avalanche Craft is released in the widely used standard, *EPUB*, which can be read on almost all devices; and Kindle, Amazon's propriety eBook format. Visit Kobe, Amazon or similar online stores to preview and look inside at table of contents. I purchased the Kindle eBook for less than six dollars, that's right, less than six dollars. I like to display Kindle pages on my large desktop monitor, but it works just as well on smaller mobile devices. The Kindle eBook has 234 pages and 1769 locations. That's a big return for your small investment. Don't fret verbal overload, most pages are filled with multi-colored figures, many are high quality, full-page color photos. *Avalanche Craft* is more than a collection of pictures and links. It's well organized, accessible at entry level, and clearly written, but I have one gripe which I'll bring up shortly.

Let's look at snowpack tests, discussed on Kindle pages 100 to 117. After a brief introduction, the authors give us a link to a 24-minute video which covers seven popular tests. Let's choose the Extended Column Test (ECT), discussed on Kindle pages 109 to 111 with photos, figures and two video links. The first is a three-minute introduction, ECT in a Nutshell; the second, a 16-minute more detailed video. Suppose you practiced the ECT in the field with class and instructor. Now you are on your own. Do you remember all the details? Well, they are on your mobile for a self-check.

The authors conclude their snowpack test section with this qualification highlighted in orange on Kindle page 117.

> *Snowpack tests are better indicators of instability than stability. At least 10% of the time these tests give misleadingly high scores (suggesting stability) near slopes people have triggered.*

Here's my gripe. Do you understand that qualification? I don't, even though I read it several times. What do the authors mean by "better indicators of instability than stability?" Besides, doesn't "At least 10%" mean More than 10%? Then, what is the range, 10% to 15%, 10% to 20%, 10% to 30%? Is there an upper bound on the range? It appears the authors are opting for brevity over clarity in their highlighted qualification of snowpack tests.

Many *Avalanche Craft* web links will exist into the foreseeable future. Some will disappear, new ones will arise. The authors want to hear from you. They provide the contact. Can you suggest links and supplementary material? Can you suggest ways to improve *Avalanche Craft*? Think of *Avalanche Craft* as an ongoing community project.

Sixty years ago as a new Alta ski-patroller I was required to take an avalanche course. Our only reading assignment was Ed LaChapelle's 60-page *Snow Avalanches*, USDA Handbook 194. Kids today can't imagine how we managed without the web and mobile devices. Drew Hardesty recently explained to me:

> *The vast information exchange these days is really something. It's easy sometimes to look at today's "kids" and say, "kids today!" but in fact they are way better skiers, way better informed (educated and savvy) and find that knowing about conditions is "cool." I'm glad for that.*

Those "kids today" will be instructors tomorrow. *Avalanche Craft* rides with them into the future. ⬢

Route-finding notes from Chapter 4.

IN REPLY TO PERLA

Regarding Ron's gripe: If one of the clearest writers about avalanches finds that paragraph unclear, it need fixing! Swiss and Canadian studies in the 1980s and 1990s found that 10 or more percent of rutschblock and compression tests gave high scores (suggesting stability) at carefully selected sites on slopes that people (mostly skiers) triggered. Terry and I could have included a upper limit of the false stable rate in these studies. However, in the real world of backcountry recreation, the upper limit will depend on the site selection skill of recreationists. To fix that paragraph, Terry and I need to review the recent studies with improved tests, like the ECT, and summarize the false stable rate for tests at carefully selected sites on slopes that people have triggered.

Ron's astute comment and—hopefully—other comments from readers will trigger minor revisions in *Avalanche Craft*. EBooks are easy to update!

In addition, we distribute the epub edition of *Avalanche Craft* on https://thepowdercloud.com/shop/ and the Kindle edition on Amazon.

The Powder Cloud store was offline when I was trying to get the epub or Kindle edition to Ron for his review so I posted the epub on Kobo. The epub is still on Kobo and is also now available through the Powder Cloud store.

—Bruce Jamieson
brucejamieson.ca/videos

RON PERLA looks up at start zones, but no longer visits them. These days he sits at a computer and works on an avalanche dynamics model. He hasn't performed a snowpack test or even dug a single snowpit in over 30 years. However, he claims to hold the record for number of snowpack tests performed between 1966 and 1990.

HYPOTHERMIA: show me the evidence

BY ALISON SHEETS

Accidental hypothermia is defined as a drop in the body's core temperature to <35∞ C, occurring in otherwise healthy people from exposure to a cold environment. The body's loss of thermoregulation is both from the direct effects of cold on cellular metabolism and the loss of calories sufficient to maintain body temperature. Other factors may complicate assessment of hypothermia such as asphyxia, trauma, infection, intoxicants, medical comorbidities, and extremes of age.

Backcountry users should be aware of the prevention and treatment of hypothermia and know how to recognize early symptoms. In the presence of cold stress, the body responds in a variety of ways, many of which can be observed by the attentive companion or first responder. Shivering is a way for the body to generate heat through skeletal muscle movement and is often accompanied by increases in respiratory rate and heart rate. Early mental status changes may be subtle with confusion, clumsiness, and loss of dexterity indicating central nervous system cooling. Interventions to reduce further heat loss, rewarm, or give calories may prevent or reverse the progression to more severe stages.

As hypothermia progresses all body systems slow down leading to decreased responsiveness or coma, hypotension, bradycardia, and potentially, cardiac arrest. Patients in this condition require significant resources and advanced medical care. While there are many treatment flow charts available, the basics of emergency care are the same—the ABCs (address life threats,) *prevent further heat loss* and consider hypothermia stage. Staging the severity of hypothermia in a patient, especially when ill enough to need rescue, influences triage, urgency, evacuation, and treatment decisions. Estimating the risk of deterioration informs prognosis and determines disposition.

Backcountry users should be aware of the prevention and treatment of hypothermia and know how to recognize early symptoms.

In "Clinical staging of hypothermia: the Revised Swiss System, Recommendations of the International Commission for Mountain Emergency Medicine"[1] we reviewed the current evidence regarding field estimation of core body temperature using the original Swiss Staging System. This system, like others[2], stages hypothermia based on the *estimated* core temperature as assumed by various physical findings as discussed above. The bottom line is that estimating core body temperature in the field based on mental status, shivering, or vital signs is only a little better than a coin toss.[3, 4] Furthermore, even getting a core temperature in the field, accurate or not, is difficult. Core temperatures are useful in the hospital and can be correlated with known physiologic changes but are less helpful for the team digging a patient out of the snow and knowing what to do with them.

The Revised Swiss System made three important changes from the original to be straightforward for the first responder in the field and to better reflect the known science. The first change was to make the goal of staging hypothermia in the field to be the assessment of the risk of hypothermic cardiac arrest. Instead of estimating core temperature based on signs and symptoms, then assigning a stage, we stage based on signs and symptoms, then assign risk of cardiac arrest. Responders can better predict and plan for patient deterioration.

Our second change attempted to simplify and standardize the evaluation of mental status using the widely recognized AVPU scale, with "A" meaning awake and alert, "V" representing responsive to verbal stimulus, "P" when patient is only responsive to painful or noxious stimulus and "U" for the unresponsive patient. Certainly, there is overlap at either end of these assessment levels and other causes for mental status changes-asphyxia, trauma, intoxicants, etc. must be considered.

The third change was the removal of shivering from the staging system. Historically shivering has been included in most staging systems however, the presence or absence of shivering correlates poorly with core temperature. While shivering usually means core temperature is >30∞ C, it can occur in much colder patients and can lead to underestimating risk of cardiac arrest.

The Revised Swiss System (*Table 1*) graphically depicts the stages with the AVPU scale and the correlating risk of hypothermic cardiac arrest. Stage three and four differ by the presence or absence of vital signs. Remember that in the very cold patient, the pulse can be quite slow necessitating a 60-second pulse check. Central pulses like the carotid or femoral pulse should be accessed whenever possible as more peripheral pulses such

THE REVISED SWISS SYSTEM (RSS)

	STAGE 1	STAGE 2	STAGE 3	STAGE 4
Clinical Findings[A]	"Alert" from AVPU	"Verbal" from AVPU	"Painful" or "Unconscious" from AVPU Vital Signs present	"Unconscious" from AVPU AND No detectable vital signs[B]
Risk of cardiac arrest[C]	LOW	MODERATE	HIGH	HYPOTHERMIC CARDIAC ARREST

▲ Table 1

[A] In the Revised Swiss System, "Alert" corresponds to a GCS score of 15; "Verbal" corresponds to a GCS score of 9-14, including confused patients; "Painful" and "Unconscious" correspond to a GCS score <9. While shivering is not used as a stage-defining sign in the Revised Swiss System, its presence usually means that the temperature is >30°C, a temperature at which hypothermic CA is unlikely to occur.[8]

[B] No respiration, no palpable carotid or femoral pulse, no measurable blood pressure. Check for signs of life (pulse and, especially, respiration) for up to 1 minute.[1]

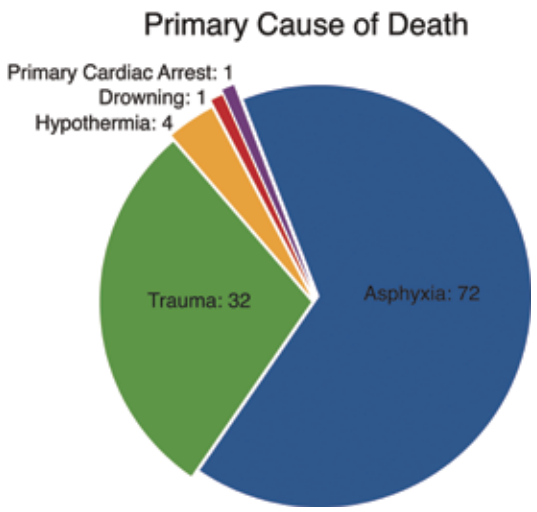
[C] The transition of colors between stages represents the overlap of patients within groups. The estimated risk of cardiac arrest is based on accidental hypothermia being the only cause of the clinical findings. If other conditions impair consciousness, such as asphyxia, intoxication, or trauma, the revised Swiss System may falsely predict a higher risk of cardiac arrest due to hypothermia. Caution should be taken if a patient remains "alert" or "verbal" showing signs of hemodynamic or respiratory instability like bradycardia, bradypnea, hypotension since it may suggest transition to a stage with higher risk of cardiac arrest.

Late fall, Highway 20, Washington Pass.
SERGIO ROJO

as the radial pulse at the wrist can be difficult to detect when a patient is bradycardic and rescuer's fingers are cold.

Cardiac arrest from accidental hypothermia is potentially survivable with good neurologic outcomes, even in the backcountry environment. There are multiple examples of hypothermic patients with witnessed cardiac arrest, undergoing lengthy CPR or even intermittent CPR who have had complete recoveries. Depending on your local EMS protocols and hospital systems, and when resources support it, hypothermic cardiac arrest patients should be treated as viable and resuscitative efforts continued until evaluated at a hospital.

Understanding the assessment and staging of hypothermia is important for any winter backcountry user but its usefulness in avalanche accidents must be put in context. In "Causes of Death Among Avalanche Fatalities in Colorado: A 21-Year Review,"[5] hypothermia was determined to be the cause of death in only 3.6% (4) of 110 avalanche fatalities. Asphyxia is by far the most common cause of death at 65% (72) with trauma second at 29% (32). (*Figure 1*) The other consideration



in assessing the unconscious patient, hypothermia stage 3 or 4, is the time it takes for an avalanche victim to get hypothermic enough to be unconscious or in cardiac arrest. Cooling rates are quite variable and depend on weather, clothing, activity at time of avalanche (ascent or descent), body composition, post-extraction cooling, and other factors. Most avalanche resuscitation protocols assume stage 4 hypothermia is unlikely in less than 60 minutes. However, a recent case report[6] highlighted four cases of avalanche victims that had "extreme" cooling rates (>5∞C/Hour) documented. Of the three survivors, none had unwitnessed cardiac arrest. The likelihood of survival in an avalanche victim found in cardiac arrest is extremely low, regardless of cause.

Accidental hypothermia is a potentially treatable condition if recognized early and interventions taken. Medical assessment and decision-making in the field can be extremely challenging and should be practiced before venturing into the backcountry. For accidental hypothermia, mental status is key for staging and prognosis. And finally, if your EMS system supports it, consider prolonged or intermittent CPR for hypothermic cardiac arrest. ⬢

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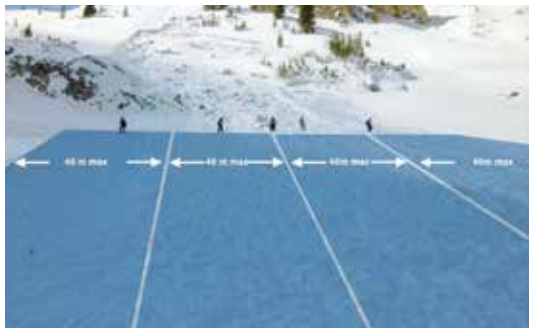
GROUP SEARCHING:

BY BRUCE EDGERLY & JIM CONWAY

It's a temptation that's hard to resist. You trained for years to pass your guiding exam or pro avalanche course, especially the transceiver test, which requires finding up to four victims in less than seven minutes–without turning off any of the victims' beacons. You worked so hard to master this scenario, of course you want to teach it to your team or your students!

When searching in parallel for multiple victims, it is essential to maintain "lane discipline." Lane widths should roughly equal the width of the debris divided by the number of available beacon searchers.



The lane (or search strip width) for each searcher is dependent on the scenario, but can vary from as narrow as five meters to as wide as 40 meters or each manufacturer's maximum recommended search strip width.

Lack of lane discipline will result in all searchers flocking to the first detected signal, but other areas remaining unchecked. This is analogous to early-childhood soccer, where players often swarm the ball, leaving the rest of the field undefended.

The ability of a single expert rescuer to find multiple buried beacons is an established standard required to pass both guide and professional avalanche worker training in the U.S. and Canada. This is an incredibly valuable tool for any rescuer to have, whether a pro or a recreationist. The purpose of this article is not to question its utility, since it's the foundation of any rescuer's skill set. But is it always appropriate? In many cases, when instructing advanced recreationists, that time might be better spent teaching how to lead a group rescue, sometimes called "searching in parallel."

A seasoned rescuer typically has a range of tools and techniques to expedite the search and the rescue of a victim(s) based on many factors, including the size and accessibility of the avalanche debris, the number of rescuers available, and the skill or experience of available rescuers. While much energy has been expended teaching and testing single searcher/multiple victim rescues, the skill of organizing and managing a group of capable rescuers has not been emphasized much outside of Avalanche Search and Rescue (AvSAR) curriculums, at least in the United States. American Avalanche Association (A3) curriculum for Basic Avalanche Rescue has no requirement to actively teach Searching in Parallel: the topic often gets a passing reference in one of the course's PowerPoint slides, but is typically not practiced in the field (often due to time constraints or student capabilities).

At our annual BCA ambassador training, held each fall on the sandy expanses of Boulder Reservoir, we teach and practice all these methods, with multiple scenarios set up with 2, 3, 4, and even an unknown number of buried transmitters. It was during one of these training sessions in 2019 that our team became aware that even expert users need additional practice in the area of organizing and managing group rescue scenarios. We teach our employees and ambassadors marking, signal suppression, scanning and big-picture functions, micro search strips, the three-circle method and even "micro circles." But how many advanced users get regular training at leading a rescue team in a parallel search? What has come into focus is that the ability to lead a group rescue is as challenging as managing the technical nuances of a complex multiple victim scenario with a single searcher.

More recently, we've included group searching scenarios in our training, where multiple searchers line up and search in parallel for multiple transmitters. Invariably, all transmitters are located in less than half the time that it takes for a single rescuer to find all the victims consecutively. "Why isn't this part of standard avalanche rescue curriculum in the US?" is a common refrain from the professional avalanche instructors on our team. Anecdotally, BCA ambassador and avalanche educator Jim "Sarge" Conway has been piloting course segments that put more emphasis on group rescue techniques using the parallel search method. "My initial observations indicate people are actually pretty capable of managing other people when the challenge is put before them" Jim says. "And the effectiveness of the group after even half a day of intensive training (everyone taking turns leading a team) is remarkable."

Based on Jim's anecdotal observations and BCA's continued commitment to improve all backcountry users' skill sets, we produced a video this year called "Avalanche Group Rescue Techniques: Searching in Parallel." This video was released in December 2021 and can be viewed on BCA's YouTube page (https://www.youtube.com/watch?v=brr-zhr0uhk).

The key concepts of the method are 1) lane discipline, 2) concise communication, and

USING PEOPLE POWER TO SIMPLIFY COMPLEX BURIALS

If a beacon searcher stops to probe and dig, and no other rescuers are available, then the leader should readjust the lane widths to ensure the entire debris pile is checked below the excavation area.

In this case, the leader suspected close proximity burials and enough rescuers were available so search strips could be reduced to 10 meters. Beacon searchers should stick to their lanes and commit to the fine search only once their distance reading is less than 10 meters.

3) effective leadership. All three are required for a successful outcome. A leader takes in all the information from the rescuers to think multiple steps ahead to further expedite and streamline the rescue.

Lane discipline is all about spreading the rescuers apart, no wider than 40 meters or each manufacturer's recommended search strip width between searchers (width used depends on number of searchers, debris size, and searcher experience) then sticking to those lanes. This prevents all the searchers from swarming to the closest victim, like six-year-olds playing soccer. The crux move is to abandon your lane only when the distance reading on your transceiver is less than your lane width.

The second key concept, **concise communication**, is all about relaying critical information to the leader, but not overloading him or her with information. Relay info only at the most crucial stages: initial signal acquisition, decreasing distance readings in 10-meter increments, lane abandonment, probing, and victim depth. Indeed, very little has been published on what is relevant to communicate in a rescue. Imagine four or five rescuers all calling out their course search distance readings every two meters: this can be overwhelming to a leader. In this video, we present a disciplined communication system that delivers necessary information in a more concise format. This provides the leader with better situational awareness and enables him or her to take the intensity down a notch with a more deliberative communication process.

