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the **AVALANCHE**

PAST LESSONS, PRESENT CHANGES, FUTURE PROGRESS

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.

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## the AVALANCHE REVIEW

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#### ON THE COVER

##### HATCHER PASS AVALANCHE CENTER:

Valentine's Cycle from February 14–18, 2022, with 50 inches of new snow and eight inches SWE. Punk Spines meets Marmot 2. For more details see the Hatcher Pass season summary on page 36.

■ ALLIE BARKER



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# FROM THE EDITOR

**FAC:** Looking up the bed surface of a small avalanche triggered on Mt. Brown in Glacier National Park. The rider escaped to the looker's left. ■ ZACH ARMSTRONG



**N**ovember already, how did that happen? By the time you're reading this, it'll be December. Goes faster every year but it seems that the snow arrives later and later, although I've been skiing deep powder on a meter base before Thanksgiving in the Tetons this year!

I hope you got to attend a SAW this autumn, either in person or remotely. I always attend WYSAW (as the MC) but this year was able to pop into the 4 Corners SAW in Silverton and the Utah ProSAW because nothing compares to being there in person. I missed you folks. I value my interactions with you all, whether I ran into you on top of a remote Alaskan peak, bought bindings from you, or shared a beer post-SAW. Remote attendance is

a Covid relic that I am pleased has stuck around. You can absorb talks and questions on a drop-in basis, but you miss the energy inside and the interplay outside the auditorium. On that note, I am excited to see publicity and specifics for ISSW 2023 in Bend. Register early as there will be high demand.

In this issue you'll find a stack of important news from A3: election results, farewells to finishing Board Trustees, and updates on two important publications, SWAG and the latest *Snowy Torrents*. Welcome to new or returning trustees and thank you so much for your service to Halsted Morris, Eeva Latosu, and Jonathan Shefftz (see next TAR for his profile).

Also in this TAR, under the decision-making and human factors header, we have a second installment in her public health series from Kelly McNeil in addition to results from a survey about backcountry skiing during Covid presented by David Fiore. In the snow science department, you'll see an important story from Robb Larson about his research into RACS effectiveness and some guidelines for categorizing terrain from Mark Staples of the UAC.

Under the Crown Profiles tab, we have an astonishing story from Todd Richards of his experience in a huge avalanche outside Telluride in 1989. It's riveting and horrifying at the same time; his lessons are vivid even 33 years later. Then this issue finishes with the remainder of last season's summaries, once again I remind you of the importance of reading these critically. Patterns recognized after the fact bring useful learning for the present as well.

—LYNNE WOLFE

## AVALANCHE ENCYCLOPEDIA UPDATE

The National Avalanche Center and the American Avalanche Association are excited to announce an updated version of the Avalanche Encyclopedia hosted on [avalanche.org](http://avalanche.org). The new Encyclopedia includes an expanded glossary of over 400 avalanche-related terms, new and updated text descriptions, and extensive use of photos, videos, and diagrams to supplement the reading material. The work was authored by Zach Guy with revisions and contributions from Ethan Davis, Karl Birkeland, and Simon Trautman. Graphic design and web development are from Jen Reddy and Chris Lundy, respectively.







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# FROM THE EXECUTIVE DIRECTOR

## PRESENT CHANGES

One of the most rewarding elements of my job is the opportunity to connect with A3 members at regional Snow and Avalanche Workshops (SAWs) each fall. It's no small feat to fill nearly every week/weekend from October 8th through November 12th with travel across the western half of the country, but it is absolutely worth it.

This SAW season in particular has been especially meaningful because it provided the first chance for many of us to gather again in person. I want to thank each hosting committee for putting together such impactful programing for avalanche professionals and rec users alike. There are too many highlights to name, but if you've been following A3 social media, you'll have seen a glimpse at some of the memorable moments! Barring any unforeseen circumstances (I'm writing this with three workshops left to go) this SAW season, I will have traveled more than 2,170 miles via automobile, crossed four state lines in a pickup truck, flown through four different airports, and witnessed Karl Birkeland present six times (just kidding about that last one!). In all seriousness, if our paths crossed at a SAW this year, please know that I valued that connection. With so many members spread out so far across the US, it's moments like these that keep our team connected. If I missed your regional SAW this year, you are on the top of my radar for fall 2023!

Speaking of connections, as you'll see in the following pages, we are honoring several board members who are stepping down from their A3 board service this year. Halsted and Eeva, thank you for your connection and dedication to A3. Together, you represent decades of commitment to this cause, bettering the avalanche industry and A3 specifically in countless ways. I also want to acknowledge and thank Jonathan Shefftz who will be rolling off of the A3 board after 10+ years of service. Jonathan's time with A3 will be honored in the next issue of TAR.

Finally, I want to welcome the NEW board members who were elected by the membership this October. These folks will officially begin their two-year board terms on January 1, 2023. I hope you will join me in welcoming the following new and returning individuals to the board!

As always, I am honored to work on behalf of the A3 membership and to be a part of such a special community of people.

See you out there,  
—JTN

## NEW AND RETURNING BOARD MEMBERS

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## Thanks to retiring A3 Board President Halsted Morris

BY DAN KAVENEY

After serving two terms as President of the American Avalanche Association, Halsted “Hacksaw” Morris will be stepping down this coming January 1. Thanks to Halsted’s many accomplishments, incoming president Scotty Savage will take the helm of an organization standing firmly on a solid financial foundation, expanding and solidifying its services and benefits to members, and moving decidedly toward an even brighter future. Halsted likes to keep a low profile, and his quiet approach to the presidency has sometimes meant he hasn’t enjoyed widespread recognition for his many achievements. It is my hope that this article will ruin his efforts to lurk quietly in the shadows.

Halsted has a long history of service to A3. He took up board membership in 1988 when Knox Williams, President at the time, appointed him as the Affiliate Rep. Later, after earning Professional Membership, he moved on to serve as Awards Chair (a role that he will retain), Vice President (two terms), and President (two terms). His professional avalanche career includes stints at Loveland Pass, CAIC, Ortovox, and Friends of Berthoud Pass.

When Hacksaw assumed the presidency A3 was going through some difficult times. We had recently completed the enormous, critically important task of creating the Pro Training Program, and the effort left the organization struggling. A3 members valued the Pro Training Program highly, and the formidable job of making it sustainable loomed large before us. Halsted recognized that shoring up our shaky finances needed to be our priority, but our recent focus on Pro Training had also left us behind in other key venues such as corporate fundraising, new member recruitment, outreach (digital communications, social media, online publishing), organizational management (strategic planning, accounting practices, working more effectively with our partner organizations), and becoming a more inclusive organization. There was much to do!

Since that time Halsted has worked with the membership as well as two boards, two Executive Directors (myself and Jayne Thompson Nolan), and a dedicated group of staffers, volunteers, and partners to help bring about remarkable improvements to A3. Halsted always stayed focused on our basic mission, and simultaneously recognized that to achieve our mission and remain healthy we needed to grow and evolve. As he vacates the Presidency, Halsted leaves all of us with a dramatically improved organization. It’s hard to list just a “few” key accomplishments, but consider the following things achieved during his two terms:

- Greatly improved finances.
- Introduction of a robust digital outreach program, including a digital version of *The Avalanche Review*, an active social media program, and an online seminar series.
- Expansion of both SAW grants and research grants.
- Improved partnership with the USFS National Avalanche Center that has supported expansion and improvement of [avalanche.org](http://avalanche.org).
- Introduction of a new scholarship program for professional training, with an eye toward supporting women and underserved populations.
- Launch of new Resiliency Program grants to support mental health services for avalanche professionals.
- Meaningful—and well-deserved—pay increases for A3 staff as well as the introduction of staff retirement benefits.
- Completion of a robust strategic plan.
- Substantial increases in membership.
- Sizeable increases in charitable giving and corporate sponsorship.
- Significant improvements to the Pro Training Program that have put it on a clear path toward long-term sustainability.
- Strong focus on building a more inclusive organization.

The entire membership, staff, and board have worked together since 1986 to make A3 the terrific organization it is today. Through his leadership, Halsted Morris has written a chapter in that history with his understated presence, humility, and dogged resolve to serve the avalanche community. On behalf of all of us, my friend, thank you. ●

**DAN KAVENEY** was Executive Director of the American Avalanche Association from 2018—2021. He currently serves as A3’s Board Treasurer.



## Thanks Eeva for your service on the A3 Board

BY KATE KOONS

As Eeva Latusuo steps off the Board this fall, I have the honor of writing a farewell, thanking her for her years of service. I’m not much of a writer but I sure am a fan of Eeva. As soon as I committed to writing this piece, I got nervous thinking about how in the world I could possibly honor my friend and colleague, so I enlisted people in the greater avalanche community to confirm what we already know: Eeva is a boss.



Don Sharaf responded almost immediately to my email and had this to say, “What’s it like working with Eeva? It’s humbling—she’s consistently more organized, more fit, more energetic, and happier than everyone around her. Eeva is always searching for more information and answers to difficult, if not unanswerable questions. Grad school is a good fit for her insatiable appetite to learn more, hopefully it doesn’t cut into her skiing too much.”

Eeva Makela, ACMG Ski Guide from Finland, has known Eeva for 30 years. They attended their NOLS instructor course together almost 30 years ago and have had countless adventures in the mountains and teaching through the years. Eeva M. shared this story. “In the late 90s we did a ski mountaineering race together with one other woman. We were definitely not the fastest team on uphill sections since there were also many world-class cross-country ski athletes in the race as well, so these fast male teams always passed us on uphill sections. Their well-trained spandex butts kept us motivated when following up the skin tracks. We got a good laugh out of it and wondered if we should take the race more seriously. On downhill sections we sure enjoyed every turn and dusted some of the teams only to be motivated on the next uphill section again. Any trip or expedition with Eeva is always guaranteed to be fun and have lots of laughter.”

Emma Walker, AIARE curriculum manager and former student of Eeva’s at APU, says: “Eeva’s mentorship has been so formative to me both professionally and as a human, it’s tough to distill her impact into a sentence or two. What I can say is that I’m so grateful for her patient mentorship and friendship, both of which have encouraged me to stick it out even when things get tough. We are all so lucky to have Eeva in our lives!”

Brooke Edwards, avalanche educator and ski guide, says: “Eeva is the quintessential mentor, showing up for others with passionate engagement as she challenges people to rise up into who they were meant to become. It has always been an honor and a treasure to both be mentored by her as well as work side by side as colleagues in the avalanche education realm.”

The avalanche industry is better because Eeva is a part of it. As Don said, she is immensely curious, always organized, serious when she needs to be and ready to flash that amazing smile and giggle at just the right time. Her professionalism is unparalleled and the way she makes avalanche education accessible to all is something we can all learn from.

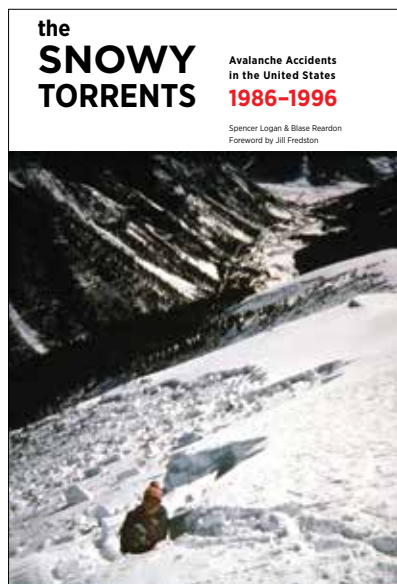
Eeva started her PhD this fall at Simon Fraser University, and we are thrilled to know that she will continue to be a part of the avalanche community. We look forward to continuing to learn from you Eeva. Thank you for your energy and excellence on the A3 board. ●

**KATE KOONS** lives in Victor, Idaho where she manages risk, skis powder, and keeps track of two excitable spaniels. She serves as A3’s At-Large Pro Trustee.





# WHAT WE CAN LEARN FROM 55 YEARS OF THE SNOWY TORRENTS



BY EMMA WALKER

[PURCHASE THE SNOWY TORRENTS HERE!](#)

## PAST LESSONS

*The Snowy Torrents* is not exactly light reading. I mean this figuratively, of course—the sixth volume, published this fall, chronicles the worst days of a couple hundred people's lives—and also liter-

ally, because it tips the scales at a little over 400 pages. Despite that I cannot in good conscience recommend it over, say, an affable Louis L'Amour novel for your next beach vacation, I believe it continues to be a valuable resource for practitioners and recreationists alike.

This edition covers avalanche accidents that took place between 1986 and 1996, and it has been in the works for a very long time. I guess you could say it's been in progress, in one form or another, since its chronological predecessor was published in 1996. To understand why this volume has been in progress for so long, we need to venture into the depths of the project's history.

The first-ever volume of *The Snowy Torrents*, authored by the trailblazing US Forest Service snow ranger Dale Gallagher, was published in 1967 and covered accidents between 1910 and 1966. Knox Williams wrote a second volume (covering accidents between 1967 and 1971) in 1975; eight years later, he would go on to found the CAIC. Next, Knox joined forces with Betsy Armstrong—prolific researcher and protégé of snow science pioneer Ed LaChapelle—to co-author a third volume (1972–1979), published in 1984. It would be twelve years before Nick Logan and Dale Atkins' fourth volume (1980–1986), was released, and another twenty years after that before Knox reemerged to co-author the volume covering 1996–2004 with Spencer Logan.

No history of the *Snowy Torrents* project would be complete without Dale. An inventive writer and apt observer of the human condition, Dale is a seminal figure in our community's tradition of analyzing and debriefing accidents. His philosophy on accident analysis—"Only when we can identify and share the why-it-made-sense reasoning will there be a real opportunity to prevent future accidents," he writes on his website—has not only shaped the character of the *Snowy Torrents* series, it has rippled into the broader discussion of accident analysis and prevention in the outdoors.

The A3 and the Colorado Avalanche Information Center began a joint effort to get this volume rolling in the spring of 2017. But the challenge with collections like *The Snowy Torrents* is that this star-studded list of authors is, by nature, difficult to pin down. In their professional lives, they are forecasters, patrollers, educators, guides, writers, community members. On their days off, they are partners, parents, children, friends, and, as I have occasionally been reminded as I edited this volume, skiers who would like very much to turn off their phones and ignore their inboxes and make some nice powder turns.

It is no small undertaking to spend hundreds of hours conducting interviews with survivors and investigators, diligently scrutinizing countless primary sources, and digging up painful, long-dormant memories. And it's not like the authors are raking in the dough from the proceeds of this publication; they do it because this information is a vital contribution to our community. This is what *Snowy Torrents* authors have been doing since 1967. That's why it's taken so long.

Which brings us to the present. This volume is a collaboration between A3 and the CAIC, who enlisted Blase Reardon and Spencer Logan, respectively, to analyze and summarize a decade of accidents and near-misses. The team has also sophisticated our use of callouts for this edition; now you can flip through the book and see common accident factors highlighted in the margins, then dive into the text at approximately that point to learn more about the specifics. It's a beast of an undertaking, and there's been no shortage of

events over the last five-plus years (ranging from research roadblocks and career changes to the onset of a global pandemic) that threatened to sink the whole enterprise. It's taken some tenacity to get this volume into your hands.

The final product, I believe, is worth the wait. It's bound by an empathetic approach that's at times demanding to wrap your head around; when you read about the same fatal mistakes over and over again, it can be difficult not to despair, a feeling Jill Fredston alludes to in her eloquent foreword. But as Spencer and Blase have made clear in this volume, each of the people described in this book was just that: human. They, too, were partners, parents, children, and friends. They were skiers and sledders, or kids playing in the snow, or climbers pushing their limits. They had aspirations, and they also had off days. Unfortunately, those off days are what fill this book—with the hope that readers can learn from those mistakes and avoid them.

There is some darkness in these pages, for sure, but *The Snowy Torrents* isn't all doom and gloom. There are some relatively happy endings described in this volume (including one of my personal favorites, the first live subject on record to be found by an avalanche dog). These lessons learned by those who almost didn't get away with it are the stories that give me hope.

They remind me that there is some joy punctuating even the most difficult moments: the joy of dropping into fresh powder on a crisp winter morning, of pausing in the skintrack and hearing absolutely nothing, of clinking cold glasses with friends after a day well spent. Often, the folks described in this volume lived those moments just seconds before their lives were cut short. With that in mind, I have two things to ask of readers:

First, remember that what's contained in the pages of *The Snowy Torrents* is only as accurate as its sources. The nature of this project means that decades have passed since each of these accidents took place, and sometimes primary sources' memories (and sometimes original coverage) differ or are understandably hazy. I tell you this to ask for some grace, but also to remind you that we all have the power to become excellent sources. Report your observations and your close calls to your local avalanche center. Your near-miss could be the story that makes it all click for someone else.

Second, and most importantly, I encourage you to place yourself in the scenes Spencer and Blase have written about. Internalize them. Think back to them on your next tour. Let them give you a reason to make the boring, conservative decision; let them remind you that there will be more bluebird days. With a little more thinking like this, we can put the authors of *The Snowy Torrents* out of business for good. They'll be grateful to have more time to ski. ●



Authors Spencer Logan and Blase Reardon with A3 ED Jayne Nolan at WYSAW.

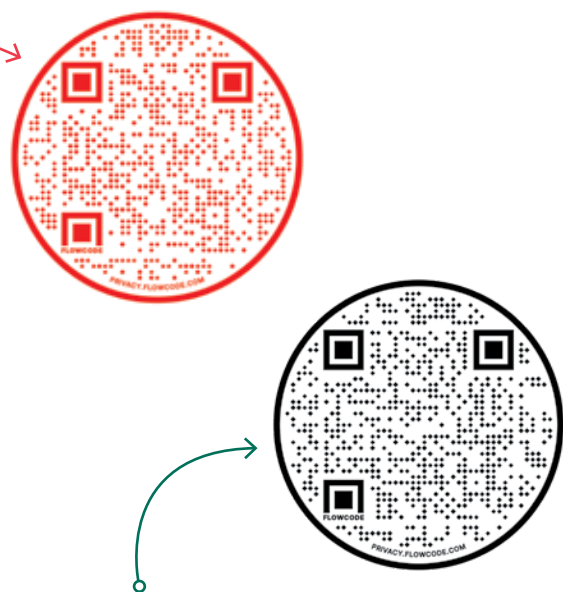


EMMA WALKER holds an MS degree in outdoor and environmental education from Alaska Pacific University. She is the author of *Dead Reckoning: Learning from Accidents in the Outdoors*, has edited two volumes of *The Snowy Torrents*, and works as AIARE's Curriculum Manager.



# THE 4TH EDITION OF SNOW, WEATHER, AND AVALANCHES: Observation Guidelines for Avalanche Programs in the United States

BY ETHAN GREENE



ORDER SWAG HERE!



Front Cover: An avalanche crown on Chair Peak, Washington.  
 ■ BRYCE HILL

The American Avalanche Association (A3), in cooperation with the USFS National Avalanche School (NAS), published the 4th edition of *Snow, Weather, and Avalanches: Observation Guidelines for Avalanche Programs in the United States* (SWAG) in October of 2022. To create the 4th edition, A3's *Committee on Observation Standards* (Karl Birkeland, Kelly Elder, Ian McCammon, Mark Staples, Don Sharaf, Simon Trautman, Wendy Wagner, and myself as committee chair) began reviewing the 3rd edition, collecting suggested updates and additions from professional training course providers, and reaching out to colleagues in other disciplines and in other parts of the world in the spring of 2022. This work produced a list of potential revisions. The committee met several times during the summer of 2022 to select revisions and updates. Revisions were complete by September and we worked with Jayne Nolan, Emma Walker, and McKenzie Long to create the 4th edition of SWAG, which is now available on A3's website.