The third key concept is the importance of an **effective leader**. The leader's job is to maintain the integrity of the lanes, to minimize distracting "rogue" signals from interference or bystanders, and to allocate resources to maximize survival chances. Ideally, this is best accomplished by following behind the designated searchers instead of participating in the searching, probing, and shoveling process.

Once a victim is found, the leader has the option to assign probers and shovelers to that victim and have the remaining rescuers continue locating all the victims. In that case, the leader should increase the lane widths below the first found victim so no areas are left unchecked. If one or more rescuers reach the end of their lanes without performing a fine search, they can also be re-assigned, most likely to search any remaining unchecked areas in the deposition area.

The use and efficacy of this method is very situationally specific and there are many factors that can make this more or less effective compared to other methods (ie: number and experience of searchers). The method presented in the video is also a definitive "lead from the back" technique with a dedicated leader. Some situations, such as a smaller group, may dictate a "lead from the front" strategy where the leader also has a rescue task such as transceiver searches. Leading from the front is obviously a more complicated task as your brain must multitask: As far as training goes, we feel initially it is best for people to focus primarily on building their leadership skills before taking on a multitask scenario.

Part of the reason this particular skill set does not get the attention it deserves is simple logistics. Beacon training parks and patroller practice fields make it easy for pros or recreationists to practice advanced multiple beacon rescue skills in a self-paced format. Organizing a group search scenario involves more time and commitment from a team to implement. To offer more opportunities to train with groups, and to further gain insight and data as to what works best, BCA and Conway will hold *Practice is Faster* group search events this season at select locations in the U.S. If you'd like to host a *Practice is Faster* event with BCA and/or Sarge, please e-mail edge@backcountryaccess.com. BCA will also partner with *Backcountry Magazine* this season for *Practice is Faster* group search sessions at Backcountry Basecamp, the publication's annual tour of resorts to promote backcountry riding and safety.

Some organizations and teams are already prioritizing this skill and our hats are off to them. Searching in Parallel is another important tool for every pro or advanced recreationist to have in his or her rescue toolbox. ⬢

The authors thank Jordy Shepherd of the Canadian Avalanche Association for his contribution to this article.

BRUCE "EDGE" EDGERLY is co-founder of Backcountry Access, Inc. (BCA), a leading manufacturer of backcountry skiing and snow safety equipment, including Tracker avalanche transceivers, Float airbags, BC Link radios, shovels, and probes. He met Sarge at the 1994 U.S. Extreme Skiing Championships, where they were the two oldest competitors, by far.

JIM "SARGE" CONWAY is a lead AAI/AIARE avalanche and SAR instructor. He was lead guide and snow safety director for Teton Gravity Research (TGR) for ten years, following his career as a TGR athlete. He founded TGR's Pro Rider Workshop curriculum. He also owns/operates Tordrillo North Ski and Snowboard Adventures in Alaska.

INTERSECTIONAL HEURISTICS IN BACKCOUNTRY DECISION-MAKING

BY AIDAN GOLDIE-AHUMADA

Ian McCammon's 2003 article published in the Volume 22 of *The Avalanche Review* provided a heuristic framework that would go on to inform avalanche education and professional training for years to come. The framework builds on the idea of heuristics in the field of psychology that describes human tendencies to take shortcuts to decision-making based on a variety of different factors. These shortcuts are often positive, allowing us to expedite the minutia of everyday life. However, when these shortcuts to decision-making begin to unconsciously trickle into decisions that carry more consequences, like those found in a backcountry recreation context, those heuristic traps can lead an individual or group towards more serious consequences. Consequences that, upon reflection, backcountry users would identify as "red flags" that could have been identified in the field.

This framework provided by McCammon (2003), paired with an acronym FACETS, has proven to be a useful tool often used by recreational backcountry skiers and riders as well as avalanche course instructors alike. There is no doubt that this framework has spared backcountry users from venturing into avalanche terrain when conditions were not aligned to do so. This article critically reflects on the use of this framework and asserts that there is a missing element of *intersectional heuristics*, shortcuts to decision-making driven by unbalanced power structures, within the backcountry recreation and education settings that will continue to have detrimental effects in the industry if not addressed. Ultimately this article will suggest an amendment to be made for a more inclusive framework for decision-making in avalanche terrain.

First, let's summarize the framework as described by McCammon in their seminal 2003 article that will be referenced in this article.

▾ Table 1: McCammon (2003). Heuristic traps in recreational avalanche accidents. *The Avalanche Review* (Vol. 22, nos. 2 & 3).

FAMILIARITY	Rely(ing) on our past actions to guide our behavior in familiar settings.
ACCEPTANCE	Tendency to engage in activities that we think will get us noticed or accepted by people we like or respect, or by people who we want to like or respect us.
CONSISTENCY	Maintain consistency with the first decision. A desire to be consistent overrules critical new information about an impending hazard.
EXPERT HALO	An overall positive impression of the leader within the party leads them to ascribe avalanche skills to that person that they may not have.
TRACKS (SCARCITY)	Tendency to value resources or opportunities in proportion to the chance that you may lose them, especially to a competitor (Cialdini, 2001).
SOCIAL FACILITATION	Presence of other people enhances or attenuates risk-taking by a subject, depending on the subject's confidence in their risk-taking skills.

Using this framework, we can tease apart an avalanche incident and retrospectively apply these categories. A group of four skiers is venturing into the Utah backcountry, each has varying degrees of experience with backcountry travel but all carrying the requisite avalanche transceiver, probe, and shovel. The avalanche forecast has been slowly trending towards stability after a record-breaking storm in the past week. Four skiers make a plan at the parking lot to ski an eastern aspect at treeline. Upon gaining the summit ridge, the skiers begin to observe the impact that high winds have had on the surface snow. Wind from the west eroded the windward side of the ridge and deposited snow on the leeward side. The skiers stop to assess conditions before skiing the line. A female skier in the group brings up her apprehension due to the westerly winds and the potential loading that the eastern aspect may have. The group talks and ultimately her idea is dismissed due to a variety of other factors. This is a slope commonly skied by members of the group. The trees in the line could provide anchoring against large slab avalanches. There is no other evidence of instability on this elevation and aspect. Ultimately all four skiers agree to ski the slope. Upon reaching the bottom, they realize that only three skiers made it to the bottom. Inspecting the slope above them, they see a small D1.5 avalanche that has run close to the top of the slope and towards the trees below. The group skins back up to the site, perform an avalanche rescue, and find a deceased member of their party that was caught in a wind slab and dragged through the trees.

Upon reflection, all surviving members of the group identified that there were "red flags" that were observed and ultimately ignored as part of their decision-making process. In their debrief of the incident, they identify that

the expert halo and familiarity heuristic traps led to their poor decisions that day. The expert halo took form through a single member of the group who possessed a higher level of backcountry travel experience and to whom other group members deferred. The familiarity trap—a confirmation bias that translated previous positive experiences to the most recent outing played a role in terrain selection. But would have the outcome been different if a male member of the group first brought up their concern with the observed wind loading?

A NEW CATEGORY OF HEURISTIC TRAP

These heuristic traps are a common occurrence according to Johnson, Mannberg, Hendrikx, Hetland, Stephensen, (2020) as well as McCammon (2003). Heuristic traps can be everyday occurrences that do not often lead to an avalanche incident or fatality. An analysis of this incident, among many others, finds the dismissal of valid ideas or concerns from members of the touring group. This is a type of heuristic trap that is often attributed to the "expert halo" or a sort of "social facilitation." However, these categories do not adequately describe the nuance of the social interactions that were at play in a situation like this one and the larger societal paradigm that drives everyday interactions.

I argue that there likely was some sort of identity bias. We see this very commonly with gender identities where those who identify as female will commonly have their opinions dismissed by their male counterparts. McCammon (2003) touches on this idea under the "Acceptance" category under the guise of a male skier attempting to impress their female counterpart, potentially leading to higher-risk taking.

What is not addressed is the power dynamics that are at play in these decision-making routines. In a patriarchal society, male backcountry users carry a societally constructed dominance over female backcountry users and will consciously or unconsciously use that power to diminish the voice and opinion of the female team member, despite the findings that "women may be less likely to die in avalanches when participating in recreational alpine activities because they tend to take less risk" Sola, Reese, Kulbacka (2002). In this article, I wish to extend that idea further by making the link between unconscious heuristics to unconscious bias. The male-female power dynamic is only one of many negative power structures that impact decision-making even though this dynamic is the one that tends to be talked about most in the industry. I am encouraging our field to better examine all power structures in our society and how they can influence the everyday decisions made in avalanche terrain.

This is not a new idea but instead builds on a body of work done by many leading scholars on social theory. First coined as the term "intersectional" by Kimberlé Crenshaw in their 1989 paper titled *Demarginalizing the intersection of race and sex in the Journal of Feminist Legal Theory*, Crenshaw describes how intersecting identities of race, gender, among many others, will impact the way that individuals are treated within certain community structures. The backcountry recreation community and the avalanche industry have a community structure that is dominated by white, middle-aged, cis-gendered males (Warren, Latosuo, Stimberis, & Morris, 2020). Despite the good-faith intentions of individuals within this

▲ Figure 1: individuals are not defined by a single identity but instead by a myriad of social and political identities. Within societal power structures, certain identities that hold less power are considered marginalized. Adapted from Sylvia Duckworth's Wheel of Power/Privilege. (Bauer 2021).

community, the current structure of the community leads to a vulnerability to what this article will refer to as *intersectional heuristics*.

INTERSECTIONAL HEURISTICS

Intersectional Heuristics is the missing heuristic trap that makes backcountry groups vulnerable to unconscious bias towards various identities. Any marginalized identity (*Figure 1*) that an individual possesses runs the risk of having their input in backcountry decision-making dismissed by the group at large if an imbalanced power structure exists. Like our adoption of heuristics from the field of psychology, I am encouraging the avalanche field to adopt the idea of intersectionality in our everyday practice, including avalanche education.

Intersectionality comes into the conversation when we reflect on the way that the idea of diversity and inclusion has been approached in the industry already. This phenomenon of female-male power imbalances is seen as the obstacle that had to be overcome in order for the industry to be equitable. As a result, we have seen numerous female affinity group avalanche courses, female-specific scholarships, and female-specific mentorship programs. What is largely ignored are other intersections of race, gender identity, class, and ability that impact backcountry recreation and backcountry decision-making. Two female ski tourers on paper will be perceived as having overcome the previously mentioned "acceptance" heuristic trap. Under McCammon's (2003) framework, they will need to better concern themselves with the other five possible heuristic traps. Under the lens of intersectionality, gender is not the only identity that creates power imbalances. One of these female team members could be of color, and in a community structure that values the experiences of white backcountry skiers as seen in print and visual media, this creates a power imbalance that can impact decision-making.

Here is another case study to explore. At a winter sports festival hosted in the western slope of Colorado every year, a group of three black backcountry skiers, ice climbers, and riders reach out to one another and attend as an affinity group. They move through the events as a group with hopes that they can overcome previous discomforts that they each have experienced at similar events. When they ride lifts at the resort, the lift operators preemptively slow down the lifts for them despite their competence to board without issues. When they hit the skin track and plan a mellow tour to explore an unfamiliar zone, they are met by other backcountry skiers with probing questions like "Are you part of a group or class?" "What brings you here?," and "Have you read the avalanche bulletin?": questions that other groups that are part of the community majority do not receive. When walking through the festival, a police officer reflexively places their hand on their gun whenever the group walks by. These microaggressions are commonplace and expected by this marginalized group often "othered" in these spaces.

When I sat down and chatted with these backcountry users, the importance of intersectional heuristics becomes apparent. Even though on paper these three athletes had a shared marginalized identity, they were also able to identify, and be cognizant of, multiple intersecting identities. Varying sexuality, gender, class, and ability were identified in this group of three skiers and riders. These are athletes who know all too well what it feels like to have their opinions in the backcountry dismissed. With the idea of identity heuristics on their mind, this group recognized a variety of unbalanced power structures and actively fought against those biases in their decision-making with frequent check-ins to make sure everyone's ideas and opinions about avalanche hazards are being heard, and having up-front conversations if those power-imbalances were influencing their decisions for the day.

Here is what is sometimes lost in the discussion around intersectionality and creating inclusive environments. Lost diversity in groups is a loss of lived experience. Having diversity in risk tolerance is a good thing. Discussing competing ideas is best practice. The uniformity that an exclusive avalanche industry promotes is not ideal; it can potentially be dangerous. The literature has shown that having a diversity of ideas and lived experiences will improve student education and group decision making (Bogan, Just, Dev, 2013) This applies to backcountry skiing in a fundamental way. Diversity of experiences leads to a diversity of thought that introduces legitimately competing perspectives towards more conservative risk-taking.

POSSIBLE SOLUTIONS

With the identification of the seventh heuristic trap, *intersectional heuristics*, one begins to question how to best address it in the avalanche industry. I will outline three tangible solutions that are either implemented on small scales or can be readily implemented in greater professional contexts.

Increased opportunities for meaningful mentorship. Mentorship opportunities in

recreational spaces are hard to come by. Mentorship opportunities for those with intersecting marginalized identities are even harder to come by. For the latter to happen, one needs to find a mentor who not only has a wealth of experience in backcountry travel they are willing to share, but also a mentor who shares similar lived experiences to the mentee. The Scarpa Athlete-Mentor Initiative could provide a good model for what meaningful mentorship could look like. In this initiative, mentees who self-identify as members of marginalized communities are paired with mentors from Scarpa's athlete team. Scarpa Mentors are all given anti-bias training prior to the start of the mentor-mentee relationship and these relationships are given support by other Scarpa team-members and third-party consultants. Initiatives like this can not only lower the barrier to entry into the backcountry recreation world but also create a more linear path towards gaining experience and allow marginalized athletes to become mentors for others.

Intersectional heuristics curriculum in avalanche education. The field of avalanche education has made great changes in the last decades. From informal education in the form of mentorship to formal avalanche education, introductory avalanche education has slowly focused more on the decision-making and terrain selection aspect of a tour than the snow science side of things. With that in mind, students should be introduced to the idea of intersectional heuristics in this introductory avalanche education. If students are asked to confront their unconscious biases and asked to be cognizant of power structures in their backcountry decision-making, then there could be an inclusive shift in the way decisions are made in the backcountry.

Affinity group avalanche education. The paradigm will not shift if avalanche education students are learning in spaces that uphold traditional power structures. Guiding organizations and avalanche education providers can provide affinity group programming, intentional courses that are filled by members who share marginalized identities. Programs like these can remove the anxiety that comes with being a marginalized identity in an educational context. When learning with others that share similar lived experiences, then students can better build individual and team confidence in backcountry decision-making that can be applied in future backcountry tours. A bottleneck in this solution is a shortage of certified guides that can adequately lead an affinity course like this one. A solution to this problem would be to make an intentional move to train more guides that possess marginalized identities to become course leaders. Initiatives like the Kizaki-Wolf Scholarship are one example already working towards this goal. Additionally, existing guides can be trained in intersectional heuristics and building inclusive classrooms in their own guide training.

The avalanche industry is continually learning and evolving. With that evolution comes a continued examination of the parts of humanity that influence decision-making.

CONCLUSION

The avalanche industry is continually learning and evolving. With that evolution comes a continued examination of the parts of humanity that influence decision-making. This is relevant both in a professional and recreational context as both backcountry operations and individuals are vulnerable to be influenced by community-level power structures. The avalanche industry is noted to have a lack of diversity within its workforce as shown by the 2020 survey by Warren, Latosuo, Stimberis, & Morris. This makes our industry critically vulnerable to *intersectional heuristics*, a shortcut to decision-making driven by an unbalanced power structure. This paper serves as a jumping-off point for the industry to examine how to best address this issue in an operational setting as well as in the education setting.

How can I ensure that everyone feels comfortable enough to share their opinions and apprehensions about interacting with avalanche terrain?

This should be a question that is at the forefront of the minds of all industry leadership, course leaders, and recreational touring groups going forward. ⬢

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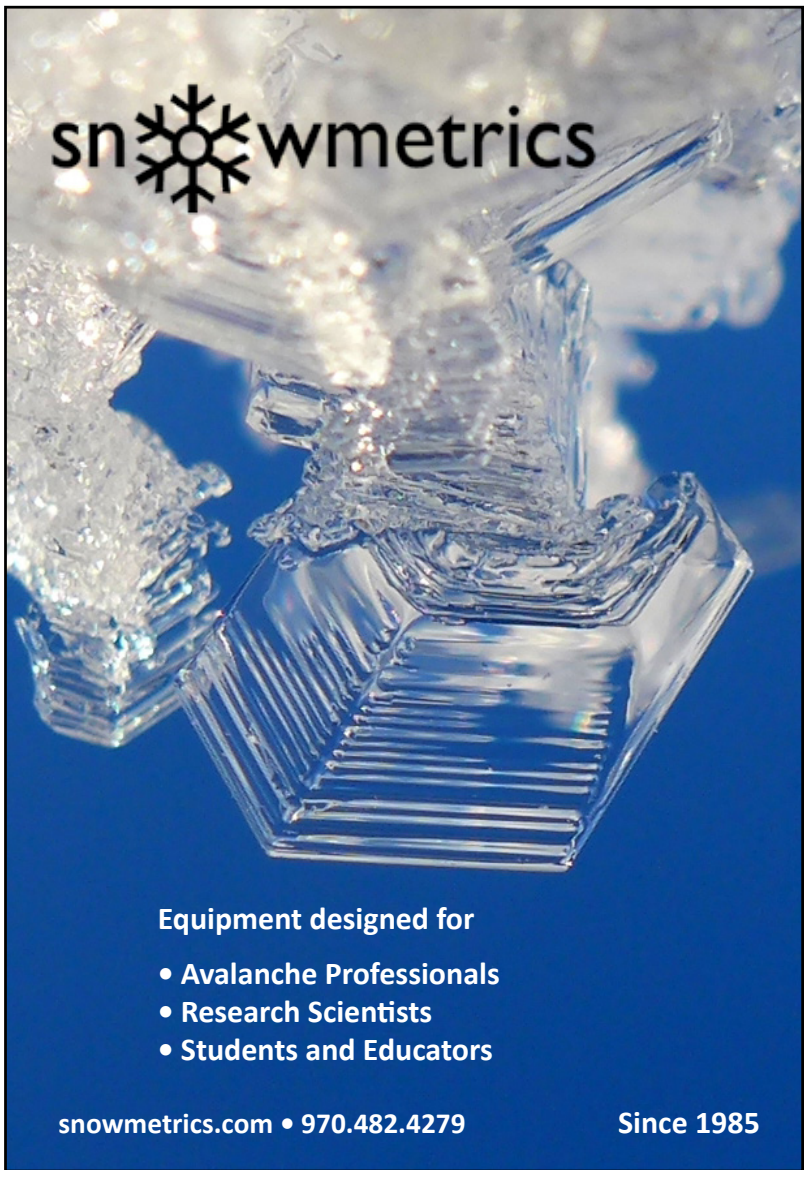


AIDAN GOLDIE teaches, climbs, and backcountry skis on the traditional lands of the Núu-agha-tʉvʉ-pʉ (Ute) tribe in the Rocky Mountains. Aidan feels most at home in cold winter environments with something sharp strapped to his feet. He is continually shaping his mountain ethic to instill pedagogical values of environmental justice, equity, and cultural relevance.

CRYSTAL MOUNTAIN Case Study

BY JAKE SKEEN & ROBIN PENDERY

On December 18th, 2018, a call came in over the radio that no avalanche forecaster ever wants to hear. A patroller at Crystal Mountain was caught and carried in a large avalanche triggered by a single small explosive while doing control work.

The crown was four to six feet deep and extended approximately 500 feet across multiple paths and terrain features. This event happened during an early season storm cycle that coincided with pending terrain expansion at the ski area. The patroller walked away uninjured, but the event served as a "free lesson" and highlighted some decision-making traps that we fall into as professionals.

After a dry fall of 2018, Mother Nature's faucet opened in early December. The ski patrol was busy running control routes in preparation to open much of the upper mountain for the first time that season. Just 11 days prior to this event, the height of snow at the corresponding elevation was about one foot. The structure of this early season snowpack was problematic, with layers of both facets and surface hoar on top of a basal rain crust. Unsurprisingly, this was the failure plane for the patroller-involved avalanche.

We were keeping tabs on this interface throughout the storm cycle. A heavy-handed mitigation strategy was implemented as soon as the snowfall began, adding deformity to the poor structure and testing each additional load thoroughly. This produced a couple of D2 results and allowed us to open limited terrain that had seen an abundance of early season ski touring traffic. The snowfall continued and so did the control work. By December 17th, we had not seen a result on the PWL in five days despite two feet of snow with 2.25" of water and a lot of explosives testing. Our strategic mindset had not shifted despite this unreactive trend. The storm cycle wasn't over, and we still had new terrain to control.

The morning of December 18th greeted us with 15" of new snow and strong SW winds. Two patrollers were controlling paths that hadn't been shot yet on the NE side of a broad, fall line ridge. One of them was on his first avalanche control mission, ever. He was working with an experienced route leader. After throwing numerous shots in previously controlled terrain with no big results, they continued to work down the windward side of this ridge, leapfrogging each other to efficiently hit each steep path on the north side. The patrollers began working in terrain that had not been controlled that year.

The route leader was instructing the rookie where to position himself based off his previous knowledge of the terrain. This ridge looks different every year, however, so it can be hard to keep consistent with designated safe zones. Unfortunately, the new patroller wasn't standing far enough back given the loading patterns leading up to this event as well as the energetic nature of persistent slab release. His shot triggered a large avalanche, and the crown broke just inches above the patroller's skis. He was swept down into the path, carried through a band of trees, and out into the open runout zone 500 feet below. His airbag was deployed, and he ended up on the surface of the debris. The avalanche was classified as SS-R4-D3-AE-O.

There were a couple of lessons learned from this event regarding both operational strategy as well as individual decision-making in the field. It is important to recognize the unpredictability of snow distribution from one season to the next, and we all know that familiarity can push people into operating within narrower margins. Persistent weak layers amplify this unpredictability as well. The majority of avalanche control work in the Pacific Northwest targets direct-action events as opposed to persistent problems. Therefore, the word entrenchment sounds quite foreign to us up here. Forecasting teams need to consider their messaging and use extra caution when instructing teams on managing rare or unusual conditions.

Operationally, it could have been beneficial to create more separation between zones in the day's strategy. We needed to shoot 15" of storm snow within our open terrain to prepare it for the public and we also needed to continue to test the PWL in our closed terrain, especially given a substantial new load. Taking on both of these very different missions in a short time frame during a long, sleepless week is a tall order. The evidence provided by explosives makes it difficult for patrollers to ignore past results when entering terrain containing a new and very different set of avalanche problems. As an operation, we no longer combine test shots and routine storm slab management in the same control route. It is beneficial to lose efficiency by sending a separate mission if it encourages patrollers to treat a unique problem with added care.

Finally, we implemented additional measures to help mark the ridgeline, and encourage patrollers to choose safe locations to stand. This ridgeline was notorious for being difficult to assess and changing over the course of the winter. We added markers on trees in the surrounding area to indicate where the physical ridge actually was during the summer, so patrollers did not place themselves out over the cornice edge in the winter.

We were very lucky to learn these lessons without any serious consequences. The lessons from this event highlight how familiarity can cause us to make errors, and how difficult it can be for professionals to appropriately apply past evidence to new problems. We hope that these lessons are useful to other operations in the future. ⬢

Ski patroller's poles remain just uphill from where he was standing before the slide was triggered.
CRYSTAL MOUNTAIN SKI PATROL

JAKE SKEEN is driven by his passion for skiing and exploration in the mountains. He works as the assistant snow safety director at Crystal Mountain, teaches avalanche courses, and guides climbing and ski trips in the Tetons and Cascades.

ROBIN PENDERY is an avalanche professional and mountain guide in the Pacific Northwest. She has forecasted for Crystal Mountain and worked as a professional observer for the Northwest Avalanche Center. Now she can be found touring in between nursing school test .

BY CHRISTY NAMEE ERIKSEN

DEEP Persistent Slab

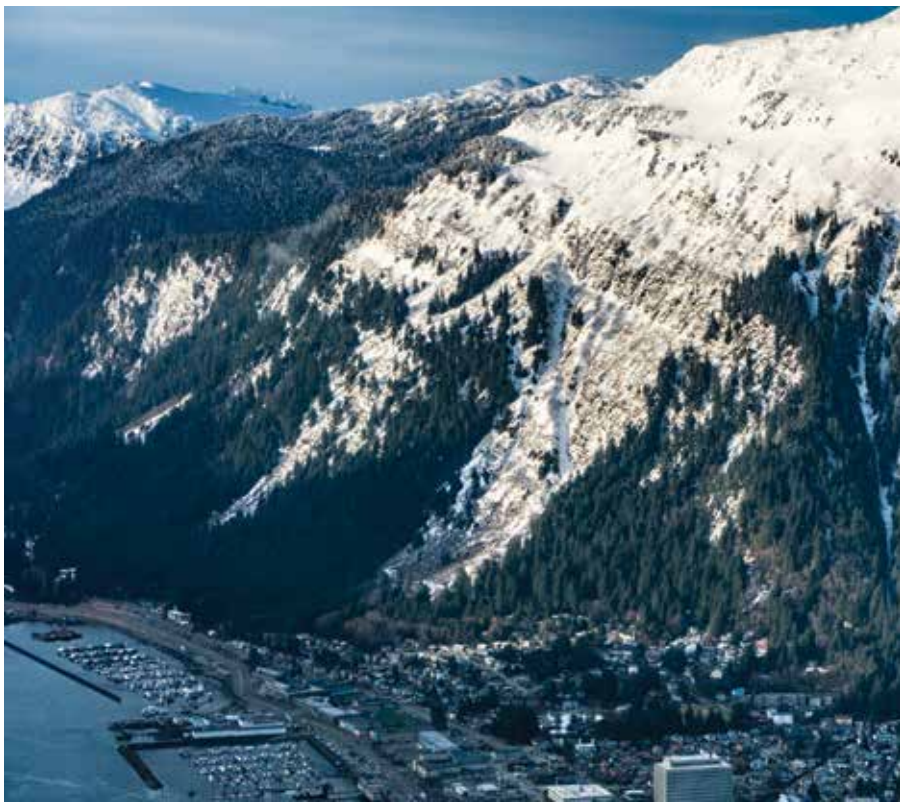
Previously I only used the word avalanche as a verb. It meant, "I am crying and I cannot stop."

Still, owning a home in an avalanche zone, I have been recently compelled to try to make sense of my city's urban avalanche advisories. They use the word avalanche in a way that means "a massive amount of snow, ice, and rocks falling down a mountainside."

Please forgive my errors or oversimplification, but here's my attempt at translating. It appears that it matters what kind of day a mountain is having. Depending on the weather, snow settles into different kinds of layers, and these layers stack up over time. What I understand to be our biggest current problem is what's called a "deep persistent slab."

A deep persistent slab is a big piece of snow with a very weak layer inside it. The weak layer is so deep you almost don't know it's there unless you're looking for it. Another layer inside it might be a crust, which in a way amplifies the weak layer because you could poke the crust a long ways away and the poke would reverberate across the crust, and this is how one light touch could trigger an avalanche of giant proportions. No matter how soft or how strong the snow is, if you touch it when or where it is tender, it will drop to the depth and the width of its weakest part. And so an avalanche is not just snow, and it is not just the trigger, it is the result of holding too much when you were not properly grounded.

On the same day, one year apart, I packed a bag. That's a lie; one year ago my friend Melissa packed my bag, because I was avalanching on the living room floor. My sister had called. My father was fighting for his life in the ICU. At that time they said they didn't think he would make it through the night, and I could not fly out until morning.





Juneau's urban avalanche problem. TOM MATTICE

Sometimes you don't get a warning

I can't separate the experience of saying goodbye to the home my dad built me from the experience of saying goodbye to my dad at this precise time last year. There are all kinds of natural disasters. They say our bodies remember grief anniversaries, which baffles me since my own grief is very bad at time management. Perhaps grief is just a weak layer and it doesn't matter how deep it's buried. A smell or a bird or the sunrise on a particular day can always touch it.

Grief, I mean the director of emergency management, knocked on my door Saturday morning to explain the danger of wishing for the best.

And to give us a blessing; a chance, a minute. To take the irreplaceable with us.

If the avalanche were to hit our homes, they predicted it could be fourteen feet deep going fifty-seven mph across a quarter mile. I really can't see how a human house could survive that, and yet I am familiar with praying against the odds. My father survived his first night, and on the second night, he briefly woke up. It was today, one year ago: my mother's birthday. A miracle, they said, and the nurses had chills. It filled me with catastrophic hope.

When we dug our way out, we told my dad that we loved him, and that he didn't have to worry about us. This was the third day. We said goodbye, because we were warned; and it's better to say goodbye and walk away than to be destroyed inside it. That was 364 days ago. Some mornings I can walk on that layer and some mornings I'm still buried under the snow.

What type of weather do we want? my friends asked, and I don't know enough avalanche science beyond "we want spring" to answer this. In grief counseling, no weather is bad; I think the goal is that you heal your deep persistent layers so no slab could kill you. The director of emergency management lowered the danger level from "extreme" to "high," so I know that with the right conditions even an avalanche can change. The weak layer can strengthen, the facets can face the wind. The load can lighten and aspects can melt. It can be touched without breaking.

Often it just takes time

MIKE JANES

This piece originally appeared in the Freeman's *issue on change, published by Grove, and is reproduced by permission.*

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Pattern Recognition in an Ever-changing World

BY BEN VANDENBOS

I am composing this article in my head from the skin track, breaking trail through 50cm of new snow while looking down the barrel of a five-day storm. This marks the start of my sixth winter working at the Sawtooth Avalanche Center and no two years have been alike. I've found surface hoar grains that, four months after burial, produced propagating snowpack test results. I've seen wet slab avalanches that hit houses that had been in place for 50 years and played my way through some of the wettest and driest winters back to back. We've dealt with depth hoar that we couldn't trust until it was in the rivers and seen widespread wet/dry avalanche cycles during periods of fluctuating rain lines. Pattern recognition is a huge part of the avalanche forecasting process, but it becomes a whole lot harder to use when you're dealing with patterns that you haven't seen before. If we can't recognize the pattern, we at least have to be able to recognize that we can't recognize the pattern. And that none of us recognize patterns we've never seen.

Our winter started out with a bang in October when a storm delivered us a quick three to four inches of SWE, building an instant base to the season. Or so we'd hoped. An extended drought followed, complete with multiple days of record heat

▲ Northwest bowl of Galena Peak, Idaho. This avalanche was observed during a window of clear skies one day into the second atmospheric river of the season. It was photographed on December 24, 2021 and likely failed the night before, as this article was being penned from the skin track. 📷 SCOTTY SAVAGE

in the valleys and temperatures that approached 50 degrees F in the mountains. This heatwave burned most of the snow off of aspects that faced the sun and built sets of ambient temperature crusts on shaded slopes as high as 11,000'. I spent two weeks romping through the mountains, never once seeing a soul strange enough to be riding a bike on black ice to ski November corn. Travel advice: sharpen your rock skis and don't forget your crampons. Studded bike tires probably wouldn't have hurt.

Finally, the cold returned and had a nearly instantaneous effect on the snowpack. I struggled to wrap my head around the rate of change as the grains in the upper snowpack turned into chains of striated depth hoar in the span of a few days. Weak, faceted snow on slopes that face away from the sun? Quite common. Ambient temperature crusts interspersed with newborn depth hoar chains? Shall we call them DHsf? We know that strong temperature gradients facet snowpacks, but I'd never watched it happen so quickly. It turns out that well-aerated ambient temperature crusts make for excellent gradient concentrators: the first pattern I didn't recognize.

And then came the flood. South-central Idaho is a desert until it's a rainforest. An Atmospheric River drew a bead on the north coast of

It's a tricky thing isn't it? Finding patterns that exist and not pretending to see ones that don't.

—Mark Staples, UAC

▾ Wind-generated patterns in the central Sawtooth Mountains at sunrise on the solstice.

California, sliding just north of the Sierra, trucking water our way. A deep low off the coast of Washington spun water off this sky river into our desert for the next four days, and the results were dramatic. Every remote weather station in our area at least doubled their reported precipitation. Many tripled. A few quadrupled. We started the forecast season at HIGH danger and issued a Warning the following morning.

In the days that followed, the new slab of snow rapidly settled and stiffened. In less than 72 hours we saw 1F hardness at the base of the slab and another day had us sticking a pencil in the thing. Collapsing rapidly diminished, but the weak layer continued to produce very unstable snowpack test scores and did not improve visually. By my second forecast shift, just eight days into the season, it felt like I was describing a deep slab problem. Another new pattern. It is not uncommon to see a snowpack that looks like this in our mountains, but it usually takes a month or two to develop. In the span of one week I'd gone from being by

◂ Natural avalanches that failed on the east face of McDonald Peak in the Sawtooth Mountains in the days after the first atmospheric river event of the season, when an uptick in wind speed overnight set off a localized avalanche cycle. The photograph was captured on the morning of the solstice, roughly 60 hours before this article was written.

myself with the crunch of my crampons to sharing the hills with hundreds of smiles and a newborn dragon.

I'd be a fool to tell you I know how this season will play out, but there are patterns I can see that I recognize. We have a proven weak layer, a meaty slab on top, and an extended loading event that looks like it will pile on five inches of SWE before this is all over. I can't tell you exactly where and precisely when; I can't tell you how large, how wide, and how deep; but I can tell you with confidence that there are avalanches happening in our Forecast Area as I build this skin track. With any luck, you'll be reading these words set to photos of a few of them.

The world makes more sense when we can tell ourselves stories that we know, stories that we recognize. But this world doesn't exist to make sense to you. My father taught me at a young age, "Benny, elk are where you find them." I believe the same is true with the patterns in our snowy world. I've added a few to my mental quilt already this season and I'm sure I'll be adding a few more as the weeks and months slide by. Expectations, then observations; repeat. Mind open to the complexity and the uncertainty, fresh eyes on an ever-changing world. We are swimming through uncharted territory but we still remember how to swim. ⬢

▴ Natural avalanches in the Prairie Creek drainage of the Smoky Mountains, south of the Sawtooths. The crowns span over 1,000' of terrain and are an estimated 6-8' deep at their deepest. The deeper avalanches failed on remnant snow from October storms while the shallower slides appear to have failed at the interface between the first two atmospheric river events.

The world makes more sense when we can tell ourselves stories that we know, stories that we recognize. But this world doesn't exist to make sense to you.

BEN VANDENBOS is a snowy mountain traveler by passion and profession. He spends 200 days a year skiing. He enjoys questioning his own assumptions, finding boxes and thinking outside of them, and skin track mantras. Today's? Head in the clouds, feet in the cryosphere, heart in between.

A Pattern

of Deep Persistent Slabs in the Washington Cascades

BY MATT PRIMOMO

Following an impressive and prolonged deep persistent avalanche cycle in the Washington Cascades in late winter of 2021, my co-workers and I at the Northwest Avalanche Center wanted to broaden our perspective and understanding of this avalanche problem.