Most of the changes to SWAG for the 4th edition fall into the following categories:

- Minor text updates or clarifications
- Correction of typos or inconsistencies with other industry documents or international standards
- Updated material from other sources
- Updated references
- Updated figures and tables
- New images

Significant additions and updates for the 4th edition of SWAG include:

- Section 2.7 Column and Block Tests
  - Improved consistency between test sections
  - Incorporated research results into test sections

- Section 2.7.7—Propagation Saw Test
  - Removed the requirement of layer location and date in the coding
  - Added coding for when no fracture occurs
- Section 3.6.4 Avalanche Trigger
  - Added AN for Motorized Snow Bike
  - Amended AW to Wild or Domesticated Animal
  - Amended AP to Pre-placed, on or in the snow, remotely detonated explosive charge
- Section 3.6.5.2 Avalanche Size—Relative to Path
  - Clarified how to use the scale to maintain consistency with the Westwide Avalanche Network dataset
    - R-size is not a measure of the start zone proportion that releases
  - R-size is the relative size of an avalanche compared to the size of all avalanches that particular path could produce
  - R-size is a holistic measure considering everything that contributes to the size of the avalanche, including the depth and width of the slab, the distance from the crown to the stachwall, and the amount of snow entrained in the track
- Section 3.6.11—Avalanche Runout
  - Improved description of runout angle and alpha angle
  - Added equation to calculate runout angle from avalanche dimensions
- Section G.5—North American Public Avalanche Danger Scale
  - Included updated graphics and definitions
  - Clarified that hazard and danger are often used interchangeably with respect to avalanches but have different means in the broader risk communication community
- Section G.7—Conceptual Model of Avalanche Hazard
  - Include material for reference
    - Spatial Distribution
    - Sensitivity to Triggers
    - Likelihood of avalanches
    - Avalanche Problem Types
    - Avalanche Problem Type—Physical Characteristics
    - Avalanche Problem Type—Typical Risk Mitigation

Although the 4th edition of SWAG is complete, work on the evolution of the document is ongoing. We hope to set a regular interval to publish future editions of SWAG. During this review process we identified opportunities to improve the document that would involve larger rewrites, even without major changes to specific observations. Eventually, we would like the document to be as usable in the field as in the office. We envision many opportunities for multimedia components and ways to integrate the material into professional training programs. Although it is important to make changes to standard observations and long-term data records slowly, there are always ways to improve how we collect data for our operations and the research community. Hopefully, SWAG will continue to be a valued resource for avalanche workers as our industry evolves and our work environments become more complex. ●

ETHAN GREENE is the Director of the Colorado Avalanche Information Center and Chair of the American Avalanche Association's Committee on Observation Standards.



# IN MEMORIAM:

## KAREN SAHN



TRACY MARTIN

BY ALISON OSIUS

This story first appeared in Climbing Magazine August 23, 2022, and is reproduced by permission.

### KAREN SAHN (1969–2022), LONGTIME CLIMBER AND GUIDE, REMEMBERED IN ASPEN

Core climber, ski patroller, and backcountry skier, she struggled with an illness that besets too many.

Karen Sahn was a great athlete with the soul of an artist. She made jewelry with beads and turquoise and sold it or gave it away; she painted flowers and made cards. Sahn was also a Division 1 collegiate runner; multiple winner of the brutal Aspen, Colorado, uphill ski race called the Inferno; an early woman ski patroller and snow-safety expert; and a committed climber and guide. She did Denali and she did 5.11–5.12 sport routes. On August 18 well over 100 people from the ski, guiding, and climbing communities gathered at the base of Aspen Highlands ski area on a rare beautiful evening amid weeks of a welcome monsoon, and remembered a kind and gentle person who also knew how to rock and roll. Sahn died May 21 at age 53.

Many women wore her jewelry in tribute. Cari Kaplan, dear friend on the Snowmass Ski Patrol starting in 1997, says, “Because her friends are all mountain women and didn’t have much jewelry, we’d wear it all the time and break it. She’d laugh and say, ‘Bring it over, I’ll fix it.’”

Sahn was described in loving and often hilarious remembrances by her mother, Gene Marsh, who cared for her in her final period, achieving great closeness; sister, Stacey Sahn Petersen; niece and nephew; aunt; two stepsisters (whom Karen had dubbed sisters, “stomping out the step”); a phys-ed teacher; and many friends. One climbing friend flew in from Ottawa, and three close college friends, “the Carolina girls,” came from the Southeast to honor their “Sahnny.”

Karen was an exceedingly involved aunt to Stacey’s daughter and two sons, present for

birthdays, school events, and track meets, and taking them outdoors.

“Every February she took us out of school to come ski, and all January I looked forward to it,” her nephew Turner said. She taught the children about backcountry skiing and safety as well as resort skiing.

Amos Whiting, who worked with Sahn for a decade at Aspen Expeditions, described what a solid presence she was in the mountains, and how in the backcountry and in climbing, “She always had your back.” Whiting last year, with Karen’s permission, named a new route in Independence Pass after her and her long battle with illness, calling it *K-Fight* (5.11).

People spoke feelingly of the chronic eating disorder from which Karen suffered. As an excellent family obituary from the *Aspen Times* states, “She struggled for years with an eating disorder and hoped that others with similar illnesses would be open about their conditions, seek early treatment and return their lives to normal.” With the help of her family, she entered recovery programs, and about a year ago posted videos on Facebook to raise awareness and try to help others.

A ski patroller for nearly 20 years, she started at Snowmass and advanced in the ranks of snow science at Aspen Highlands as a snow safety technician. Yet at a certain point she was not able to wear ski boots anymore, due to bone spurs, and transitioned into rock climbing and guiding more.

*Editor’s note: Karen wrote about bootpacking in the Continental climate for TAR 29.4, based on her experiences at Aspen Highlands. Her enthusiasm and curiosity for her topic were unmatched; she was a joy to correspond with.*

Sahn worked many summers with Aspen Expeditions, and five years ago wintered to teach climbing in Cayman Brac. Aside from Denali, she skied the Haute Route and climbed Mont Blanc and Island Peak in Nepal. Much of her climbing was in Aspen, where she grew up aside from three years in Tucson, but she was a regular in Indian Creek, Utah, and Rifle, Colorado, and in later years spent happy and productive seasons with a new community in Las Vegas.

Karen was known as fun: She loved to dress up, in colorful, flowy clothes, and had her own style, such as sneakers with sparkles. She loved music, from techno to Widespread Panic (she and Kaplan went to several shows), reading (fiction), and dancing, hence her nickname of “Shaka” for Karen Sahn/Chaka Khan. Some dancing happened to occur on tables.

When Sahn entered hospice care last year, many climbers and patrollers visited her in Salida, at the home of her mother, Gene Marsh, an R.N., PhD.

When the illness reached a terminus, and Karen asked a doctor how much time she had, the reply was about Labor Day last year. By strength of will she made it nearly to Memorial Day 2022.

“I’m thankful for every day,” she texted her close friend Tracy Martin in Las Vegas.

I was among the many who visited Karen in Salida, where she always turned the conversation around to ask friends and visitors about *their* lives. I asked what she still enjoyed, and she said she loved her coffee every morning, being outdoors, seeing flowers and connecting with people. She, her mother, and friends sometimes went off camping while she was still able.

Karen had dearly loved climbing. “I miss it,” she said, “but I don’t miss being hard on myself about it.” I have known many women and a few men who have suffered from anorexia or disordered eating, and climbers are vulnerable, because it is considered a strength-to-weight-ratio sport and its difficulty is measured in numbers and letters. Climbing is an intense sport and can become obsessive.



ANDREA CUTTER

Most of those I have known with eating disorders have been, like Karen, outstanding athletes and learners, with high expectations of themselves.

Sahn was reliable, conscientious. Dick Jackson, former owner of Aspen Expeditions, says she was “a pillar of strength and so quietly confident. The epitome of safety-minded.”

Says her friend Cari Kaplan, “She was a true sister. The patrol sister thing—[as a] minority, we bond. I’m so grateful for those times. I miss her so much.”

*Per the Aspen Times obituary: donations may be made to Mountain Rescue Aspen or the Outdoor Education Fund of the Aspen Middle School (select Annual Restricted Fund in the dropdown menu, and enter Karen Sahn ODE fund) in comments.*

ALISON OSIUS of Carbondale, CO, was a longtime editor at *Climbing* and *Rock and Ice* magazines. She is now a travel editor at Outside Online.

### AVAILANCHE MITIGATION in the CONTINENTAL CLIMATE

Guide to an effective boot-packing program

Story by Karen Sahn

*Ski areas in the continental climate are challenged with safely opening steep terrain early season. Providing a skiable product with timeliness correlates to increased revenue and maximizing profit.*

**Boot-Packing Program Initiation**

By the time the end of March has arrived, there are enough prospective skiers to justify boot-packing operations. All skiers must have an avalanche rescue and rescue training, and they must be trained in the program rules and guidelines. Patrollers must work with the ski area’s avalanche control team to ensure that the program is safe and effective. Patrollers must work with the ski area’s avalanche control team to ensure that the program is safe and effective. Patrollers must work with the ski area’s avalanche control team to ensure that the program is safe and effective.

**Safety Protocol and Packing Methods**

Patrollers must be trained in the use of the avalanche rescue and rescue training, and they must be trained in the program rules and guidelines. Patrollers must work with the ski area’s avalanche control team to ensure that the program is safe and effective. Patrollers must work with the ski area’s avalanche control team to ensure that the program is safe and effective.