▸ Debris from the Phantom slide path at Alpental, February 1990. NWAC COLLECTION

I spent much of the summer and fall digging into past events in the Pacific Northwest including; NWAC's annual summaries, accident records, old photos, and interviews with longtime professionals, etc. It's worth noting that I wasn't able to compile a complete list of one of the most important pieces of information for this research—avalanche occurrence data. As such, anecdotal reports combined with sporadic avalanche occurrence information were utilized. The following is a summary of the findings.

There is a long and tragic history with deep persistent slabs (DPS) in the Cascades. A few of the more famous deep persistent slab events that have happened in the region are:

March 1, 1910 Wellington, WA: 96 people were killed while sleeping on a train at the Wellington Station just west of Stevens Pass. There's no way to know for sure if the avalanche/s responsible for this disaster would classify by today's definition as deep persistent slabs, but based on prior research (Andrews ISSW 2004), weather history, and anecdotal reports it seems likely.

January 25, 1971 Yodelin, WA: An avalanche buried two cabins, killing two adults, two children and injured eight others just east of Stevens Pass.

February 10, 1990 Alpental, WA: The Phantom avalanche path on Snoqualmie Mountain ran big, clearing ~23 acres of old growth forest and depositing hundreds of trees into the upper Alpental Parking lot. Ten cars and a dump truck were destroyed.

March 1, 2021 Alpental, WA: The East Bowl of Chair Peak released 'wall to wall' with a 15ft deep crown between Sunday evening and Monday morning (HS-N-R4-D4-O). This was considered the biggest near-miss of the season by many. The area is arguably the busiest backcountry zone in the state, and an estimated 50-100+ people passed through the impact zone the previous two days.

The bottom line is that these slides have the potential to cause large-scale fatal accidents, serious damage to infrastructure, and can be difficult to forecast.

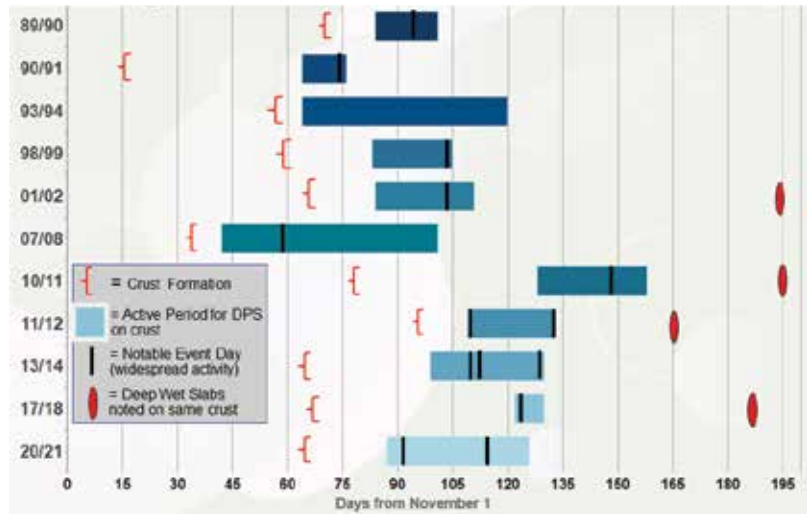
A closer look at the past 32 years revealed more insight into understanding the frequency and extent of these events. An avalanche was counted as a deep persistent slab if the crown depths were >3ft deep, and the weak layer involved old snow. Crown depths ranged from 3 ft to 20 ft+, but the average was 8–10 ft.

Within the 32 years of records since 1989, 11 events in the region seemed to fit as a 'cycle' for the main Cascade Range of Washington. A cycle was listed if there were multiple occurrences documented in multiple zones on the same weak layer. There were more DPS events than are in the graph. The ones that didn't make it appeared to be more sporadic or isolated occurrences.

I was able to find evidence of deep slabs in several of our forecasting zones for the majority of the events listed. This speaks to the regionality of the associated crust/weak layer formation, and subsequent slab building process. Many dates of crust/weak layers and avalanche occurrences even correlated well with records from the Coquihalla Highway in southern British Columbia. The area is essentially an extension of the North Cascades, and seeing deep slab avalanches occur on same or nearby dates speaks to a region wide occurrence pattern. Not every event occurred on a region wide basis though. Sometimes, a crust may not have formed in a particular zone for various reasons. Crust formation can be localized in nature, such as a freezing rain crust that may form due to micro-scale weather in any one area.

NOTABLE CHARACTERISTICS OF DPS IN THE PNW:

The large majority of deep persistent slab cycles occurred on some type of faceted layer near a crust, or a crust/facet/crust combo. All of the cycles in the graph fit this description. One can dig up a few exceptions, but these are



▸ Notable Deep Persistent Slab Avalanche Cycles In the Washington Cascades: 1989–90 to 2020–2021

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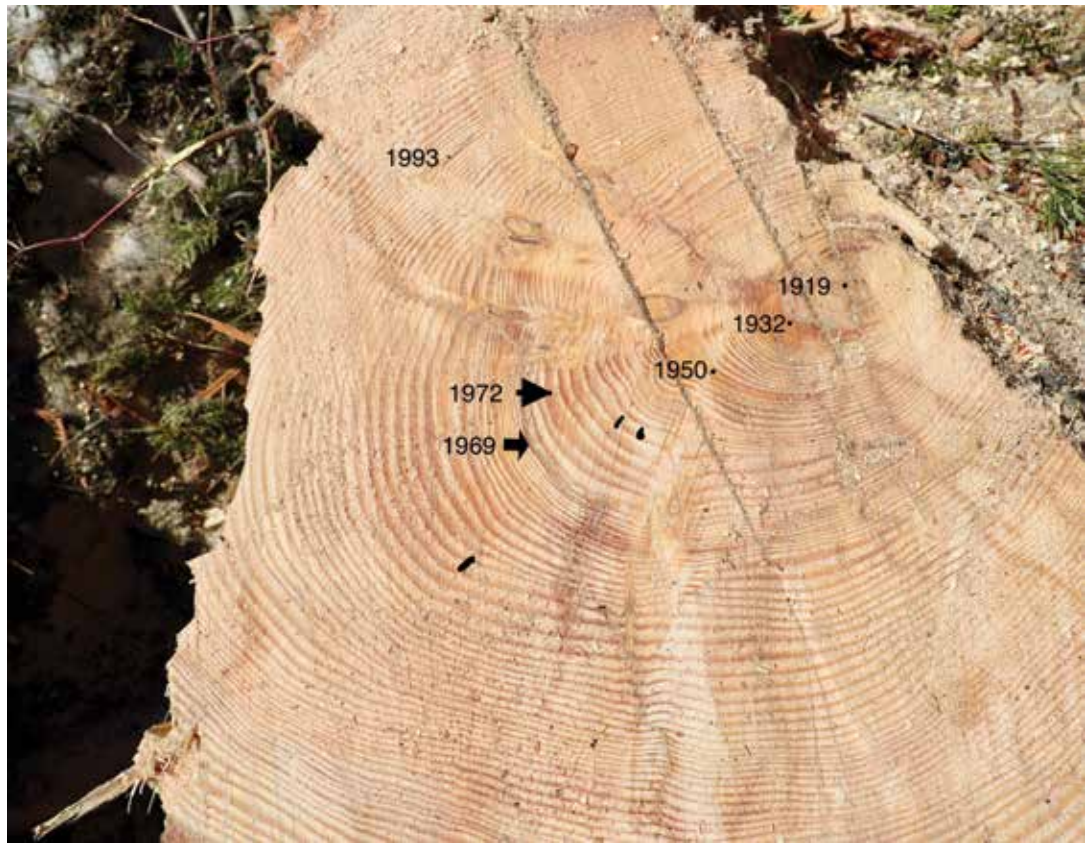
few and far between. A few of the old slide photos in the NWAC vaults tell the tale of some deeper slabs that released directly on the ground at Crystal Mountain in March of 1980.

The graph shows the date of crust formation and the documented 'active cycle' of DPS avalanches. Looking at the graph, it's apparent that weak layer structure responsible for DPS can form anytime in the middle of the season in the PNW. Campbell and MacDonald (ISSW 2010) found that the typical recipe for DPS in the Coast Ranges of Canada involve a widespread crust formation in late fall or early winter, followed by an arctic air outbreak. Although crusts from November and early December can act as the bed surface for DPS avalanches in the Washington Cascades, the more notable events tend to occur on crusts that form later in the season. The mean date for crust formation was right around January 1. This is also later than typically observed for weak layer formation for DPS avalanches in Intermountain and Continental ranges of the western US (Marienthal et. al, ISSW 2014). In some cases for these cycles in the Washington Cascades, the crust formed as late as early February. Looking further into the spring, the red ovals in the graph represent deep wet slab cycles that were suspected to have occurred on the same weak layer. There were probably many more deep wet slab cycles that have gone undocumented, largely due to the fact that many operations, including NWAC and ski areas wrap up their seasons, while a deep snowpack may still exist.

DPS cycles tend to occur once every three years on average, but the cycle that occurred in late February 2021 came with a longer recurrence interval. We were able to look at some trees that had snapped from a large D4 in the West Camp Path above Highway 2. The slide ripped out 2-3 acres of trees in a couple different areas, and knocked over a row of powerlines. The majority of the trees were 52 to 75 years old, but one dated back to 1919. Through the spring and into summer, folks were finding evidence of very large avalanches across the Central and North Cascades, often with large timber in the debris. One slide out of Boston Basin in North Cascades National Park left a massive pile of trees, snow and rocks that blocked Cascade River road until crews finally worked through it in mid-July.



▲ Annotated tree rings from a cross section of a tree that got splintered the Berne Camp Path. This tree was dated back to 1919. 📷 HARLAN SHEPPARD

PATTERN RECOGNITION

It probably takes repeated cycles over the course of many years to fully understand the patterns that occur with DPS in any given mountain range, but because instability waxes and wanes during a prolonged DPS event, we can begin to pick out distinct signals within it.

It's a deep slab, so we need to think critically about the slab just as much as, if not more than the weak layer structure. Besides heavy loading of new snow, other indicators that can be tied to DPS occurrences in the PNW are slow warming trends. Warming trends over a 3-5 day period tended to produce activity during the 2021 cycle. Extreme danger manifested itself when a warming trend occurred with heavy snowfall and strong winds during an atmospheric river, but earlier and later times of increased activity occurred with more subtle snowfall and wind events. A few even occurred with seemingly minimal weather inputs, besides some sunshine and warming. These 'fair weather' warming trends tended to produce activity especially after coming out of a cooler and snowier period. This is consistent with what Conlan and Jamieson have documented (2016), and incorporated into their Deep Slab Toolkit.

WHAT NOW?

There are a lot more questions to answer including; What leads a crust/facet layer to become the weak layers for a deep persistent slab cycle, vs those that don't? Crusts form all the time in the Washington Cascades, but they don't always lead to persistent or deep persistent slab avalanche cycles.

Another one is: Why do some persistent slab and DPS events re-awaken as deep wet slabs in the spring, but others don't? In the case of the 2021 cycle, we didn't observe deep wet slab activity with spring warm-ups, although most suspected it might happen.

Until now you've probably read that Deep Persistent Slabs are 'rare' or 'unusual' in the Pacific Northwest. I'm starting to think about it differently though, and we hope that many educators will as well. As an avalanche community, we need to change the way that we think and teach about DPS to reflect on their common characteristics at a mountain range scale, and over many seasons. We hope this research will continue to spur more work on the topic, and give avalanche professionals a better understanding of the beast that we sometimes have to face in the Washington Cascades. ⬢

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Avalanche Control with Reforestation

Planting the Big Burn on Highway 3

BY MARK GRIST

Most US readers may not be familiar with the 1946 Big Burn on Highway 3 in the North Cascades, located in SW British Columbia and the "Manning Park Gallows" sign erected afterwards. Ben Bradley's excellent book *British Columbia by the Road*[1] tells the story of how 2,300 hectares (5,680 acres) of forest burnt as a result of a campfire left unattended by prospectors, and how the parks branch seized the opportunity to make a memorable roadside sign. Relatively unknown is how the former Department of Highways undertook an aggressive tree planting program to reforest the burnt out avalanche start zones in the late 1970s.

The project emerged as a legacy of the January 1974 avalanche that claimed seven lives at the North Route Café on Highway 16 west of Terrace, B.C.[2] The provincial government formed the Avalanche Task Force to look at ways to prevent future accidents. The task force submitted its report to government in October 1974[3]. One specific recommendation it made to safeguard highways was the use of reforestation as a "permanent avalanche control measure."

Requesting assistance from the research division of the Ministry of Forests, the technical aspects of reforestation along Highway 3 were outlined in a 43-page report[4] by legendary BC forester Karel Klinka and RW Mitchell in November of 1976. *Avalanche Control with Reforestation—Experimental Project 781.02* was published two months later, in January 1977. The total project cost (in 1977 dollars) was $135,250 or $181,750 (about $550,000 and $750,000 in today's dollars, respectively) depending on seedling type chosen[5]. This budget included 286 hours of helicopter time.

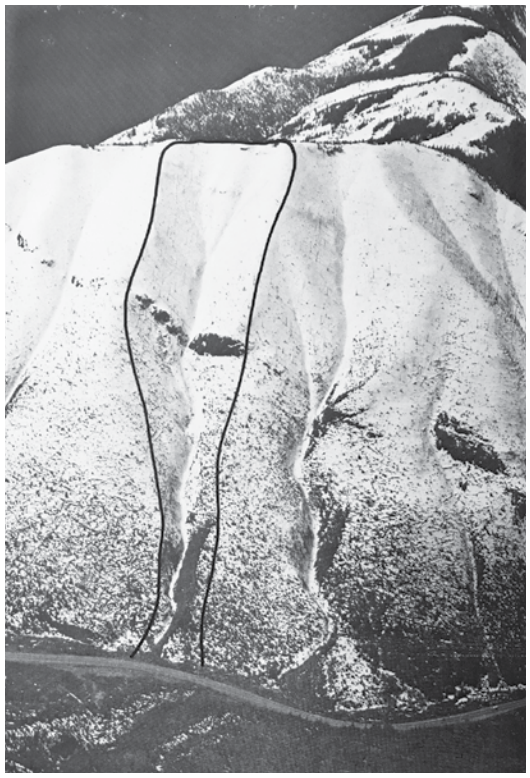
On-the-ground reconnaissance "to find severe sites, similar to those of the avalanche starting zones, along roads" took place during the fall of 1977. Preliminary field trials of seedling test stock started at two sites in Manning Park in late September of 1978, with 1,977 seedlings planted.

Over the next three years, over 40,000 seedlings were planted in the start zones of highway avalanche paths, including 11,799 trees in the Burn North paths in spring 1981. A mix of species was planted, including Engelmann spruce, Douglas fir, lodgepole pine, and subalpine fir (the best performer on north aspects). Interestingly, receipts from 1979 showed fuel charges at 26 cents per/litre ($1.15 USD/gallon) and helicopter time billed at $300 per hour (about $1,060 per hour in 2021 dollars) from Highland Helicopters Ltd. in Vancouver—a similar machine would cost $1,500 per hour today!

In the *Avalanche Task Force–Technical Supplement*[6], Allison Pass (Highway 3 between Hope and Manning Park) was rated as a MODERATE Avalanche Hazard Area (index rating between 10-100) back in 1974, noting "the highest avalanche hazard exists in the Burn." Table 1 qualifies "the avalanches according to the damage which they can produce to traffic" and predicts their frequency[6]. Thanks to reforestation (including 164,000 seedlings planted on lower slopes between 1953 and 1960)[4], the frequency in all categories has been zero for several years now.

Peter Schaerer authored the technical supplement section for Allison Pass and predicted, "Restoration of the forest would eliminate the avalanches on the south side, and infrequent large avalanches only would be observed on the north side." Indeed, the trees have held and the last notable avalanche was in 2009, while the last avalanche to affect the road was in 1996.

It remains to be seen whether we have entered a new norm of severe summer wildfire seasons, but we can say that the three worst in BC's recorded history have all happened in the past five years. After significant wildfires, RAAMS simulations by Campbell et al. showed an increase in runout distance near Waterton, AB and measured post-wildfire runout extents increased on Mt Whymper[7]. While RACS and passive defense structures are excellent solutions to be implemented on a short time scale, one could make the case for reforestation being the forgotten, 'semi-permanent' avalanche solution where climate and soils allow, especially considering that treelines have been increasing in elevation[8,9] and will continue to do so if climate trends continue. ⬢



▲ LEFT: Path 53.9 from the MoTI Avalanche Atlas (1981). ▲ RIGHT: Aerial photo taken March 16th, 2020.

▲ LEFT: Avalanche track at the Burn. April 8th, 1974. In the same Technical Supplement[6], Peter Schaerer comments on the path Burn South 2 (52.5), noting: "Forest regeneration is apparent and promotion of the growth of trees appears to be the best control method." ▲ RIGHT: The same image taken March 30th, 2021.

LW: Mark do you have any data on whether those paths have been avalanching less often or if they have put less debris on the road over time?

MG: Great question...I ran a query in our SAWS (Snow Avalanche Weather System) database from 1980/09/01 to 2021/03/22. It shows 113 avalanche occurrences (the vast majority were in the 1980s and 90s, and none since 2009), of which six were on the road (two from the Dec 31st, 1990 storm and four from the Dec 29/30th, 1996 storm).

So the short answer is BOTH!

R1 (Snow dust or wind blast only) 6.5 events/year affecting 1150' of road

R2 (Sluff: small bank avalanches) 0 events/year

R3 (Light snow: Deposits on road 1-4' deep) 1.3 events/year affecting 600' of road

R4 (Deep snow: Deposits >4' deep on road) 1.98 events/year affecting 1950' of road.

▲ Table 1: Avalanche Task Force (1974) predicted frequency and length of road affected by four different categories of avalanche events for the Big Burn area[6].

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Crust / Facet / Curiosity

BY DON SHARAF

Lynne: "So I heard you did a talk for ESAW about crusts and facets."

Don: "Ummm... yeah... and..."

Lynne: "Would you be willing to write an article for TAR..."

What was I thinking? Great brains are studying faceting around crusts and we still don't know when they are strong enough. We still don't know whether cutting the crust during the stability tests creates an unrealistic picture of propagation potential. "We" don't know much and I feel like I know less. So what could I write that might be helpful? What follows are a few anecdotes, resources, and questions that I hope will spur your curiosity and help you consider all possible outcomes when dealing with facet crust combos.

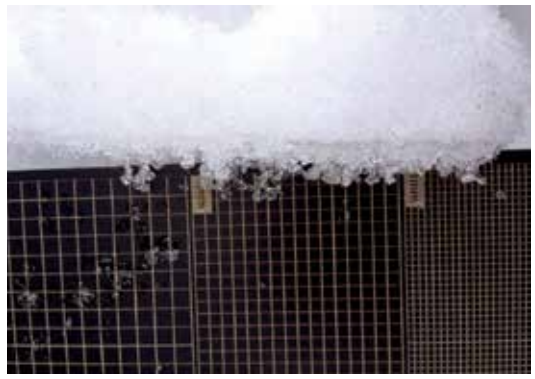
The starting point. **Crusts are strong and Facets are weak.** This simple statement is the source of a big problem. If you have facets below a crust, then the slab that needs to be built to cause weak layer failure is likely going to be BIG.

Scott Savage presented a fascinating ISSW talk in 2006 on Deep Slabs at Big Sky Resort in Montana. Among his data set, 100% of the deep slab avalanches were associated with a crust or ice. Wow! I was just working there a week ago and the persistent weak layer within the snowpack at treeline and above was a crust-facet-crust sandwich. The current Big Sky snow safety team, Mike Buotte and Chelan Babineau-Z, were facing a question they face almost every year: How much load will tip the balance, or will it tip at all? I don't know. Crust-facet stability is difficult to predict and it takes constant vigilance as loading and subsequent slab character changes.

The variables and the most important questions to ask when trying to assess your problem:

How did the crust facet combo form? If you know this, then you have some ideas on distribution.

- **Rain event on pre-existing snow** with a cooling trend at the end of the storm. You likely are going to see a set up for **Melt-Layer Recrystallization**. This pattern is elevationally driven. All rain and no snow will result in a thick rain crust when the storm ends and cold temperatures return. All snow and you won't have a warm layer where liquid water exists. The future problems can be found in those transitionary elevations that have had rain and then a thin layer of snow at the end of the storm. I have seen this confined to 1000' vertical, but have also seen it span 2500' (Dam Facets, TAR 33.2, December 2013). With an elevation-driven problem, you don't have safe aspects to run to – your only recourse, as a non-mitigator, is to limit slope angle.
- **Rain event on pre-existing snow.** Rain-soaked snow freezes into a crust and then a layer of snow sits on top, exposed to diurnal faceting near-surface gradients. This problem is going to be a little more aspect-driven, especially if there was any wind associated with the snowfall. South aspects might cook into sun crusts or, if cloudy, may have rapid diurnal facet growth. Leeward aspects to the wind may hold a thicker layer of facets or may be so dense that they were resistant to faceting. Windward may not have any snow at all and not present a problem for the future.
- **Sun-formed crusts** usually pair with radiation recrystallization facets – In terms of distribution they are often aspect-driven. Steep slopes and high elevations lead to rapid facet growth over what will become a very thin crust. In my experience, these layers react so quickly to load that they seldom develop deep slabs.



▲ This was the December 28, 2011 rain crust over basal facets/depth hoar. The photo was taken on January 8, 2012, so the facets beneath the crust were the result of around 11 days of that process. MATT PRIMOMO

Other insights into crust/ facet layers

- **Facets around a crust due to micro-scale temperature gradients.** Ethan Greene (2006) and Kevin Hammonds (2016) have done great work showing that faceting occurs on either side of a crust and that thermometers are poor tools to assess those gradients. The scale of the kinetic gradients is within millimeters of the crust, so that gradient remains undetectable to tools that are designed for a larger scale and lower precision. The bottom line here is that visual inspection of the grains is the best assessment tool and that you are going to have to dig to that layer to assess it over time.

Have you ever wondered what causes crusts to 'decompose?' Well, that is likely due to strong gradients immediately adjacent to either side of the crust. So what? A crust that initially was strong enough to support additional load may lose strength over time AND the grains around that crust may become facets… or even bigger facets. Elevation and aspect aren't helpful here – you have to dig and assess if you are seeing results in your stability and propagation tests, or if you suspect there could be a future problem.

- **Age and size matter:** A study by Bruce Jamieson and Paul Langevin (2004) looked at avalanches associated with crusts. They found that new snow (PP and DF) avalanches on a crust were a short-lived problem (no longer than six days from time of burial). In the scope of their study they noted that 94% of the avalanches that occurred on crusts were associated with persistent grain types. Surface hoar on a crust proved to be more persistent (lasting up to 33 days), but facets associated with a crust had the greatest longevity with avalanches to three months following burial. As an aside we saw a wet slab cycle in the Tetons reawaken a facet crust combination 123 days following the formation and burial of that layer!

Some commonalities between Jamieson's and Savage's observations is that the weak layer thickness of the facet layer is commonly 2 cm or less and that the grain size of the facets is 2mm or less. Jamieson did observe that larger facets often were responsible for the avalanches that occurred the farthest out from burial.

So how thick a crust is thick enough to prevent further avalanches?

It really doesn't matter if the facets overlie the crust, but if the facets are below, then it is going to take larger and larger loads (or triggers) to affect those facets. With the infamous MLK crust of 2011 it took massive loads to cause the crust and weak layer to fail. Crystal Mountain saw massive wet slabs running down to that layer (Morin 2012).

I wish I could say a crust of a given thickness and hardness is going to lock down everything below that layer, but it really does depend. One factor I consider when pondering this question is the likelihood that rain crusts will likely decrease in thickness as elevation increases. With this increase in elevation the slab depth overlying the crust will also likely increase (due to higher precipitation and wind loading). Consequently, the lower and mid-elevations may remain locked down, while the highest elevations might be susceptible to reactivation. That was the case in the Wasatch with the MLK layer later in the season. (Nalli 2012, Havlick 2012)

▲ The sheen of the MLK crust on White Limbo gives a hint of things to come after it is loaded by snow and thumped by cornice fall. 📷 CRAIG PATTERSON

INTERFACE BONDING		INTERNAL LAMINATION	
1	Little to no bonding between layers, clean separation with minimal shearing force	1	Little to no bonding. Very difficult or not possible to handle without breaking/ crumbling.
2	Poorly bonded, separates easily, fractures with light pressure, light brushing may be required to isolate crust layer	2	Bonds between individual ice grains are discernible, but not strong or extensive. Difficult but possible to isolate block. Sample crumbles easily.
3	Moderate bonding, requires hard brushing or very light scraping to isolate crust layer	3	Bonding between individual ice grains is moderate. Bonds are discernible and hold the sample together with light handling. Sample crumbles slightly with light handling.
4	Well bonded, requires light to moderate scraping to isolate crust layer	4	Well bonded. Sample has strong bonding between individual ice grains. Sample maintains shape with handling and cutting. Sample has a tendency to break rather than crumble when handled roughly.
5	Very well bonded, difficult to separate layers, requires hard scraping or saw to isolate crust layer	5	Samples is almost completely bonded. Bonds and grains are difficult to discern as the sample is nearly uniform. Pure ice would be 5+ as it would be entirely bonded. Sample does not crumble, but rather breaks if loaded to failure.

▲ Table 1: Crust Index definitions. The interface bonding describes the bonding between a melt-freeze crust and the layers above and below. The internal lamination describes the bonding between grains within a melt-freeze crust.

CONSISTENT OBSERVATIONS AND COMMUNICATION

Ryan Buhler et al (2012) came up with a crust index. Using this index to observe crust layers over time will give you some physical properties to track as the snowpack stability improves or degrades.

SO WHAT

Facet Crust combos are persistent problems. Not only are they capable of producing large avalanches, but they can be a problem that lasts all season. If an avalanche flushes down to the crust layer and then a little bit of snow sits on that bed surface for enough time for diurnal faceting to weaken it, then you have strong potential for a repeat offender that season. This structure is also a great set-up for being the "funny business" that Reardon (2004) referred to in his initial study of wet slab avalanches in Glacier NP, MT. Having both a high porosity, low strength weak layer over a water drainage barrier is a great set up for wet slab formation. Liam Fitzgerald said some words that stick with me, something to the effect of "If you have a layer that has been a problem throughout the season, then watch for it again when spring hits.."

I hope this article has given you some things to think about when pondering next steps with your current crust facet mess. As I have said, I don't have a lot of answers, but I do have some specifics to think about as those layers evolve and the slabs build. Hopefully this focuses your curiosity.

"Good luck with those rotten bastards!" ⬢

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DON SHARAF has traded hats within the avalanche industry. Following professional level avalanche courses in Canada, he has taken a deep dive into work for Dave Hamre and Associates. In his free time he continues with his welding commitments and SAR callouts. His wife says he is still making poor decisions in the time management realm.

Patterns in Accidents

Education and Experience Levels of People Involved in Avalanches during the 2019–202020 and 2020–2021 Colorado Avalanche Seasons

BY ETHAN GREENE & SPENCER LOGAN

Have you ever seen a social media post or news report about an avalanche accident where the people involved were described as experts? They often use language like "expert skiers" or "experienced snowmobilers," but the single label can conflate someone's riding skills and avalanche experience. Sometimes people will proclaim the group displayed a significant lack of experience, understanding of avalanche phenomena, or implementation of common safety practices. Occasionally someone asserts that people with more avalanche training are caught in avalanches more frequently. We decided to dig a little deeper into Colorado avalanche accidents during the 2019–202020 and 2020–2021 seasons and take a closer look at the avalanche education and experience levels of the people involved. The onset of the COVID-19 pandemic also provided an opportunity to look at accidents before and after the shutdown in the spring of 2020.

AVALANCHE ACCIDENT TRACKING IN COLORADO

The Colorado Avalanche Information Center (CAIC) has been documenting avalanche accidents for decades. Over the years the effort has grown from just fatal accidents to include all avalanche involvements in Colorado. Basically, we try to collect some information any time someone is caught, carried, or buried in an avalanche. We learn about these events from reports people send us, connections with sheriff's offices or search and rescue groups, media articles, social media threads, or when people tag us in their posts. Sometimes when we're just talking to people at the grocery store or when a friend hears a rumor. We reach out to the people involved, try to verify some details, and gather whatever additional information we can. When someone is killed in an avalanche we conduct a detailed investigation and interview as many witnesses and survivors as possible. You can read those reports at https://avalanche.state.co.us/accidents/colorado/ and see a summary of what we've collected over the last 20 years in Figure 1.

WHAT WE DID

Other researchers have examined the education and experience levels of people involved in avalanches, but they focused on the victim's avalanche training and self-assessed avalanche experience (McCammon 2000, Zweifel et al. 2012, Martensson et al. 2013). Because we don't interview everyone involved in every accident, we don't know all the avalanche classes taken by all the people in the group or their self-assessed avalanche skills. So we built two scales that allow us to rank people's avalanche education and their avalanche experience.

For avalanche education, we created the Avalanche Education Level (AEL) scale (*Table 1*), based on the American Avalanche Association's course progression (https://avalanche.org/avalanche-courses/). The AEL just looks at whether someone either has or has not reported taking an avalanche class at a particular level.

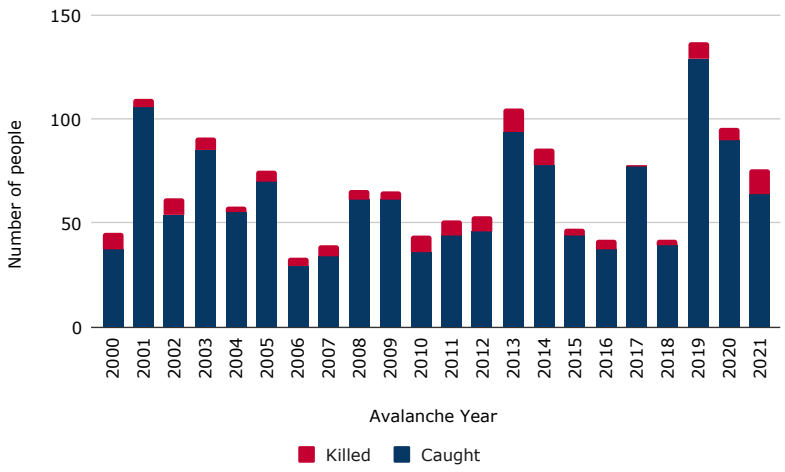
We also developed the Inferred Avalanche Experience Level (IAEL) scale (*Table 2*) to rank avalanche experience from indirect evidence like an observation report, interviews, or someone's description of how other groups moved through avalanche terrain. We based the IAEL on the National Institutes of Health's Competencies Proficiency Scale (CPS). The CPS is a human-resources tool that allows interviewers to rank a candidates' experience. It is also used as a self-assessment to see where your experience places you in your career progression. The CPS has parallels with the Dreyfuss Learning Model (Dreyfuss and Dreyfuss 1980) that allows researchers to assess how well people learned a set of skills or knowledge through training and instruction. Researchers in Canada (St Clair 2019) used similar models to assess avalanche forecast users. None of the previous models were directly applicable to what we tried to do, but did allow us to develop a scale that relates to other assessment efforts. At each level, we developed examples of evidence to help us infer experience. We used evidence like statements from the group, their use of technical language in an observation, descriptions of pre-trip planning, and if they used safe travel practices. The IAEL is a subjective scale, but one that is relatively repeatable between researchers.

We used the definitions in *Snow, Weather, and Avalanches: Observation Guidelines for Avalanche Programs in the United States* (American Avalanche Association, 2016) to define the types of avalanche involvements and select events for the dataset. We identified as many people as possible involved in these avalanche incidents. If there were five people in a party, but only one person caught, we determined individual IAEL values for each of the five people. While imperfect, this allowed us to include people who were not caught in the avalanche, but participated in the event and in decisions made by the group.

We applied the AEL and IAEL scales to all the people we identified. We used all information the CAIC gathered, from detailed interviews and accident reports to brief observations submitted by the public. Some involvements were reported second-hand, with no information directly from the parties involved. The AEL and IAEL scales allowed us to assign levels to people when there were different amounts or different types of information.

We used the Tier 1 avalanche danger rating to examine avalanche danger relevant to avalanche incidents. **The Tier 1 rating is the highest avalanche danger level issued for a specific place and time.** It's displayed on maps of avalanche danger and used as the overall danger for a forecast region. The CAIC issues forecasts with different spatial extents depending on the time of year, and the Tier 1 rating allows for consistent comparisons between different days in the forecast season.

Significant impacts of the global COVID-19 pandemic began in Colorado in mid-March 2020.



◂ Figure 1: Number of reports to the Colorado Avalanche Information Center of people caught and killed in avalanches during the last twenty Colorado avalanche seasons.

AEL	REPORTED EDUCATION
UNKNOWN (UNK)	Unable to categorize
NONE	No formal avalanche training
AWARENESS (AWARE)	Awareness or introductory avalanche education
LEVEL 1 (LEV 1)	Three-day course for recreationalists that includes instruction in classroom and field
LEVEL 2 (LEV 2)	Advanced training for recreationalists
PROFESSIONAL (PRO)	Professional-level courses with structured evaluation

▲ Table 1. The Avalanche Education Level (AEL) scale we used to categorize people's education levels and brief descriptions of the courses.

IAEL	GUIDANCE
UNKNOWN (UNK)	Unable to categorize
NONE	• Report came from a party not involved in the avalanche • Statement from reporting party that involved party "didn't know what they were doing" or "had no idea"
BEGINNER (BEGIN)	• Involved party reported the avalanche • Mention of checking or using the avalanche forecast • Demonstrated basic travel practices (e.g. exposing one person at a time to avalanche hazards)
INTERMEDIATE (INT)	• Party demonstrated skills learned in a Level 1 recreational avalanche course • Report used basic terminology correctly • Evidence of pre-trip planning
ADVANCED (ADV)	• Trip planning discussed or documented • Snow profiles or tests conducted and interpreted • Adjusted plans based on field observations
EXPERT (EXP)	• Discussion of avalanche or terrain use concepts showed a high level of understanding • Evidence of multiple seasons of applied skills • Recognized as "person to ask" among peer group
AUTHORITY (AUTH)	Professional expert with experience in multiple professional roles Developed new research, references, or tools

▸ Table 2. The Inferred Avalanche Experience Level (IAEL) scale and some of the guidance we used to categorize people's experience.

To examine potential changes in patterns of avalanche involvement, we chose 13 March 2020 as the pre- and post-pandemic division. On or around that date, cities and counties began imposing a patchwork of travel restrictions and public health rules. The State of Colorado closed ski areas and other public venues to reduce the virus transmission. CAIC staff and other professionals noted a significant increase in backcountry use following the closures. Anecdotal and indirect data indicated that the increased backcountry use continued through the 2020–2021 season. For comparative purposes, we also looked at differences in the 2020–2021 season before and after March 13, 2021.

WHAT WE FOUND

The CAIC documented 86 avalanche incidents during the 2019–2020 season and 82 avalanche incidents during the 2020–2021 season. We identified a total of 232 people involved in those 168 incidents. We categorized all 232 people with the AEL and IAEL (*Table 2*).

We were able to determine an AEL other than Unknown for 61 people. Of those, 32% appeared to have no formal avalanche education and 30% had taken a Level 1 avalanche class. Five of the 14 fatal avalanche accidents involved people who had taken a Recreation Track—Level 1 avalanche class. Three fatal accidents involved people with professional avalanche education. That may indicate a selection bias. CAIC investigators try to collect avalanche education levels when investigating fatal avalanches. When people self-report an avalanche involvement, we often don't have the opportunity to collect this information.