Material	Quantity	Cost	Total
Boots	1,212	\$600,000	\$727,200
Shovels	30	\$20	\$600
Shovel	120	\$200	\$24,000
<b>Total</b>			<b>\$751,800</b>



# Remembering the lives of friends

## LEO LLOYD



■ COURTESY SCOTT SHOLES

BY SCOTT SHOLES

### IN MEMORIAM—LEO W. LLOYD, III

Leo grinned as we hunkered down, backs to the wind, preparing to ski off the north side of Red Mountain No. 3 in the San Juans of Colorado. I knew exactly what came next. “I wonder what all the little people are doing today?” he leaned in and shouted. At first, this line was used whenever we could see a town far below, but eventually he just had to say it. Leo Lloyd was a connoisseur of the repeat, whether it was the same climb, same ski descent, or same playful comment atop nearly every summit.

Finding both satisfaction and perfection in repetition, Leo’s legacy was to have passionately trained and mentored hundreds of others over three decades. He continually honed his skills and shared them. And as he mentored a new paramedic or technical rescue volunteer, they would commonly end up climbing or backcountry skiing together. Although his protégées were fortunate to join him outside of work, they also learned something his friends knew all too well: “Avoid the Lloyd” was a sincere caution. Mildly put, there was no easy day in the outdoors with Leo. But each time out was educational.

After growing up in Montana, Leo moved to Durango to attend Fort Lewis College in 1980. His grandfather, Leo Lloyd I, was a general surgeon at the old Mercy Hospital, and the family had frequently visited Durango, which later drew Leo to the town and the San Juan Mountains. He joined the newly-formed La Plata County Search and Rescue as a Fort Lewis College student, and soon began recruiting other students. His passion for serving others, particularly in austere settings, only accelerated from that point on.

In 1985, while completing his undergraduate degree in cellular and molecular biology, Leo joined me working for the hospital-based Mercy Ambulance, first as an EMT and then as a certified paramedic in 1988. While at Mercy, Leo developed the Mountain Response Team which creatively embedded paramedics into backcountry

rescue missions, predating the helicopter EMS programs of today. He also flew with Mercy Air Care as a fixed-wing flight medic, igniting his passion for flight medicine.

Although acquainted as local climbers, our friendship developed through our working relationship as we partnered on hundreds of ambulance calls and numerous backcountry rescue missions well into the 1990s. But while I stayed with Durango’s EMS system, Leo was much more restless—and prolific. During his 35-year career, he was a paramedic, flight nurse, surgical nurse, technical rope rescue instructor, EMS Training Captain, backcountry skills and survival consultant, and search and rescue volunteer. His work included Mercy Medical Center in Durango, San Juan Regional Air Care, Animas Surgical Hospital, Durango Fire & Rescue, Rigging for Rescue, La Plata County Search and Rescue, Silverton Avalanche School, Silverton Ambulance, San Juan County Search and Rescue, Hardrock 100, Friends of the San Juans, Khumbu Climbing Center in Nepal, and Denali Rescue Volunteers.

Eventually I was able to persuade Leo to return to our ground ambulance system in 2002 to help develop a new fire department-based EMS program. While full-time at DFPD, Leo also instructed professionally with Rigging for Rescue, teaching technical rescue for numerous organizations around the U.S. and internationally. In 2017, he successfully pleaded for an extended time away from work to help train Nepali high-altitude Sherpas at the Khumbu Climbing Center in Phortse, Nepal. He also recently served on two climbing ranger rotations on Denali, in Alaska, performing high-altitude rescues on both tours. Days before he died, Leo completed what was to be his last search and rescue mission, climbing all three Trinity Peaks in the Grenadier Range as part of a search.

Larger than life is a cliché too often used to describe someone who is gone. But those who knew Leo were genuinely puzzled at how any single person could be so productive. Despite this astonishing schedule of commitments, both paid and volunteer, Leo also found plenty of time for his marriage and family. He and his wife Susie raised three boys, each uniquely different, yet with similar high-energy personalities. He also found time to get outside with friends, whether it be skiing, climbing, or mountain biking. And of course there were those repeats. We may never know the actual count, but Leo climbed Castleton Tower near Moab at least 50 times, most often with different partners.

Not long after his death, I hiked a local peak alone. After a few weeks of memorial planning and endless conversations about how to fill numerous gaps without him, some time to decompress was overdue. Town below bustled with cars and people and I smiled at the thought of his summit doggerel. I didn’t feel alone up there, though. In spirit, Leo will always join those of us who treasured days outside with him. And, of course, he’ll have been there before.

*Leo Lloyd suffered a fatal sudden cardiac arrest while mountain biking with his son, Ande,*

*on August 4, 2022. A celebration of life, held on August 30, filled the Fort Lewis College Concert Hall. Hundreds more watched the event livestream. He was 60 years old. ●*



SCOTT SHOLES is the EMS Chief with the Durango Fire Protection District and President of the Emergency Medical Services Association of Colorado. He’s

been climbing and backcountry skiing since the mid-1970s. Despite all the experience, he never really learned how to “avoid the Lloyd,” enjoying adventures and suffering epics instead.

BY TYLER GEORGE

I had been the Director of Silverton Ambulance for less than a month and I was 200 feet over a cliff ledge off the highway outside of Silverton, CO. We had two patients, one ejected from the car, one trapped in the vehicle and in real trouble. My partner and I were trying to deliver patient care while I was wondering if the volunteers we had left on the road were going to be able to set up a technical rope-raise. The patient was as unstable as the vehicle which teetered on the edge of a cliff that would be its final drop down into the Animas River. I was overwhelmed, I was thinking about how arrogant I was to believe that I could be the Director of this entire organization when I couldn’t even handle my first acute call. I was thinking “what would Leo do?”

As I was considering whether it would be better to formally resign my position or throw myself off the cliff... out of nowhere, Leo appeared, as if I had manifested him out of fresh air. Leo instructed me that our people had a raise ready, the first patient was out and stable, and ‘what do you need?’ Not only did I immediately have a sense of calm, but I felt competent, and I knew everything was going to be okay.

Leo could inspire people to rise above their training and experience and operate at a higher level. He could inspire people to do things that they did not believe they were capable of. After the call, and after giving us some constructive criticism on a few of the finer points of our mechanical advantage system, he told us “Great job you guys, you saved lives today.” The truth is that we didn’t save anyone that day. Without Leo and the training that he made sure our team received, his demand for repetition and practice, and his constant encouragement, we wouldn’t have had the slimmest chance of executing such a complex rescue. Leo was responsible for those lives saved.

This story is not special in Southwestern Colorado, at least not the part where Leo showed up out of nowhere at just the right time. Leo had a knack for showing up to the most difficult calls. Leo was there for the multiple victim avalanche burials as a rescuer and to give incident management direction. He was there when a hiker’s leg had become entrapped near the summit of Grizzly Peak. He was with us when a runner got lost and he led the climbing team on the technical



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routes where we thought we may find the lost man. He was there the first time I had to tell a patient's family that their son had not made it out alive. In each of these cases he was not only helpful as an individual rescuer, but he made every team he joined better. He could not only execute the minutia of every call, but he always had an eye on the bigger picture, never getting tunnel vision on an individual task, one of the hardest things to do in an emergency.

I was born in 1982 and grew up at the St. Paul Ski Lodge on Red Mt. Pass just outside of Silverton. The 'Lodge' was the first backcountry ski operation in San Juan County and due to our location and my dad's avalanche and forecasting expertise (we hosted avalanche schools and he forecasted for CDOT) I was fortunate to grow up surrounded by experienced backcountry skiers, climbers, avalanche professionals, and rescue teams. Leo was one of the many accomplished practitioners. I don't remember life before him, he was a constant at the Lodge, he took my brother and me climbing and skiing, he taught us how to climb desert towers and travel safely in the winter. He reviewed rescue techniques and medical procedures with us. One of the things that startles me to this day is that he listened to us, he treated us with respect, and he valued our opinions, even at an early age. Back then, I thought I was the luckiest boy in the world to have somebody with Leo's knowledge as my own 'private' mentor. It wasn't until many years later, when I had entered the world of EMS that I realized the scope of his influence. Leo would take time out of his already busy schedule to help anyone who wanted to hone their skill set, whether it was avalanche rescue,



Leo and Tyler.

traveling safely in the backcountry, technical rope rescue, or austere medicine, if you were passionate about it, he would help you. Since I have been in EMS/SAR world I have met hundreds of people whom Leo has instructed, mentored, or influenced, and everyone who had the privilege of his company agrees that there was no better teacher.

The unique trait Leo had was not only did he wear many hats (most everyone in our small mountain communities does) but he was an expert in all the roles he took on. He was not just 'proficient' in pre-hospital medicine, technical rope rescue, avalanche rescue, helicopter operations, mountaineering (to name a few), he was The Expert. He was also a teacher. If you had a question about austere medicine or rescue, he was the one you called. He was so willing to share his knowledge, nothing was proprietary, and there were no prerequisites for someone to learn from him. He was always teaching a course somewhere or helping someone one-on-one, he shared his knowledge freely.

Leo's death has created a huge hole in our community both personally and professionally. He volunteered so much time to Silverton teaching us technical rescue techniques, medical techniques, best response practices, the list goes on and on; and if we weren't learning something new, we were reviewing everything he had previously taught us. There is no one person who will be able to fill the hole he left, but, in perfect Leo fashion, he left us prepared to cope in his absence. If you spent enough time practicing a skillset and you were passionate about a discipline, he would invite you to shadow him, then teach alongside of him, and finally teach on your own. Many of those who became instructors under Leo's tutelage have said that the ability and willingness to share knowledge was a part of his curriculum. Those EMS and rescue professionals who were Lloyd acolytes have adopted his love of teaching and, my hope is, that we can begin to fill the holes left in his absence.