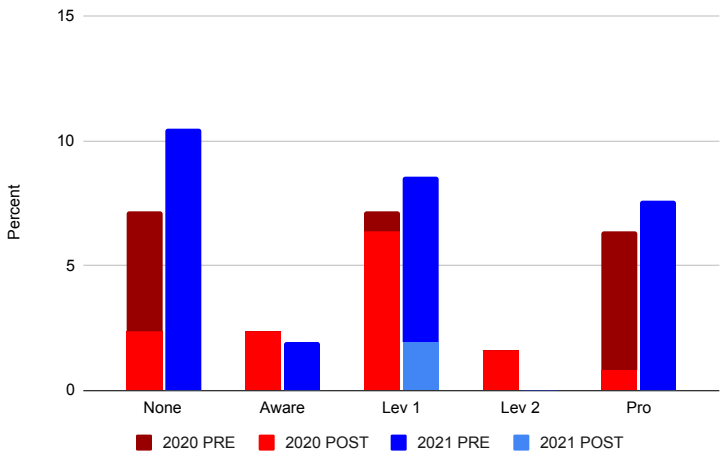
We assigned IAEL to 175 people. Fourteen percent of people were categorized as beginners, 20% intermediate, and 30% advanced. We saw the expected correlation with AEL and IAEL (*Table 3*)—the more experienced a person was with avalanches, the more formal education they tended to have. There were five people with advanced experience that had not taken formal avalanche classes, a reminder that avalanche classes are important, but not the only way to gain knowledge. Likewise, we found a range of IAEL for people who had taken a Level 1 avalanche class. Education is important but not a substitute for applied experience.

Half of the people involved in avalanches had intermediate or advanced levels of experience, which is consistent with previous research (McCammon 2000, Tase 2004). McCammon (2002) found that avalanche education did not reduce avalanche exposure. Our results suggest people were using their training and experience to spend more time traveling in avalanche terrain, or choosing to travel during more avalanche-prone conditions.

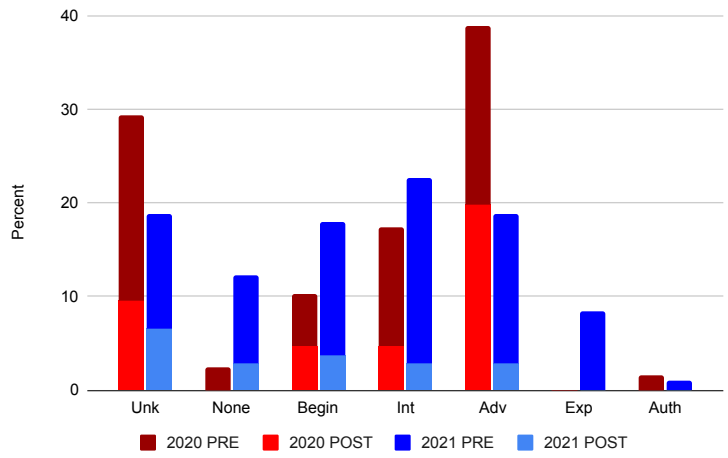
There was not a significant difference in the distribution of AEL between the two seasons (*Figure 2*). However, the distribution of AEL differed significantly ($p = 0.002$, Fisher exact test with p

	2019–202020						2020–2021					
AEL IAEL	**UNK**	**NONE**	**AWARE**	**LEV 1**	**LEV 2**	**PRO**	**UNK**	**NONE**	**AWARE**	**LEV 1**	**LEV 2**	**PRO**
UNKNOWN	37						20					
NONE		3					10	2	1			
BEGIN	10	2	1				14	3	1	1		
INT	18		2	2			18	5		1		
ADV	30	4		7	2	6	11	1		7		1
EXP							3					6
AUTH						2						1

▲ Table 3. Counts of IAEL (vertical) and AEL (horizontal) for the two years in our study.



▲ Figure 2. Avalanche Education Level for the two seasons in the study. Data has been normalized within the season (we were unable to determine avalanche education for 75% of people in 2019–2020 and 71% of people in 2020–2021). The shaded bars indicate the percentage of involvements before or after March 13 of the respective seasons. The "Unknown" category is not shown to allow for more detail in the other categories.



▲ Figure 3. Inferred Avalanche Experience Level for the two seasons in the study. Data has been normalized within the season. The hues within the bars indicate the percentage of involvements before or after March 13 of the respective seasons.

values simulated from 2000 replicates) prior to and post pandemic-related closures in 2019–2020. There were not statistically significant differences in the distribution of AEL before and after March 13 in the 2020–2021 season.

There was a statistically significant difference in IAEL between the two seasons ($p < 0.001$, Fisher exact test with p values simulated from 2000 replicates). When decomposing the seasons into two pre-March 13 and two post-March 13 groups (*Figure 3*), the IAEL distribution for post-March 13 2020 was significantly different from the other three distributions ($p<0.01$, P values adjusted based on Holm's method).

The proportion of people involved in avalanches in the spring of 2020 shifted to more educated and experienced backcountry travelers after the pandemic-related March 13 2020 closures. We don't know why this occurred, but there's some anecdotal evidence that may help explain the shift. As recreation increased after pandemic closures of ski areas and other activities, easily-accessible areas became crowded and tracked up. More skilled recreators used those skills to push into less-familiar terrain or explore new areas. Like McCammon (2004) showed, they were using their skills while accepting an increase in avalanche exposure. Some observers reported an "increase in risky behavior" or people "taking more avalanche risks." These are very subjective observations, but consistent with research on increased risk acceptance in stressful situations (See Sapolsky 2017 for a summary). The uncertainty of a global pandemic certainly created a stressful environment.

In Colorado, most avalanche accidents occur when the avalanche danger rating is either Moderate (Level 2) or Considerable (Level 3) (Logan and Greene 2018). This was also true during the 2019–202020 avalanche season with 60% of the incidents occurring at Moderate (Level 2) and 30% at Considerable (Level 3). An important point is that the CAIC issued a Moderate (Level 2) rating for 68% of forecast days in 2019–2020. For a better comparison of incidents and danger ratings we looked at the ratio of the number of incidents at a Tier 1 danger rating to the total number of days with that Tier 1 danger rating (*Figure 4*).While the number of incidents in 2020 at a T1 danger level did not differ significantly before or after the pandemic closures, the ratio of incidents to the number of days at a T1 danger rating was significantly different ($p < 0.001$, Fisher exact test with p values simulated from 2000 replicates). The proportion of incidents at Considerable (Level 3) after March 13 suggests that backcountry travelers were accepting greater avalanche exposure during hazardous periods in the spring of 2020.

The two seasons show very different seasonal patterns of when people were involved in avalanches (*Figure 5*). In 2019–2020 there was a fairly constant period of involvement through January and mid-February. There was a lull in avalanche involvements from mid-February to mid-March, corresponding to a period with a relatively stable snowpack. There was a notable spike in avalanche involvements in the second half of March, after the pandemic-related closures and after snowfall that rapidly increased the avalanche danger. Spring storms in late April led to another increase in avalanche involvements.

In contrast, December 2020 and February 2021 were particularly tragic months in Colorado, with large numbers of avalanche involvements and fatal accidents. There was an increase in avalanche involvements in the second half of March 2021, but almost half the number of people compared to March 2020. The snowpack in spring 2021 was relatively stable compared to both earlier that winter and the spring of 2020.

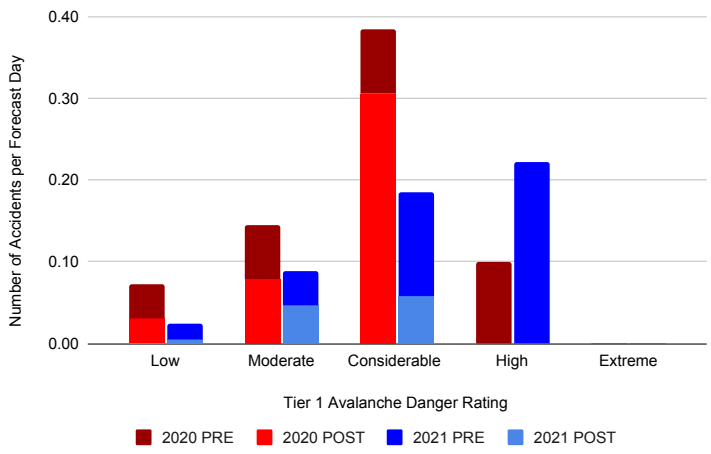
OUR THOUGHTS ON WHAT THIS MEANS

These results add to the ongoing discussion about education, experience, and avalanche accidents. Our approach provides a novel way to look at the experience level of people involved in avalanches, but there are also some limitations to keep in mind. First, our dataset is relatively small, consisting of two seasons in Colorado and just the avalanche involvements reported to the CAIC. Second, our dataset is biased, as it only includes people involved in avalanches. The people who successfully avoid avalanches, with and without formal training and years of experience, are not included. Third, we looked at two years of data from Colorado, but neither of these were normal years. The first year contained a shutdown in the middle of the avalanche season due to a global pandemic. The second year had the highest number of people killed in avalanches in 28 years.

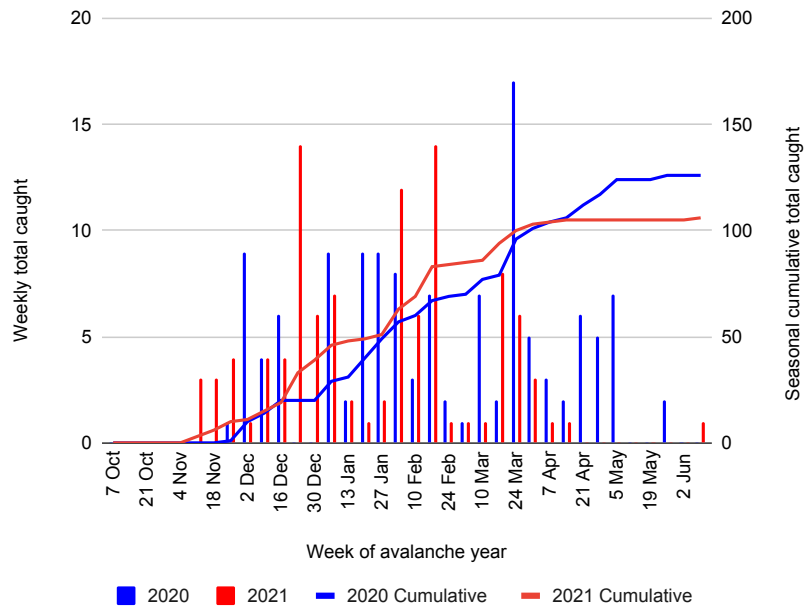
Nearly 40% of the people caught in an avalanche, or in a group with someone caught in an avalanche, had taken a Recreation Track - Level 1 avalanche class. According to our IAEL, about 54% had intermediate or more advanced avalanche experience. This begs the question: Does formal, field-based training or avalanche experience increase or decrease your chance of getting caught in an avalanche? This study cannot answer that question. People that invest in avalanche education and gain experience in the mountains typically do so because they spend time in avalanche terrain, which increases their exposure to avalanches. In aggregate, the additional exposure may offset the application of risk-reduction strategies.

Over the two seasons, about 7% of the people caught or buried in avalanches were professionals at work. In separate incidents, two CAIC forecasters triggered and were caught in avalanches while doing fieldwork in the backcountry. In seven avalanches, six ski patrollers were caught, and one fully buried. We documented three separate avalanche incidents with guided groups, including one natural icefall avalanche on January 18, 2020 that buried and killed a client. These incidents are a reminder that snow safety work can be hazardous and professional level training does not make you immune to avalanches. Two professionals were involved in fatal recreational accidents, which may indicate a difference in acceptable risk in workplace vs recreational settings.

The impacts of COVID-19 produced a dramatic increase in backcountry recreation in the spring of 2020. Our comparison of pre- and post-COVID periods suggests the increase in avalanche accidents was not driven solely by a flood of new users. Clearly the conditions that led to an increase in avalanche accidents



▲ Figure 4: The ratio of the number of incidents at a Tier 1 avalanche danger rating compared to the number of forecast days with the Tier 1 avalanche danger rating. The shaded bars indicate the percentage of involvements before or after March 13 of the respective seasons. The Tier 1 rating is the highest single rating for any area issues for a 24 hour period.



▲ Figure 5: The number of people involved in avalanche incidents, binned by week of avalanche year (Oct 1 to Sep 30) for the respective seasons, 2019–202020 in blue and 2020–2021 in red. Columns show the total weekly involvements on the left axis. The lines show cumulative involvement through the season on the right axis.

involved the interaction of multiple factors: more people in avalanche terrain, more use in easily accessible areas, more people moving into new areas looking for solitude or fresh snow, changes in the distribution of education and experience, the distribution of snow and avalanche conditions, and a myriad of other factors.

CONCLUDING REMARKS

Our goal was to better understand the relationship between avalanche education, avalanche experience, and avalanche accidents. To do this we developed a new way to rank people's experience with avalanches. The patterns we observed using this method are consistent with previous work. We found that the distribution of avalanche education levels of people involved in avalanche accidents was fairly consistent between the two years and before and after the pandemic shutdown. However, there was a significant shift in the experience levels of these people before and after that shutdown. That shift was towards a higher level of experience.

The IAEL provides a repeatable and relatively objective way for researchers to rank people's avalanche education and avalanche experience levels. Our results may raise as many questions as they answer. Without knowing more about people's exposure and days without involvements it is impossible to really understand the effect of avalanche training on the potential for an avalanche accident. However, it does appear that we should continue to consider who we are targeting with avalanche safety products and training programs, and ask hard questions about whether the information and training we're providing is producing the decrease in avalanche involvements we desire. ⬢

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ETHAN GREENE has worked in snow and avalanches since 1990 and directed the Colorado Avalanche Information Center since 2005.

SPENCER LOGAN has forecast weather and avalanches in Colorado since 2004. He is currently the Lead Avalanche Scientist at the Colorado Avalanche Information Center and oversees the avalanche accident database for the United States.

SNOW & AVALANCHE
Workshop Reports

All photos of interesting snow conditions in the Wasatch. MARK WHITE

2021 SAW stats

A3 supported 8 Snow and Avalanche Workshops across the U.S. in fall 2021. These workshops had the following impact:

54 education sessions with more than 6,000 hours of total view time

Participants from more than 13 countries and 29 states

in-person attendees:	virtual attendees:	expert speakers:
718	9,669	131

4SAW

	250
	40
	15

Silverton Avalanche School presented the Third Annual **Four Corners Snow and Avalanche Workshop** (4SAW) on October 9, 2021, at the Kendall Mountain Recreational Center in Silverton, CO. 4SAW is an annual gathering for avalanche practitioners, mountain professionals, and backcountry recreationists. Over 200 people attended this event. Safety protocols requiring proof of vaccination or a negative COVID-19 test were implemented. Speakers were both in person and brought in virtually.

4SAW's 2021 theme explored **Mountains; Water Towers of The West** The mighty peaks, lofty summits, backcountry bowls and high basins of the Southern Rocky Mountains, annually replenished by the snows and slides of winter, are the water towers from which all life flows.

Representatives from the regional avalanche forecasting centers, the Taos Avalanche Center, Kachina Peaks Avalanche Center, Utah Avalanche Center, Colorado Avalanche Information Center opened the workshop with seasonal summaries from 2020. Mark Miller (meteorologist, US National Weather Service Grand Junction Colorado) gave a forward looking talk on what the climate seasonal predictions were in the "2021–2022 Winter Weather Outlook."

Dr. Jerry Johnson (Montana State University Snow and Avalanche Lab) gave a synopsis of human factors research related to both professional and recreational audiences in "Unpacking the Human Factor." Dr. McKenzie Skiles (University of Utah Geography, Snow Hydro Lab), "Digging up the dirt: How dust deposition impacts our changing mountain snowpack" gave an overview of her work and how "dust on snow" events have big implications for avalanche professionals and the recreational audience. Her work has also had a significant impact on water managers in the west. Laura McGladrey of the Responder Alliance presented "Stress and Avalanche; Incremental and Rapid Loading," and gave an overview of stress injuries on rescuers in avalanche rescue incidents. This pertinent talk was very useful for the audience. Kenneth Wylie, IFMGA ski guide and author of *Buried* presented the talk "Recognizing the Innocuous Steps to Catastrophe. Breaking down the unthinkable tragedy of La Traviata." Ken went into details on an accident that had long-term impacts on his life and career. This talk paired well with Laura's talk. Roz Reynolds of Wyssen Avalanche Control presented "New Developments on avalanche mitigation installations for Lizard Head Pass, SW Colorado." Roz discussed what permanent avalanche mitigation installations do and how they are managed. These structures are much more common in Europe but are becoming more common in the United States.

Drew Hardesty, forecaster with the Utah Avalanche Center, gave a self reflective talk "On the Nature of Forecasting (and Why We Get it Wrong)." This talk gave a peek under the hood of forecasting and delved deeper into the forecasting process. Travis Laverty (La Plata County Search and Rescue and San Juan County Search and Rescue), "A season of uncertainty: an exploration of two tragic cases in the San Juans." He went into detail on two accidents that took five lives in 2020. Dr. Jeff Deems of Airborne Snow Observatories, Inc. gave a talk on remote sensing of the snowpack "Snowpack from above, remote sensing the snowpack." He discussed new technology and the application of remote sensing to understanding the spatial extent and development of the snowpack over time. To wrap up the event, Josh Jesperson presented the movie "The Animas Project," describing an expedition that left from Silverton and skied various lines along the Animas River which runs through the Weminuche Wilderness. The expedition took water sample from old mines for ongoing environmental research. The event ended with an outside social time for further discussion and networking. 4SAW is a grant-supported regional event co-sponsored by the American Avalanche Association (A3). Additional support was provided by Mammut, Wyssen, and Pine Needle Mountaineering.

JIM DONOVAN is the Executive Director of the Silverton Avalanche School. He loves snow and the mountains, but occasionally sneaks away to the desert.

BENDSAW

	108
	109
	10

The Central Oregon Avalanche Center was pleased to host its fourth annual **Bend Snow and Avalanche Workshop**. As our avalanche center is relatively young and still comparatively small, I've been continuously impressed with the caliber and the diversity of speakers that we've had each year. Similarly, I continue to be surprised by just how many folks in our growing town of 100,000 people are interested in winter recreation, and I'm impressed with the community's interest in snow and avalanches.

Write-ups of this season's educational and insightful industry events

In these regards our 2021 SAW maintained the standard of our other events. We opted for a hybrid workshop where audience members could buy a limited number of in-person tickets, or attend virtually; similarly, presenters spoke in person and remotely. We sold 108 in-person tickets and 109 virtual tickets. Our list of speakers read like a "Who's Who" list of last year's *The Avalanche Review* authors, although we also had some great experts from closer to home, as well as experts from other fields that use similar risk management models to those of us that travel in avalanche terrain.

David Hill from Oregon State University kicked things off with a presentation on our changing mountain snowpack, specifically presenting different methods of modeling and tracking those changes over time. This was one talk I kept trying to recall and dissect during our especially dry and warm early season (I did my first day of forecasting in running shoes and a sweatshirt, but don't worry it's gotten snowier!).

The Executive Director and Lead Forecaster of the Wallowa Avalanche Center, Victor McNeil gave us a short history of the Wallowa Avalanche Center. This was a valuable presentation for us in Central OR and perhaps he was overdue to present at our event. As the other small non-profit Avalanche Center in OR, I think of the WAC as our sister/brother center, and while the two centers often work together informally to address similar challenges, I don't think the general public was aware of just how similar we are and how these small avalanche centers operate.

We had an especially stacked list of speakers that addressed risk management in the backcountry. Jake Hutchinson and Jenna Malone gave talks that presented strategies for mitigating risk. Eeva Latosuo summarized her work on looking at the choices that recreationalists are making as far as where they are choosing to ride and with whom. Our own board member Kevin Grove, along with Paul Diegel, formerly of the Friends of the Utah Avalanche Center, summarized their projects of integrating quizzes into the avalanche forecast. Lastly Lisa Christensen presented strategies for risk management used by the United States Air Force, and how those relate to traveling in avalanche terrain.

Our keynote address was given by Bruce Jamieson. He gave a perhaps slightly edited and updated version of the talk that he gave at the virtual 2020 ISSW about his ongoing work to better define likelihood terms in the field of avalanche forecasting. As an avalanche forecaster who routinely uses these terms and checks these boxes to provide public safety information, Bruce's work on likelihood has from the beginning had me thinking "of course this could be so much better" and so I found his presentation particularly engaging. I'm ready for more.

Thank you to the American Avalanche Association for their help with this event. I think we are all pretty lucky (maybe more like smart) that we work in a field where we get to meet, and to hear from the leaders in our field regularly at events like these snow and avalanche workshops.

GABE COLER is an IFMGA guide working in the Cascades and at Smith Rock. He is also a part-time avalanche forecaster for the Central Oregon Avalanche Center. Lately he has been reading a lot of Thich Nhat Hanh and trying to finish the wood shed that his wife requested for Christmas.

CSAW

0

1,174

19

The global pandemic makes everything more difficult and planning a professional workshop was no exception. Last year was the first virtual **Colorado Snow and Avalanche Workshop** (CSAW). We missed seeing all of our friends and colleagues, but the virtual event allowed us to partner with the USFS National Avalanche Center (NAC) and get some great talks from people outside of Colorado. This year we wanted the best of both worlds. We planned a hybrid event, one day online and one day in person, with the Friends of the CAIC and NAC. Unfortunately, the delta variant had other plans and we had to pivot to an all-virtual event for CSAW 2021. This was bittersweet in that we missed another year of seeing all the smiling faces, but we got a great slate of speakers and moderators. We're grateful to everyone who contributed to CSAW 2021. It was amazing to have so many great contributors from so many places.

CSAW 2021 was a two-day event attended by 1174 people from 13 countries and 29 states in the USA. There were seven sessions and a total of 19 speakers. Although it was virtual, we wanted to make it as interactive as possible. We left 10 minutes for questions after each talk and had two moderators for each season. Finding articulate moderators with expert knowledge of the topics in their session was crucial to making this successful. We can't give enough thanks to Ingrid Reiweger, professor and researcher from BOKU University in Vienna, Austria, Pascal Haegeli, lead of the Simon Fraser University Avalanche Research Program (SARP), Scott Savage, director of the Sawtooth Avalanche Center, Eeva Latosuo, professor at Alaska Pacific University, and Wendy Wagner, director of the Chugach National Forest Avalanche Center, for the amount of time they put in to preparing for and participating in CSAW.

The general theme of the first day of CSAW was emerging technologies and research in the avalanche industry. The three sessions were Avalanche Forecasting Tools, Avalanche Release, and Climate/Avalanches.

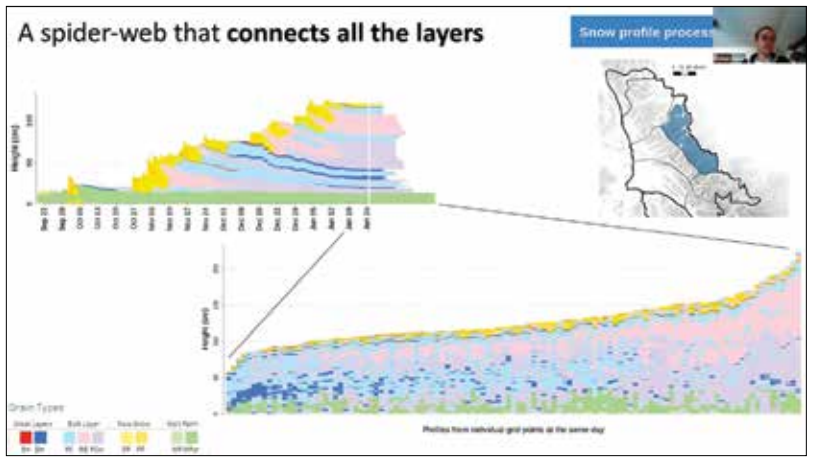
In the first session, Florian Herla, a graduate student with SARP, and Cristina Pérez-Guillén, a researcher with the WSL Institute for Snow and Avalanche Research SLF Research Unit in Davos, Switzerland, highlighted new tools to assist the avalanche forecaster. Their talks covered simulated snowpits that show a composite snowpit for large areas with very little data, and automatic danger level outputs to help check the forecast and forecaster. It will be interesting to see what these tools can provide going forward. Ben Reuter, also a researcher with the SLF in Davos, presented his research in which he used snowpack models to conduct a reanalysis of past avalanche problems. He looked at the trends of modeled avalanche problems in a location in Switzerland. He found that over a period of 60 years, from 1959 to 2019, the proportion of days per season with persistent slab avalanche problems decreased, especially after 1990. Wet snow avalanche problems increased in the proportion of days per year with an earlier seasonal onset. We rounded out the first session with a look at the effects of social media on avalanche risk by Amelie Goulet, a master's student also with SARP. Amelie looked at opportunities and challenges for forecast centers with this relatively new information pathway.

The next session featured talks from two avalanche mechanics researchers, Grégoire Bobillier, researcher with the SLF, and Johan Gaume, head of the Snow and Avalanche Simulation Laboratory at the EPFL Swiss Federal Institute of Technology, who presented their work on the new dry slab avalanche release model. The new model combines Joachim Heierli's anti-crack model and David McClung's shear model into one model covering the entire avalanche release process. It suggests that after failure initiation and initial anti-crack (collapse) propagation mode along the weak layer, the fracture mode transitions to supershear crack propagation. Both researchers used measurements of slope scale crack propagation speed to verify the new model. Interestingly, some of the speed measurement techniques are from a collaboration of work that developed from CSAW 2020.

A couple of talks related to climate capped off the first day of the workshop. First, Erich Peitzsch, research physical scientist at the U.S. Geological Survey, discussed his team's dendrochronology research in Montana in which they reconstructed a record of avalanche events back to 1867. Erich showed that prior to the 1990s, large magnitude avalanche years in Montana occurred during above-normal snow years. More recent avalanche years look to be more influenced by warmer temperatures and a shallow snowpack. The next talk, from Alexander Gershunov, research meteorologist at UC San Diego–Scripps Institution of Oceanography, looked at our future climate and modeled projections of a larger proportion of Western US winter precipitation attributed to extreme weather events such as atmospheric rivers in the future. His research also suggests that tying climate change directly to avalanche activity is complicated. Ultimately, avalanche activity in any given year is driven by the sequence of weather events through the year, and nailing down that level of detail in future projections remains elusive.

We shifted our emphasis on the second day of CSAW from promising research work to more boots-on-the-ground type talks.

Following Colorado's deadliest season of avalanches since 1993



▲ The graph screenshot is from Florian Herla's presentation *Creating regional snowpack summaries from model simulations and starting a large-scale validation project*. Co-authors were Simon Horton and Pascal Haegeli.

and the deadliest winter in the United States since World War II, a large portion of time was devoted to a recap and an analysis of these accidents. Karl Birkeland, director of the USFS National Avalanche Center, gave us a national view of last winter's accidents including thoughts on accident trends which included statistics showing the increasing age of avalanche victims. Then Spencer Logan, lead avalanche scientist at the Colorado Avalanche Information Center (CAIC), gave us a Colorado-focused accident analysis while also giving us insight into the fluid messaging campaign within the CAIC to help prevent more tragedy.

A couple of presentations from Jim Donovan, emergency manager for San Juan County, Colorado, and Trent Meisenheimer, forecaster with the Utah Avalanche Center, highlighted the difficult perspective of rescuers involved in search and rescue (SAR) and recovery efforts. Unfortunately, this is an all-too-familiar story for many in the audience. Wrapping up the SAR-focused session, Dr. Alison Sheets, emergency physician for Boulder Community Health, presented a study that shows that field estimation of core temperature is imprecise and using the patient's level of responsiveness simplifies patient assessment.

Robb Larson, professor and researcher at Montana State University, presented results of explosive overpressures from different Remote Avalanche Control Systems (RACS). This is the first comparative analysis of RACS by an independent group. Next up was Bruce Jamieson, an avalanche consultant with Snowline Associates Ltd, with a talk about operational ski cutting. It's hard to imagine a more practical talk than Jamieson's examination of operational ski cutting procedures. Is there such a thing? Should there be? Jamieson found some commonalities in procedures between many operations, but there are also many differences. Having these survey results on paper is a great resource for operations to look at what they are doing, and see if procedures set forth by other operations make sense for them.

The final session of the workshop showcased a research project on wet snow avalanches by CAIC forecaster Brandon Levy. One interesting finding was that, in Colorado, start zone characteristics are different for wet slab avalanches depending on if they were naturally occurring or artificially triggered. And reminiscent of a myth buster episode, the research group evaluated the well-known rule of thumb, "Wet slab avalanches usually occur only after three nights without a surface freeze." It turns out that this may not always be the case in Colorado.

Next, we watched a live conversation between Doug Chabot, director of the Gallatin National Forest Avalanche Center, and Riis Wilbrecht, a Dynafit athlete and experienced backcountry skier who was involved in an avalanche accident near Cooke City, Montana. Recent studies are helping us understand how users utilize the avalanche forecast. This conversation at CSAW was a live look at how a user looked at the forecast and the information that the forecaster wanted to convey.

The 20th annual CSAW closed out with the traditional Winter Weather Outlook from meteorologist Mark Miller of the National Weather Service. It is no surprise to anyone reading this article that La Niña conditions are forecast. For Colorado what this means is uncertain. Seasonal outlooks point to equal chances for average precipitation in the northern half of the state while the probability of below-average precipitation is forecast for the southern half of Colorado.

We would like to thank the talented group of speakers and moderators who really made this virtual CSAW so successful. And, while it was awesome to put on another successful virtual CSAW, we really hope we can meet again in person next year.

JASON KONIGSBERG & BRIAN ROLAND

MSUSAW


32


437


9

The 7th annual **Montana State University Snow and Avalanche Workshop** was hosted on November 4th with a small in-person audience and a much larger live-streamed audience from across Montana and beyond. The MSU SAW is completely free and serves as both a professional development opportunity to our region's numerous avalanche professionals as well as an introduction to key regional avalanche issues and tools for both student and non-student recreationalists.

This year we leaned into our capacity and our opportunity to live stream and record our in-person talks to increase access. A recording of the entire event can be found at https://www.montana.edu/outdoorrecreation/SAW.html. Dr. Jerry Johnson was our MC for the evening, and raffle prizes were generously donated by Backcountry Access and Black Diamond.

Dr. Matt Caires, Montana State University's Dean of Students, started off the evening with a welcome and a sober reminder of why his office supports the SAW event annually: because of a long history of student avalanche-related injuries and fatalities both before and during his time on campus. Dr. Caires explained how MSU has advanced snow safety initiatives as a result of these incidents and how attendees and other parents can donate to continue to support these efforts.

Our next speaker was Dr. Kaylin Green, an Associate Professor of Sociology in the department of Sociology and Anthropology at Montana State University, who shared a cutting-edge research project that sought to identify the skills and knowledge participants learned from an introductory avalanche course. Participants showed improvements in both avalanche risk assessment and assessment confidence through their participation. This study is one of the first to examine what people learn in avalanche education and whether participation is associated with beneficial or harmful outcomes. A full manuscript of the research findings is in final review and should be available in 2021.

Mike Buotte, Snow Safety Director at Big Sky Resort, drew from his 25 seasons of experience as a professional ski patroller and 29 years of skiing in Southwest Montana to provide an overview of stability considerations when storms come in at or near freezing. Mike drew from personal experience in describing how one of these storms caught him off guard and gave recommendations for hazard identification and potential hazard mitigation informed by his own experience as well as by the experiences of numerous forecasters at Northwest forecast centers and ski areas that deal with this problem more frequently.

Next up, Gallatin National Forest Avalanche Center (GNFAC) forecaster Dave Zinn interviewed Alexis Alloway, local author of the new book "Avalanche Search and Rescue: A Backcountry Field Guide." Dave and Alexis bantered back and forth about the origin story of the book and Alexis shared some backcountry safety tips from her 15+ years of experience as an avalanche educator, NOLS instructor, and SAR volunteer.

Gallatin National Forest Avalanche Center (GNFAC) forecaster Alex Marienthal took the stage next and discussed the GNFAC's website and forecast products, and then reviewed a selection of local problematic avalanche terrain and notable avalanche accidents that have occurred in the region over the years.

Our final talk of the evening was by Dr. Jesse Coil, medical director for Big Sky Ski Patrol. Coil shared some advice for his 20-year-old self related to avalanche decision-making: "unexpected things happen." Despite all our knowledge and experience, we can never control for all the variables that exist in the winter backcountry.

Thanks to the A3, the MSU Dean of Student's Office and the MSU College of Letters and Sciences for their continued support of this important event and stay safe out there!

DAN SANDBERG is the Assistant Director of the MSU Outdoor Recreation Program and member of the MSUSAW steering committee. He coordinates the avalanche safety programming for MSU and is an avy course instructor.

NRSAW

0

366

8

Presented virtually from Whitefish, Montana, our 11th **Northern Rockies Snow and Avalanche Workshop** event took place on November 11th & 13th, 2021. Over the two-day event, we hosted four sessions and eight speakers from a variety of professional and academic backgrounds. Following the event, we released the recording to our paid attendees until December 1, when we released it to the public. While participation was good, we heard about several viewing parties, which complicates getting an accurate number of participants. Regardless, the workshop's goal is to educate and thus we achieved that objective. Our topics were relevant, factual, and entertaining, and we are pleased with our lineup of speakers and how the workshop turned out. We are already brainstorming for next year and are grateful for the continued support from A3.

Topic subject-matter included:

- Debriefing last year's intense season, and learning about accident trends;
- Learning about social media as a tool for disseminating important information and how our social media habits impact our backcountry decision making;
- Tips from a physical therapist to support all the strain we put on our bodies through winter recreation; And, considerations for making your travel with partners safer.

USAW

78

6,637

39

PROSAW *and* USAW

For some time we have seen a gap in snow and avalanche workshops. ISSW is every two years and is cost-prohibitive for many avalanche professionals and ski patrollers, where the workshops tend to focus on regional topics and topics for the broader industry. We saw the need to develop a snow and avalanche workshop with professional ski patrollers as the primary audience, and we helped fill this gap with this year's **Professional Ski Patrol Snow and Avalanche Workshop** (PROSAW).

Using the same format as prior years with 15-minute presentations followed by five minutes for Q and A, we put together an eight-hour agenda featuring 16 talks and two videos. The morning focused a little more on Utah and the afternoon consisted of presentations from across the west. The themes of the day were explosives use and lessons from large avalanche cycles. Specific topics included avalanche rescue, liability considerations, and risk management. We wrapped the day up with lessons from avalanche legends.

For the **Utah Snow and Avalanche Workshop** General Sessions, we kept with the same format as last year with three hours of presentations each night for three evenings. Each session focused on a different theme, covering topics such as snowpack studies, mental health, decision-making, how we are using user surveys to improve our work, and personal stories from accidents. Sessions could be purchased individually or at a discounted rate for all three. Organizing our talks into themes allows attendees to choose the sessions that interest them most if they do not want to dedicate all three evenings.

In both the Professional and General Sessions we put a strong emphasis on storytelling. Whether it's a first-person account of an accident or a seasoned professional recounting how they managed a major avalanche cycle, we believe in the value of storytelling. Storytelling presentations continue to rank as the favorite presentations based on our survey results. Stories seem to be what we can remember best and carry with us into the backcountry every day this winter.