I believe that it is our responsibility, those of us who were fortunate enough to be mentored by him, to take what he taught us and pass it on. I believe that it is the best way for us to honor him, and hopefully the hundreds of people he taught will become thousands as we carry the torch forward in his memory. ●

TYLER GEORGE grew up in Silverton. Now he is the Director of Silverton Medical Rescue (previously The Silverton Ambulance Assoc. and San Juan County Search & Rescue). He is also a Trustee on the Silverton Town Board and, along with his brother and sister, an owner/operator of The St. Paul Ski Lodge.



# METAMORPHISM

## MOUNT SHASTA AVALANCHE CENTER UPDATES

BY NICK MEYERS, MSAC DIRECTOR

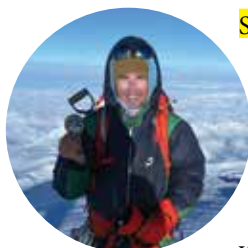
This year, we have a whole new crew. On the Friends side, we hired Michael Madden, while on the Federal side, we hired Sam Clairmont and Eric Falconer. I personally applied for and received a GS9, Mt Shasta Wilderness Program Manager position...which the short of it is same job, better pay and a full-time gig instead of the 18/8. The GS9 position is a job that my formers have been pressing for over two decades!



**Eric Falconer** grew up as a Colorado native in the Front Range. At age three, he started skiing and has never looked back. Eric's fascination with avalanches began while he attended Prescott College, and he then went on to become an adjunct faculty member instructing their intensive avalanche one-block courses. As an educator for Prescott College and the Montana Wilderness School, Eric has also worked as a guide in Yellowstone NP and on Mount Shasta. Having tasted the many flavors of the outdoor world, he is now excited to keep his hands in the snow. When snow does not exist in Eric's world, he can be found playing music, riding his horse in the mountains, or attempting to trail run.



**Michael Madden** grew up in Minnesota ice climbing along the Great Lakes of Canada and the Midwest. He moved to the Pacific Northwest after college where he's worked as an alpine climbing guide for nearly a decade. He has previously worked as a snow ranger at Mt. Rainier and mountain rescue technician at Sequoia National Park. Following an M.S. in Environmental Studies at the University of Oregon, he now spends his summers as the guide manager for Shasta Mountain Guides. This winter he will be a new forecaster at Mt. Shasta.



**Samuel Clairmont** grew up and attended college on Oahu, where he studied Geology and Geophysics at the University of Hawaii at Manoa. Shortly after graduating, he moved to Utah to learn to ski and then joined Snowbird Ski Patrol in Little Cottonwood Canyon. Spending his time in that canyon with some of the best ski patrollers in the world has provided incredible insight into this profession; he owes much of his knowledge base to his Snowbird family. He has taken his PRO 1 and is currently enrolled in a Winter Weather Forecasting course. Between winter seasons Samuel has been the Forest Service full-time Climbing Ranger for Mt. Hood in Oregon and for the winter is joining Mt. Shasta Avalanche Center as a full-time forecaster. When not working, he spends his time rock climbing across the United States or searching for good surf.

## SAWTOOTH AVALANCHE CENTER UPDATES



The Sawtooth Avalanche Center is excited to announce an addition to the forecasting team: **Jon "JP" Preuss**.

After completing degrees in Biology and Outdoor Education at Northern Vermont University, JP moved to the Wood River Valley to pursue a career in mountain guiding. Over his career, he has worked as an operations manager, SAR member, educator, and AMGA-certified ski and rock guide. JP brings a true passion for snow and avalanches, an impressive work ethic, and a great attitude to the SAC. He spends his free time hunting avalanches and hopes to one day find the missing key to forecasting Deep Persistent Slabs.

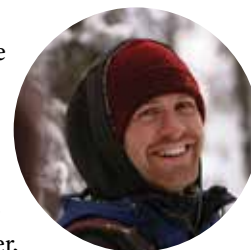
When not in the mountains, you can find JP enjoying the Wood River Valley with his wife Michele and young son Owen. Becoming an avalanche forecaster is a lifelong dream of JP's, and he looks forward to contributing to the Sawtooth Avalanche Center and our mountain community for years to come.

## FLATHEAD AVALANCHE CENTER UPDATES

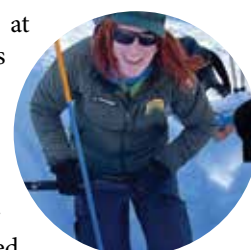
BY BLASE REARDON, FAC DIRECTOR

This winter, you'll see two new names on FAC's forecasts and at our education events.

**Rob Millsbaugh** was FAC's stalwart intern for the 2019-2020 season. His backcountry career also includes stints as a snowmobile guide, rare carnivore tracker, and state forester. Rob has an Avalanche Operations Level 1 certification from the Canadian Avalanche Association and a degree in environmental engineering. Outside of winter, Rob works as an instructor and technician with the Whitewater Rescue Institute. His interests include swimming in rivers, wrestling dogs, cussing at machines, and making "circle-foods."



Bozeman-born **Sarah Williams** started skiing at Bridger Bowl when she was two years old. Sarah's professional avalanche work began on ski patrol at Moonlight Basin and continued into guiding ski mountaineering trips in Alaska. In the summer, she works as a Wilderness Ranger on the east side of Glacier National Park. Sarah was an intern for the FAC during the 2020-21 season and then worked closely with FAC as a Park Ranger in the 2021-22 winter. Last season, she earned her Pro-1 certification and FOAC's "Above and Beyond" award. When she's not outside, Sarah works as an Occupational Therapist.

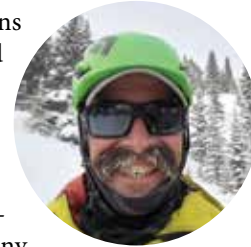


Additionally, we wish the best for long-time forecaster **Clancy Nelson**, who has moved on to the **Eastern Sierra Avalanche Center**, which is based in his hometown of Mammoth Lakes, California.

Their gain is our loss; Clancy has been FAC's go-to for technical questions large and small, from incorporating the SNOWPACK model output to syncing inReaches. Among the things we'll miss are Clancy's humorous yet rigorous observations. No one could create images that so captured the sometimes-absurd travel conditions in the region or diagrammed snowpack layering so clearly.

## COLORADO AVALANCHE INFORMATION CENTER UPDATES

**Drew Gibson** grew up in the Colorado mountains where a weekend ski patrol hobby quickly turned serious, spending 18 years wearing a white cross as an avalanche forecaster and paramedic at Copper Mountain. Throughout the years he has also worked as an educator, guide and forecaster in NZ and the US, most recently for the Bridger-Teton Avalanche Center. Drew volunteered for many years with Summit County Rescue Group and was on the board of directors of the Colorado Rapid Avalanche Deployment non-profit. Outside of avalanche work, Drew spends time riding bikes, climbing, and working as a paramedic. Drew will be working as a weather and avalanche forecaster out of the main office in Boulder and is based out of Frisco, CO.



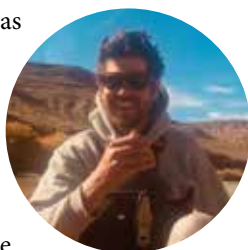
**Andrew McWilliams** started his ski career in the snow splitting time between the hotbeds of Southwestern Connecticut and Fresno, California. He moved to Colorado after studying Geology; partially for the mountains, but mostly to live in every state that starts with a "C". He comes to the CAIC after spending 10 seasons as a ski patroller, most recently working as a Lead Avalanche Technician at Arapahoe Basin after shorter stints at Breckenridge and the Remarkables in Queenstown, New Zealand. Andrew joins the CAIC as a backcountry avalanche forecaster based in Summit County.





UTAH AVALANCHE CENTER UPDATES

The Utah Avalanche Center hired **Dave Kelly** as a forecaster for the Salt Lake City office this summer in a new position designed to increase our capacity throughout the state. He was born in Colorado and grew up outside of Boston. After finishing a degree in Outdoor Recreation from Plymouth State in New Hampshire he moved to Utah to ski for one season and has been in the Intermountain West since. He has worked as a professional ski patroller for the last 16 years; the last decade he's been at Alta Ski Area, where he was the coordinator for the Alta Dog Program. His avalanche forecasting includes work at Alta, Turoa on Mt. Ruapehu, NZ, and in Alaska for the DOT and White Pass/Yukon Railroad. As an educator and instructor, he has worked for various schools across the country including NOLS, the University of Utah, and the Appalachian Mountain Club. On the government side, he has worked as a Trail Crew Lead for the Forest Service in Salt Lake City and as a River Ranger on Desolation Canyon. In the summer you can find Dave biking or boating.



The UAC has also hired long time Moab pro observer **Dave Garcia** to be the region's Community Outreach Coordinator/Assistant Forecaster. Dave has been skiing as long as he can remember, starting with his family in Connecticut. In 2002 he moved out west to study at the University of Utah where he took a semester course in Snow and Avalanche Dynamics. His interest in snow continued to grow and he took another class from UAC alumni Tom Kimbrough and Evelyn Lees. After earning a degree in Parks, Recreation, and Natural Resource Management, he spent twelve winters immersed in Little Cottonwood Canyon ski culture including two as a lift operator at Alta. Dave moved to Moab in 2015 and began submitting observations the following year. He has taught Backcountry 101 courses in the La Sal Mountains and is a member of the Winter Search and Rescue Team. He has his AIARE Level I, II, Avalanche Rescue, and Pro I certifications. ●



SEASON REMINDER: CHECK YOUR BATTERIES

BY MARK RENSON

Like any good backcountry traveler, during this off season I sent my Barryvox beacon to the manufacturer for the occasional health checkup. The Mammut "medical center" rapidly processed this and even replaced the contacts and updated the firmware. Of course, upon receiving it, I was going to install what I thought were fresh batteries and whaddya' know I noticed leakage in one of them. So, when plunking new batteries into our beacons, let's all inspect the batteries—a one or two-second check on each battery will do.