Because we reached 300% more people using the virtual format last year, we chose to use it again this year to reach as many people as possible. To have the highest quality presentations, we once again chose to stream live presenters instead of using traditional video conferencing. This benefits the presenter by allowing them to present to a small audience and helps limit the technical challenges of lighting, audio/video quality, screen sharing, and internet connectivity. We were excited to be able to broadcast the workshop from the UAC's new office and avalanche education center.

Whether it's a first-person account of an accident or a seasoned professional recounting how they managed a major avalanche cycle, we believe in the value of storytelling. Storytelling presentations continue to rank as the favorite presentations. Stories seem to be what we can remember best and carry with us into the backcountry.

What do we see as the future of USAW?

- We plan to put an emphasis on PROSAW to make it a quality continued educational opportunity for ski patrols and other professionals around the country.
- We will continue with the virtual format. The virtual format is necessary for the success of PROSAW. It also continues to make sense for the General Sessions as it allows us to reach the backcountry community outside of the Salt Lake City vicinity.
- We will continue to focus on finding talks that integrate storytelling and that can provide attendees with valuable learning lessons they can take away from the talk and implement in either their work or recreation toolbox.
- We will be contemplating a two-day format because General Session attendance drops off by the third night.

14th Annual USAW at a Glance

- Technology required for broadcast: Tricaster Mini 4K, 4 computers, 4 TVs, 4 monitors, 2 iPads, 3 cameras, 3 microphones, 5 studio lights, Google Fibre internet, and the hard work of 12 UAC staff members.
- 35 presentations
- 3,346 tickets sold
- 6,637 total views as of 1 week after the workshop
- 212 days of total view time (sum of all the time spent watching the workshop)

We found some interesting results in our surveys and the data was +/- 5% for all 4 sessions.

- This was the first USAW/PROSAW for 42% of attendees
- 30% of attendees were less than 40, 40% were 40-60, and 30% were over 60 years old
- General Session attendees preferred the virtual format over the PROSAW attendees.
- For 20% of General Session attendees, this will be their first year in the backcountry
- 60% of attendees watched the session live and 65% indicated they would use the recordings for reference later
- An overall indication of more personal stories from people who have been impacted by avalanche accidents

PROSAW covered two main themes.

1. Lessons learned from past generations and the Utah 2020–2021 season
2. A collective nationwide approach to how we can learn from one another

Recordings are available https://bit.ly/2021-PROSAW-Recordings

The General Session covered three main themes.

1. Evaluating snow structure while integrating both new and old technologies to determine avalanche hazards.

Recordings are available at https://bit.ly/2021-USAW-Day1-Recordings

2. Bridge, bombs, and blower: The snowpack and weather factors that led to underwhelming snowfall yet devastating avalanche conditions during the 2020–2021 season.

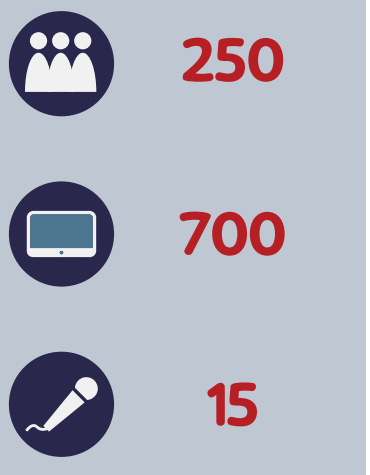
Recordings are available at https://bit.ly/2021-USAW-Day2-Recordings

3. Decision-making and human interaction with a deceptively tricky snowpack.

Recordings are available at https://bit.ly/2021-USAW-Day3-Recordings

CHAD BRACKELSBERG is the Executive Director of the nonprofit Utah Avalanche Center. He is responsible for communications, marketing, fundraising, strategy, and UAC business operations. Chad is an avid backcountry skier, ski mountaineering racer, ultrarunner, and mountain biker.

WYSAW



Over the day and a half of the 7th Annual **Wyoming Snow & Avalanche Workshop**, many speakers addressed the deadly winter of 2020–2021. For good reason, as that season saw more avalanche fatalities–37–than any other time in the modern era. But as Dr. Karl Birkeland pointed out, that number could have been higher as more people than ever ventured into the backcountry to find respite from the ongoing pandemic.

"Thirty-seven fatalities in a single season is an unimaginable loss and we certainly wish we could prevent every single fatality," said Birkeland. "That said, we had an unprecedented number of users in the backcountry and widespread instabilities. I'm incredibly proud of the whole avalanche community. Without everyone's efforts, this past year would've been a lot worse."

Held in Jackson, Wyoming, on October 22–23, WYSAW was one of the few 'SAWs' this fall to offer in-person attendance, attracting a live audience of about 250 (half the capacity of the venue at the Center for the Arts). There were another 700 registered guests online, proving that the hybrid model–despite their production challenges–continued to be a viable way of reaching a broader audience.

While the theme of risk and consequence had a prominent role, presentations covered technical advances in snow science (LiDAR and snow depth mapping), sociological behaviors and responses (human factors and stress injuries), and practical rescue lessons (a pocket guide from Alexis Alloway and a powerful case study from Teton County Search & Rescue Chief Advisor Cody Lockhart).

Do We Have an Old Guy Problem?

The youth often get lectured about the need to get educated. After last winter, older skiers should heed that same advice.

An important realization was made in the first 15 minutes of day 1, when Alloway presented a pop quiz to the audience. She asked everyone to log in to the online educational portal Kahoot, with the first three questions determining the audience members' backcountry education and experience level. Traditionally, day 1 of WYSAW has been the 'pro' day, meaning it was heavy with science and jargon intended for professionals who work in the field or have extensive experience in the backcountry. But through Alloway's quiz it became clear that more than a third of attendees (or at least those who played along with her quiz) had less than five years of experience in the backcountry; more than half had received no higher than a level one avalanche education; and 60 percent described themselves as recreational users.

Alloway even apologized for asking an advanced question in her quiz, saying she didn't realize there'd be so many rec skiers in the crowd. (Question: For a Propagation Saw Test on a weak layer buried 130 cm deep, the upslope length of the column you cut should be? Answer: 130 cm.)

A day later, during Birkeland's presentation, these demographics of the audience stuck out, at least to me. Typically, this relatively inexperienced, youthful rec group tends to get hammered on about how they need to get educated, pay better attention, and make smarter decisions. So it was good to see them so engaged at WYSAW. But considering what happened in the disastrous winter of 2020–2021, the group that might actually need a refresher are those who typically wield the hammer: Namely, men in their 40s and 50s who have years, if not decades, of experience in the backcountry. I'll go ahead and raise my hand as among them.

As Birkeland pointed out, backcountry use exploded during the pandemic: sales of backcountry skis were up 140 percent; web traffic for

avalanche sites was up 90 percent or higher; the Bozeman-based Gallatin Avalanche Center saw its web traffic spike to 1.2 million views; meanwhile, the Utah Avalanche Center had to double its capacity to handle the surge of online traffic.

The bottom line, he said, was that backcountry use had increased by 50-100 percent in many areas in just a single year. At the same time, the snowpack had an increased hazard due to persistent weak layers. It was a recipe for disaster.

But it wasn't the noobs who were most often getting avalanched. Of those 37 tragic avalanche deaths, the median age was 44. In the previous 10 years, the median age for avalanche victims was 34, representing a significant shift in demographics. Of course, one year doesn't necessarily make for concrete trends, but it's certainly a reminder of why it's so important for everyone, no matter their experience, to continue their avalanche education—be it any of the SAWs or go back and take your level one.

Birkeland said the conclusion was that some avalanche victims had a tendency to underestimate the terrain given the unusual snowpack.

An hour later, Sawtooth Avalanche Center forecaster and guide Chris Lundy took the stage and argued in his presentation that backcountry users are taking too much risk. As each generation stands on the shoulders of those who came before them, he said, they expand on what's possible in riskier terrain. The result is risk creep: "An insidious and unrecognized increase in risk that occurs despite our every effort to mitigate risk or avoid it altogether," Lundy offered as a definition. "Whether we recognize it or not," he continued, "we're probably taking more risk in the backcountry than we were 10-20-30 years ago, and it's happening slowly and not noticeably."

He said one solution is to approach each ski tour with a simple assessment: It's got to be either "Hell yes, or no way." Another way forward, he said, is to embrace low-angle, safe terrain, or what he called OGP: Old Guy/Gal Powder. But if there's a group that needs to hear that message, maybe it's the old guys themselves.

MATT HANSEN has been writing about skiing for more than 20 years, 16 as an editor for *Powder* magazine. He is the director of communications for the Teton County Search & Rescue Foundation.

ERRATA...

The photo caption in Mt. Shasta's season summary in 40.2 is incorrect. Here are both photos with the correct captions.

▲ The crown of the fatality avalanche near Etna, California. This was the first fatality avalanche in the county since the late 80s. NICK MEYERS

◂ The Mt Shasta winter was characterized by a hell of a lot of wind, primarily out of the northwest. The wind relentlessly scoured above treeline terrain over the winter. Paired with less than half of normal wet season precipitation, this left very poor spring skiing and climbing conditions on the mountain. JASON KOSTER

The KPAC season summary was omitted from TAR 40.1 and 40.2. Here it is in its entirety; The Avalanche Review *regrets the error.*

KPAC

Winter Weather & Avalanches

It was a strange winter for Kachina Peaks Avalanche Center, not just the dark cloud of the pandemic, but also the weather. In a nutshell, winter precipitation could be summed up as two big back-to-back storms in late January and the wet month of March; otherwise, prolonged drought characterized our La Niña winter.

October, November, December, and most of January were dry and warm. Snowfall was sporadic, mostly melting, evaporating, or sublimating before a snowpack could form. By late January all but the protected north-facing gullies above 11,000 feet were bare down to talus. Even on slopes where snow lingered, coverage was shallow and littered with hazardous obstacles. Avalanches were not a concern, but safe snow travel certainly was. As the calendar year changed, the National Weather Service reported 2020 as the driest year on record for Flagstaff, Arizona.

Thankfully, the drought abruptly ended January 20-26 as twin storms delivered 72 inches at 10,800 feet. Baseless and free of reactive weak layers, no natural avalanches were reported. Avalanche activity consisted of isolated storm and wind slabs triggered by explosives and ski cuts above treeline by the Arizona Snowbowl Ski Patrol.

In February, La Niña drought locked in again sending storms to our north, with only a single notable event during the entire month. As we prepared to write off the winter altogether, March was our savior. Dubbed Magic March, moisture picked up with frequent modest storms throughout the month. A slow-moving low-pressure system, March 11–14 provided another 42 inches, bringing our March snowfall total to 89 inches.

Despite some evidence of near surface facets on northern aspects and significant wind transport, only a handful of avalanches were reported. Stability was no doubt enhanced by strong storm and post storm winds (50-70 mph) which scoured much of our above treeline terrain, sending what could have become dangerous wind slabs back into the atmosphere. The few natural and skier-triggered slab avalanches that were observed were the only ones of the season.

By winter's end, capped by an additional foot in late April, we ended up recording 227 inches of snowfall at our 10,800 feet study plot. This amounted to 87% of the historical average of 260 inches/winter, and 99% of the recently recalibrated 30 year average of 229 inches/winter. In hindsight, not bad for a La Niña winter.

Avalanche Education

Direct public outreach this winter was limited by unfavorable backcountry snow conditions and the pandemic precautions. Registration numbers for Level 1 courses were strong, though regretfully we canceled more than half of those scheduled due to insufficient snow cover or an inadequate instructor pool.

Three level 1 courses were conducted for 24 participants, offering 20 partial scholarships, only six of which were actually used. In response to the pandemic, we modified our level 1 courses by replacing our customary classroom component with 6 hours of online instruction via a collaboration with American Avalanche Institute's excellent virtual instruction models. These were combined with two days of face-to-face fieldwork in very small groups using masks and distancing protocols. All considered, the combination provided high quality educational experiences for avalanche course participants.

Our traditional free Introduction to Avalanches workshops were confined to one event at a local sporting goods store. For this, the number of participants was limited to 15, and we added a virtual component.

Our weekly website based snowpack summaries and condition updates were our primary contacts with the general public. We published 21 Friday summaries, starting on November 20 and ending on April 9, and three additional condition updates. We received some attention in the aftermath of the big late January storm, when we were featured in several media releases including a spot on KNAU, the Flagstaff NPR affiliate, Fox News, and other local publications.

Website Activity

As one might expect, given the delayed start of winter, website activity was as erratic and variable as the backcountry conditions. We recorded unique visitor peaks during last January and mid-March corresponding with big storm cycles.

Overall, unique visitors to the website were up 3% from last winter to 6415, but lower than our snowy 2018–19 winter season. Use of our snowpack summaries, also based on unique visits, increased by 7% to 4302, but also reflected a minor drop from two years ago.

Fundraising and support

As true with other avalanche centers, our customary live fundraisers were curtailed by the pandemic. KPAC was fortunate to receive generous financial support from the Flagstaff Community Foundation, Arizona Snowbowl, and local outdoor retailers who sponsored our weekly snowpack summaries and allowed us to continue operations during this challenging winter. KPAC continues to have exceptional relations with the winter sports community of northern Arizona, which is a source of pride.

The 2020–2021 winter was our 16th year of operation. This challenging year has tested our resiliency and adaptability, and by doing so, provided confidence for future sustainability. In June 2020, KPAC received the US Forest Service's 2019 Citizens Stewardship and Partners Award. For this we are thankful and honored.

—David Lovejoy

Late season conditions and spring evening light. DERIK SPICE

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MONTY'S MOM

BY PHYLLIS MANDEL & TOM KIMBROUGH

I have a friend, an excellent knitter, with whom I often ski at Alta. This fall she invited me to an exhibit of textile art where a couple of pieces of hers were being shown. Walking in I noticed the sign on the door: The Mary Meigs Atwater Weaver's Guild. Atwater? Any relation to Monty? A bit of research followed. Yes, Mary was Monty's mother!

Now some of you younger readers of TAR may not know the name Monty Atwater, but for those of us who cut our avalanche teeth in the 1960s and 70s, Monty, along with Ed LaChapelle, were revered deities. They were the founders. They started all of what absorbed us. Monty was the first in the U.S. to use explosives and artillery in avalanche mitigation. Monty was the first in the U.S. to study avalanches from a scientific basis.

I am proud to say that I even had a personal connection to Monty. Atwater moved from Alta to Squaw Valley in 1956 to prepare the avalanche control program for the 1960 Winter Olympics. His protege and right-hand man was Norm Wilson. In 1967 I was hired as a ski patroller at Alpine Meadows where Norm was mountain manager and head of snow safety. Thus Monty's protege was my mentor. I even met the great man a few times when he visited Norm at Alpine.

What I have known about Atwater mostly comes from his book, *The Avalanche Hunters*, published in 1968. I knew a few other bits of his biography. He graduated from Harvard. He was a writer of adventure books for boys. He fell in love with "A Girl from Chicago." That was about the extent of my knowledge outside of his avalanche research.

I enlisted Phyllis Mandel, my Alta skiing friend, to do the research into Mary Meigs Atwater and she quickly hit the jackpot. Mary Meigs is far more famous than Monty. Mary and her family lived an adventurous life in Chicago, Paris, Bolivia, Mexico, Guatemala, Montana and other places around the mountain west, their travels driven by Max Atwater's work as a mining engineer. There is a biography of her, *A Weaving Life*, by Reiter and Patterson. Mary is considered the grand dame of American weaving. She researched and preserved forgotten patterns and restored weaving in America as an artistic endeavor. She started occupational therapy programs for war veterans using weaving skills. In her spare time, she wrote and published several mystery novels.

Monty with an early avalauncher. COURTESY OF JOHN BRENNAN

Monty Atwater and Jerry Nunn, his traveling avalauncher sales expert, examine an early avalauncher. For more on Jerry Nunn's life and career, see TAR 25.3. COURTESY OF JOHN BRENNAN

Mary's biography fills in tantalizing bits of Monty's history. Monty was born in 1904. His father, Max, died in 1919 of the "flu," perhaps a victim of the 1919 pandemic. Monty graduated from Harvard in 1926. Two years later he started a beaver ranch with Mary in northern Montana, which later became something of a dude ranch. During the Second World War Monty served in the 10th Mountain Division, first as a ski instructor at Camp Hale in Colorado then, as a Captain, he fought in the Aleutians and the Battle of the Bulge. He moved to Alta in 1945 at the suggestion of Sverre Engen, a fellow 10th Mountain Division veteran, to become the snow ranger for the Wasatch—Cache National Forest. There he managed public safety in Little Cottonwood Canyon. Over the next 20 years Monty established the first avalanche research center in the Western Hemisphere, where he invented many of the techniques and equipment used for avalanche forecasting and mitigation.

Monty's affair with "The Girl from Chicago" led to a divorce, his second, and a break with his mother. They did not have time to repair the break. Mary died in September 1956, perhaps as Monty was moving to California.

Mary lived her last ten years in a log cabin in Sandy, Utah, that Monty and Sverre Engen built for her. Apparently this cabin still exists and is now a bed and breakfast. I am tempted to book a stay there although the fee is a little out of my price range: https://www.engenhusutah.com/themed-bed-and-breakfast-utah.

If any readers of TAR don't know of Monty and Ed, I hope they will locate a copy of *The Avalanche Hunters* and travel with them back into history. Even more, my wish is that some young avalanche hunter will be inspired to write Monty Atwater's biography. His mother has one; so should he.

PHYLLIS MANDEL is a retired physician who is as passionate about fiber arts, including knitting and weaving, as she is about skiing.

TOM KIMBROUGH is one of the few surviving members of the early Avalanche Hunters, Kimbrough is hoping that his future rest home will have a bus to take him to the climbing gym and skiing at Alta.

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