Truth be known a few months ago I had several four-pack battery packages with just one battery in them (beacons usually take three AAA batteries as well as many headlamps while Duracell sells them in four-packs—get it?) and combined them all into a zip-loc. I suspect I had an older battery in that collection! Inspect your batteries prior to installation anyway—it only takes a second or two for each battery.



MARK RENSON is an AIARE Course Leader for Acadia Mountain Guides. He is also a backcountry ski patroller supporting the Mount Washington NH Avalanche Center where he shepherds our mischievous Bostonian and Quebecois friends in Tuckerman Ravine.

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# A TRANSCIEVER INTERFERENCE WORKSHOP: Considering new practices to address our gadget-filled times

BY JAYNE THOMPSON NOLAN

Most of us don't go anywhere without our Smart Phone, so it's worth knowing how that Smart Phone (and other tech/gadgets like it), might impact the digital transceivers we rely on to "be searchable" in avalanche country and by what means we might be able to mitigate those impacts.

According to Bruce Edgerly, founder of Backcountry Access, Electromagnetic Interference, or EMI "in the context of avalanche transceivers is the disruption of reliable signal acquisition by the receiving unit, caused by other electromagnetic noises in the area. EMI can result in reduced receive range and "false triggers," or misleading distance and directional readings that can distract from an efficient transceiver rescue."

Nearly all avalanche transceiver manufacturers have developed basic minimum distances they recommend their transceivers be kept from other objects, particularly electronics to function properly and limit EMI. These minimums are based on extensive testing by the manufacturers and are included in your user manual. In general, these minimum distances can be distilled down to the 20/50 rule: keep items capable of producing interference 20 cm from your transceiver in "send" mode, and, keep those same items 50 cm away while you are in "receive" mode—i.e., searching.

These rules have generally served transceiver users well. However, as technology continues to spread into every facet of our daily lives, and the electronics we choose to carry increase in number and function (heated gloves, heated jackets, touch screens, cameras, go-pros, radios, and electronic avalanche airbags) conversations started taking place about whether these



The Canadian Avalanche Association and Avalanche Canada gathered manufacturers and industry representatives for a working group to discuss EMI. ■ COURTESY JAYNE NOLAN

technical rules alone were enough to address the tidal wave of electronics entering the backcountry.

In September, the Canadian Avalanche Association and Avalanche Canada gathered manufacturers: Backcountry Access, Black Diamond/PIEPS, Ortovox, Marmot, Alpride, and Arva, as well as representatives from multiple sectors of the avalanche industry including the American Avalanche Association, American Avalanche Institute, American Institute for Avalanche Research and Education, Association of Canadian Mountain Guides, American Mountain Guides Association, the Colorado Avalanche Information Center, the National Avalanche Center, the Northwest Avalanche Center, and the Utah Avalanche Center for a multi-day conversation around EMI at Black Diamond headquarters in Salt Lake City, Utah.

All of the parties involved seemed to agree that there is room for manufacturers, educators, and avalanche centers to work together in guiding how the public understands and manages potential EMI. We also seemed to agree that the issue of EMI needs to be addressed appropriately, but not to the point of overshadowing the basic need to carry a beacon, shovel and probe. The working group sought to explore:

- Best practices around items brought into avalanche terrain that have the potential to cause interference.
- How to carry electronic devices in a manner that will not cause interference in both transmit and search modes.
- Technical considerations around additional research to assess the parameters of interference and to establish guidelines for mitigation and response.

The group reviewed and discussed transceiver technology, interference issues, knowledge gaps, desired user behavior in various settings, and ways to develop those user behaviors. The main outcome from the meeting was beginning development of a universal document for both the public and avalanche professionals. This document will include:

- Consistent messaging and information about transceiver interference.
- A list of common signs of transceiver interference.
- Emphasis on the importance of registering transceivers with the manufacturers and keeping firmware updated.
- Best practices for key settings: learning, pre-trip steps, trailhead check, and rescue settings.

This is an emerging collaboration. The process to date has been inclusive, ensuring that a wide array of perspectives is heard so that the group can offer effective practices to mitigate the potential effects of EMI to undermine rescues. Stay tuned for additional updates from this working group. ●



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# GAME CAMS

BY ZACH GUY & EVAN ROSS,  
CRESTED BUTTE AVALANCHE CENTER

## as a cost-effective solution for monitoring storm totals in data sparse areas

Every forecaster would love to see more weather stations during a storm, yet every forecast center has budget constraints that limit comprehensive ground truthing. Last winter, the CBAC experimented with an idea to address this problem: Using relatively cheap remote game cams to monitor storm totals in data sparse areas. Last year's trial run was largely a success; thus we're sharing what we learned.

Last year we deployed two game cams. We used the Barn Owl RangeCam Mini bundled with a solar panel. The setup costs about \$300 per camera and

Our biggest concern was the lifespan of the batteries, especially given how cold it gets in Crested Butte. The solar panels power a battery pack, and the camera draws from eight AA batteries as a reserve. We changed the batteries once during a mid-season visit as a precaution, but the battery life never dropped below full throughout the entire winter. Each photo comes with a battery life indicator for monitoring.

Of course we did encounter a few hiccups, like that time our 10 foot pole got buried in a single storm! Our December storm cycle delivered over 15 feet



Left: The game cam setup in the field. Above: An example of a photo delivered three times per day to our email inbox.

Right: Game cam site maintenance involved bumping the cam and snow stakes up higher in the snowpack a couple times last winter.



about \$10/month for the cellular data plan. The cameras have antennas that can improve the cellular signal beyond an ordinary cell phone, and they will tap into whatever cellular provider signal is strongest. We programmed the cameras to send us three photos each day (0530, 1100, and 1630). The cameras have night vision which worked well for our pre-dawn photo.

To design our snow stake, we installed a 10-foot PVC pipe with black electric tape and a permanent marker to label snow depths. Then we strapped the game cam to an adjacent PVC and pointed it at the snow stake. It was helpful to snap a few practice photos in the process to make sure the shot is framed appropriately. As snow depths increased, we visited the sites a few times throughout the season to bump the PVCs up further in the snowpack, using wooden boards at their bases to prevent them from sinking.

of snow in deeper areas and caused a week straight of High Danger. Our site was unsafe to access during the storm, and the camera got buried. Fortunately, we were able to probe and dig out the camera after the storm cleared and everything worked fine. Having a site that is accessible during major storms would certainly solve the issue. Otherwise, a well-marked location (flagging and GPS) is nice for rescue missions. For lack of perfectly flat terrain options, we installed one of our game cams on a very low angle slope (about 3 to 5 degrees). Snowpack creep gradually bent the PVC tubes over as snow depths increased. The easy solution is a flat slope or more frequent site maintenance.

Overall, we were pleasantly surprised at how well the cameras performed. It's fairly common for our Snotel sites to have issues during a storm. The game cams helped verify storm totals during those uncertain periods, and helped fill in the gaps for monitoring storm totals. The cameras also send temperature readings with each photo, which became useful during wet avalanche season. We're planning on using the same setup again this year. If we make any changes, it will be going to a sturdier snow stake and camera tower, something like a wood 2x4 instead of PVC. It still has to be light-weight enough for the intern to hike up there. ●



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EVAN ROSS is Zach's boss in the summer and ZACH GUY is Evan's boss in the winter. The summer is spent shredding the brown pow, shuttling cars around for hikers, and pondering avalanche center improvements. This is Evan's favorite season, mostly because he has the upper hand over ZG. In the winter the roles are switched at CBAC when ZG becomes boss and leads his fellow forecasters along the quest to decide whether the problems they face are likely, very likely, or perhaps just possible to occur...



# BEHAVIORAL

## PART 2

# SCIENCE: Potential Applications in Avalanche Education

BY KELLY MCNEIL

### FUTURE PROGRESS

*This article is part of a season-long series intended to introduce avalanche practitioners to concepts of health education and posit a process for a public health-oriented approach to the avalanche industry.*

In the October TAR, 41.1, we established some connections between public health and the avalanche industry; in this issue, we'll explore the connection between public health and, more specifically, avalanche education. Broadly speaking, public health conducts scientific research to educate the public about risk. The field of public health contains a number of core disciplines, including social and behavioral science, which are the focus of this article.

"Social and behavioral science" encompasses all the various disciplines that deal with the subject of human action. Behavioral scientists study why and when humans engage in specific behaviors and experimentally examine the impact of a variety of factors—conscious thoughts, motivation, social influences, contextual effects, and habits, to name a few—upon those behaviors.

### WHAT IS HEALTH EDUCATION?

Key to conducting this research is the influence of education and behavior change theories. Health education promotes health (and prevention) through education-driven voluntary behavior change activities. Health educators develop strategies, ranging from individual to group to community to systemic, that are meant to improve the public's knowledge, attitudes, skills, and behaviors—all towards the goal of positively influencing health behavior at the individual and at the community levels.

How does this connect? If you are an avalanche educator, some of this probably sounds familiar. A good curriculum promotes your constituents' safety and gives them tools to prevent them from being involved in avalanche incidents. Can we use the evidence-based strategies from health education to improve curricula to better meet these goals?

### WHAT DOES HEALTH EDUCATION DO?

Within health education, we use program planning models to aid in the development of interventions to address specific behaviors. Health educators do this by using models and theories to conduct needs assessments, develop evidence-based interventions, and evaluate those interventions.

At the outset, health educators work with target populations—in this case, recreational backcountry users—to understand what they need. The first step is to conduct a needs assessment to identify the community's capacity, what resources are available, the subjects' priorities, and their end goals (needs).

Based on what we learn in the needs assessment, we build activities to increase participants'

knowledge and skills, and implement programs with integrated, well-planned curricula and materials. These activities are based on behavior change theories.

Once a health education program is underway, a crucial step—and this is where many contemporary avalanche education programs leave off—is to evaluate its effectiveness on learning and behavioral outcomes. Program evaluation helps us ensure we are effectively delivering the program, meeting our goals and objectives, and adds value to the program.

### Protection Motivation Theory



Modified conceptual framework from protection motivation theory of Rogers (1983)

### THEORETICAL INFLUENCES

At the beginning of this article, I mentioned that behavior change theories heavily influence the program planning process. Essentially, behavior change theories look at personal, environmental, and behavioral characteristics to determine (and influence) behaviors. In TAR 41.1, I noted that there's some precedent for the use of behavior change theories in avalanche education (Geisler & Geisler, 2016).

Behavior change theories include social cognitive theories, planned behaviors, expectancy value, self-efficacy theories, and many others. Some are more useful than others for specific behaviors—and have the potential to fit nicely within existing avalanche education curricula. Behavior change consists of constructs within those theories that help us understand and find specific strategies we can use to help subjects (students) work on those behaviors.

A behavior change theory that I think could be useful within avalanche education is the protection motivation theory (PMT), which was developed by R. W. Rogers (1975) as a framework for a social cognition model to predict health behavior. The theory is based on the idea that people protect themselves based on two important factors around threat appraisal and coping appraisal (see [Figure 1](#)):

- **Threat appraisal** examines one's perception of the severity of the situation and how vulnerable one is to the occurrence.
- **Coping appraisal** consists of an individual's expectation of what will happen if they act on removing the threat and the belief that they have the ability to perform the particular behavior (self-efficacy).

Behavior change theories are tested in many different populations with a variety of behaviors. The PMT is only one of many theories that could be used as a framework for specific educational strategies aimed at increasing or decreasing specific behaviors while traveling in avalanche terrain.

What would it look like if we integrated program planning and behavior change theory within avalanche education by implementing this workflow?

1. assess needs
2. develop interventions based on those needs
3. evaluate the effectiveness of our interventions
4. disseminate results of this work

If we can gain a better understanding of the population we are working with and use behavior change theory to design avalanche education programs based on those needs of specific populations, we could evaluate whether the methods we are currently using are effective ways to educate our students and save lives.

My question is whether program planning models and behavior change theories might be effective within avalanche education to influence student behaviors? Research and testing will bring us answers to that question, using methods and concepts from a variety of behavioral science disciplines.

In TAR 41.3, I'll continue this discussion with a focus on the connection between public health and avalanche forecasting: how can we use public health communication best practices to increase effectiveness and outreach of avalanche forecasts? ●

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# RACS TESTING

## MEASURING THE EXPLOSIVE AIRBLAST OF REMOTE AVALANCHE CONTROL SYSTEMS

BY ROBB LARSON

### INTRODUCTION TO RACS

Remote Avalanche Control Systems (RACS) are widely deployed in Europe and installations are becoming more and more common in North America. Systems have been installed by departments of transportation, industrial operations, and ski areas to enable avalanches to be explosively triggered remotely, thus avoiding the need to put avalanche control workers in harm's way. In some situations, RACS are taking the place of artillery rounds to remotely initiate avalanches without the hazards of shrapnel or potential for trajectory mishaps.

RACS can be based on either explosive gaseous mixtures or solid explosives. The Gazex system, from the French corporation TAS, uses a mixture of oxygen and propane that is metered into a reinforced steel tube and then remotely ignited. The tubes are permanently installed on concrete supports in an avalanche starting zone, while oxygen and propane tanks are housed in a separate on-mountain storage location and gas lines are run to one or more units. The number of firings is limited only by the local gas supply. Numerous installations of three sizes (0.8, 1.5, and 3.0 cubic meter gas capacities) are present in the western U.S. and Canada.

The O'Bellx, also from TAS, uses a mixture of oxygen and hydrogen. Gas storage cylinders

are held around the perimeter of a bell-shaped explosion chamber. The O'Bellx unit is delivered by helicopter to a tower permanently installed in an avalanche starting zone. On remote command, the metered gas charge is released into the bell and ignited. The gas supply lasts for approximately 30 firings. When it is depleted, a helicopter retrieves the bell and flies it to a location where the gas can be replenished. A similar but non-fixed system called the Daisy Bell is dangled under the helicopter where the gaseous mixture is released into the bell and ignited over the target starting zone.

The Wyssen Tower from Swiss manufacturer Wyssen Avalanche Control uses gel or solid explosive charges instead of gas. A tower permanently installed in the starting zone is specially designed to receive and hold a helicopter-delivered magazine containing 12 charges. Upon remote command, a tethered charge is released from the magazine. An igniter is activated when the charge hits the end of its lanyard, where it hangs and detonates at a predetermined height above the snow surface. The first Wyssen Tower in United States was installed in November 2017 in Utah's Little Cottonwood Canyon, near the Alta Ski Resort.

Another player in the field is the Avalanche Guard by Swiss manufacturer Inauen-Schatti AG. It uses a remotely actuated pre-loaded mortar to launch solid-explosive charges from a permanently installed tower. The charges land in the predetermined target starting zone up to 200 meters from the tower and detonate within the snowpack.

Despite different designs, all RACS effectively address the need to perform avalanche control activities without endangering workers. However, each system has unique characteristics, various explosive effects, and operational advantages and challenges.

### STUDY ORIGINS

Many organizations worldwide are interested in RACS performance. Among these, the Transportation Avalanche Research Pool (TARP) is a partnership of entities whose mission is to improve the safety and effectiveness of avalanche mitigation operations in mountain transportation corridors. TARP was established through the United States Department of Transportation (USDOT) state planning and research pooled fund program (see sidebar for details). Members contribute funds, develop ideas for projects, and vote on how to spend money in the pool.



A Gazex 1.5 used by the Utah Department of Transportation above Highway 210 in Little Cottonwood Canyon, Utah. The Alta Ski Area parking lot is visible to the left.





An O'Belx system at Alta Ski Area, Utah.



Wyssen Tower system in Cardiff Bowl, Little Cottonwood Canyon, Utah.

Currently, the membership includes groups from the western United States and Alaska.

Since much of the performance data on RACS has been compiled by the manufacturers themselves or by researchers collaborating with device manufacturers, the TARP group saw a need for an independent study to evaluate RACS performance and to enable comparisons between systems. A request for proposal was issued in summer 2019 and TARP awarded the contract to Montana State University (MSU) researchers in November 2019.

I served as project lead. I was an Associate Professor in MSU's Mechanical Engineering department and had worked on projects involving avalanches and snow dynamics for over 20 years. My background in the design, development, and implementation of instrumentation and remote sensing systems aligned well with the needs of the project. Researcher Brandt Seitz became an indispensable team member and used the project as the focus of his mechanical engineering master's degree research. Professor Daniel Miller from MSU contributed expertise to the project, especially in early planning stages. Invaluable field support was provided by Pete Maleski from the Bridger Bowl ski patrol, David Richards and his Alta ski patrol crew, Damian Jackson and the avalanche control team from the Utah Department of Transportation, Jamie Yount and team from the Colorado Department of Transportation, and members of the Colorado Avalanche Information Center.

### MSU RACS PROJECT

The fundamental goal of this effort was to evaluate the blast characteristics from operational RACS and then publish results for use by practitioners. The basic task was to record accurate air pressure measurements of the blast wave, or "overpressures", for each of several RACS. The data would need to be logged at different distances and in different directions from the RACS shot to allow calculation of the peak pressure, the rate of pressure rise, the energy at a given distance, and the shape and distance of the blast effect.

A thorough review of prior research was conducted first. Foundational snow science work

from Atwater, LaChapelle, Gubler, Schweitzer and others helped to clarify the big picture. The relatively few RACS-specific efforts—especially those documented by Stephan Simioni et. al. at the WSL Institute for Snow and Avalanche Research in Davos, Switzerland—provided some helpful clues on measurement methodology and procedures. Simioni's work on early Gazex system development also provided data useful for comparison with MSU's project results. However, relatively little documented research was found, confirming the need for our work.

One of the daunting challenges was the environment and location of the RACS, which are invariably placed in steep avalanche starting zones, with typical slope angles from 30–45 degrees. Researchers needed to access many different sites to haul in and place sensitive measurement equipment and conduct testing in safety, while dealing with winter weather, variable snow conditions, high elevations, and other challenges. Most of the RACS in this study were accessed on skis. Since everything needed to perform the tests needed to be hauled in a backpack to the sites, efficient equipment selection was critical for success.

Existing computerized data loggers or data acquisition systems were too bulky, too expensive, too power-hungry, or otherwise unsuited for the need. Luckily, recent advances in micro-computer technology allowed the team to create a miniaturized portable radio-controlled data acquisition system (DAQ) to take the pressure measurements. Five identical Raspberry Pi micro-computer-based systems were built to gather high sample-rate pressure data. The DAQ systems were sized to fit in a waterproof Pelican case. Remote control was accomplished using a small custom battery-powered radio communication module, also based on a Raspberry Pi micro-computer, and housed in a 3-D printed case. Ten pressure sensors, essentially high-capacity microphones capable of surviving the pressures of the blast, were designed specifically for the project by Larcor, Inc.

These new DAQ systems allowed the team to accurately record explosive blast pressures at a

sample rate of 50,000 per second—fast enough to see precise details as the pressure wave blasted past each of the microphones positioned at various angles and distances around the source.

### TESTING

With equipment needs addressed, a phased test plan was developed and approved by the sponsor. Phase 1, validation of the equipment, was accomplished in December 2020 with assistance from Bridger Bowl ski patrol. In that testing sequence, the pressure sensors were set out in an array to record blast effects from elevated two-pound pentolite charges. Phase 1 also included measuring pressures at various heights above the snow surface to establish the six-inch standard sensor height that was used in subsequent testing. The portable system proved highly effective in this test sequence and was ready for the next phase.

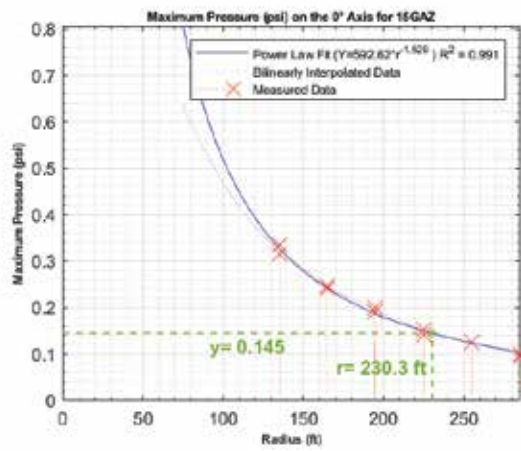
Phase 2 was the crux of the project and involved multiple trips to Utah and Colorado for testing actual Gazex, Wyssen, and O'Belx exploders, plus a few other tests using different types of explosive charges to simulate exploder performance and Avalanche Guard rounds. With help from the Alta ski patrol and Utah Department of Transportation personnel, most of the Phase 2 testing took place in Little Cottonwood Canyon, Utah. A follow-on set of tests in Colorado was recently completed thanks to great help from the Colorado Department of Transportation and Colorado Avalanche Information Center.

In Phase 3, the team investigated some of the effects of RACS placed near terrain features such as cliffs or gullies. Testing was performed with installed systems and representative explosives to begin to explore how the terrain affects the blast intensity and distribution. Results indicated enhanced directionality of the blast effect due to certain terrain features, but since an infinite number of terrain variations are possible, development of definitive conclusions that could be applied universally to proposed installations was not a realistic goal. Instead, a good practice might involve the mapping of blast effect patterns at proposed installation sites to quantify site-specific terrain effects before an actual RACS is installed.

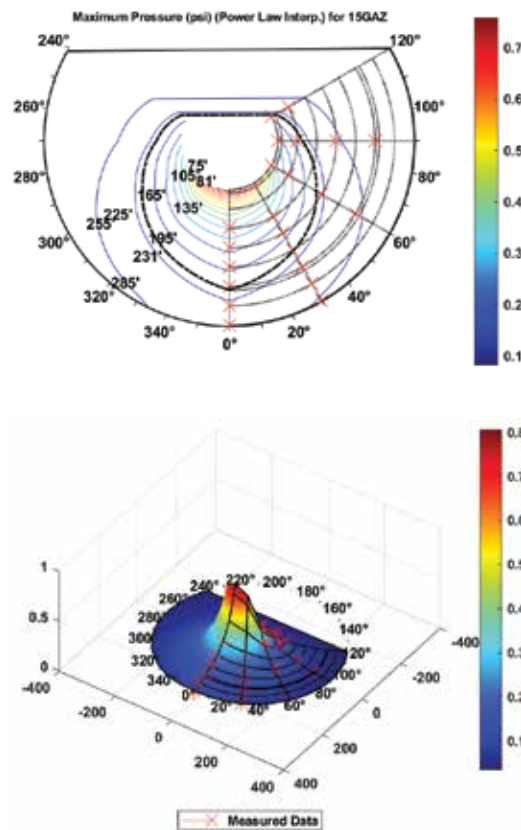


Pressure sensors for testing an O'Belx device at Alta Ski Area.



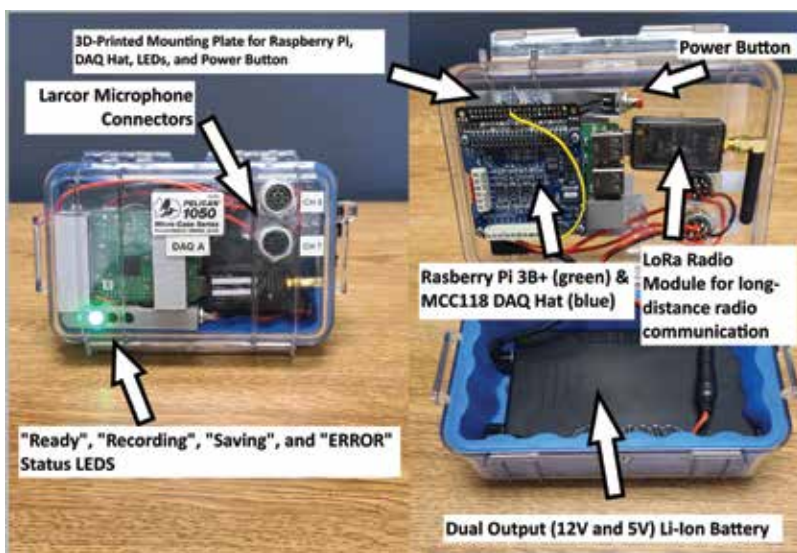


Data Processing Example 1: Pressure decay plot for sensors along one axis.



Data Processing Example 2: Contour plot of Gazex 1.5 peak pressures. Note: Data taken on one side of the 'zero axis' only and mirrored symmetrically.

Data Processing Example 3: Surface plot of Gazex peak pressures. The units of the scale on the right are in PSI.



Components of one of the five custom data acquisition systems.

**DATA PROCESSING & PRESENTATION**

The final project challenge was to process and present the mountain of results in an understandable, useful format that could be applied to both future research and RACS implementation. Multiple days of testing in Montana, Utah, and Colorado resulted in a lot of data! The team recorded data from two-pound pentolite charges, Wyssen systems using both gel and pentolite charges, two sizes of Gazex systems, O’Bellx operational systems, simulated Avalanche Guard rounds, and other configurations. During each

test, about three million discrete data points were collected by each of the 10 pressure sensors. All told, approximately 375 pressure records with about 1.125 billion discrete data points were collected and processed. Completing that processing task was perfect for a graduate student proficient in programming using MATLAB computer code.

The complete record of all data is available in table form for researchers to use, but fortunately many of the project results can be represented graphically. One type of graph created from the data is a plot of the maximum pressure seen by each of several pressure sensors located on a common axis, at various distances from the explosion.

The graph includes a dashed line marking 0.145 PSI, or one kilopascal (KPa.) That pressure value has been proposed by some researchers as the minimum pressure needed to collapse a weak layer, initiate fracture, and induce an avalanche. Importantly, not all agree on this value, and the 1 KPa pressure value is not an absolute indication of effective system range. However, identifying the distance from the blast origin where this 1KPa pressure value occurs provides a standard to compare the relative performance and blast patterns of different RACS.

Pressure decay plots from several angles can be plotted together, with lines of equal pressure added to resemble a topographical map. The resulting ‘map’ of the blast characteristics—as shown in Example 2 —makes intuitive sense. The Gazex mouth aims downhill, resulting in higher pressure downhill of the system than uphill. Intensity of the blast (psi) is indicated by color. (Different tests had more or fewer data points and testing axes depending on conditions, but this is a representative chart.) Note the thick dashed line at the 1 KPa distance.

The contour plot can also be shown as a 3D volcano plot, as seen in Data Processing Example 3. Color-coded blast intensity appears as height, mapped against distances from the explosion. Angle orientations are also marked with the 0° axis being straight downhill. This format provides a good visual indication of blast intensity and radial decay.

These three plots showing the relationship of peak pressures to distance and orientation are representative of results that were compiled for every test scenario. Similar plots were created to show pressure rise rates versus location and another set describes energy equivalent versus location for each of the tested systems.

**RESULTS AND CONCLUSIONS**

The study was designed to provide avalanche control experts with useful information on operational RACS so they could make more informed decisions on using these modern technologies. In general, the project results successfully addressed that need, but it is important to note the results are not all-encompassing, nor do they address every conceivable RACS implementation.

The numerous challenges of field-based research and relying on in-situ testing of actual installations meant only a limited number of installations were examined. Distant test sites necessitated a planned travel schedule for the project team, which meant test day snowpack characteristics and weather conditions were out of the team’s control. And, with any project involving advanced instrumentation and data processing, there are uncertainties present that affect data accuracy. The Seitz master’s thesis addresses some of these issues.

Further, the economics and operational decisions that could drive RACS implementation were outside the scope of the project. It is important to recognize that in certain snowpacks, a localized failure in a weak layer can propagate widely and affect a large area. In that situation, the size of the RACS overpressure zone may be relatively less critical. With those caveats, a few general observations can be made.

Of the systems tested in Phase 2, results indicate the peak pressures, energy equivalents, and pressure rise rates were highest for the pentolite-based explosives (Wyssen, Avalanche Guard), followed by the gel emulsion charge (Wyssen), 1.5 m3 Gazex, 0.8 m3 Gazex, and, lastly, the O’Bellx. Where these parameters are deemed the most important for inducing avalanches, a practitioner could draw some conclusions on system applicability:

- Due to its large charge mass and mostly symmetric blast wave profile, the Wyssen Tower, with either the gel emulsion or pentolite-based charge, affected the largest areas of avalanche terrain. A practitioner might select one of these systems for installation where the downslope, across-slope, and upslope directions are all equally important for avalanche initiation.
- Due to their directionality, individual Gazex systems are perhaps best suited for locations where the potential avalanche starting zones are relatively narrow and elongated downslope of the installation site, and the uphill direction is not seen as an equally likely starting zone.



Placing multiple Gazex systems in an array above a broader target area is a common way to expand that area of influence.

- The O’Bellx system, due to its relatively small combustion chamber volume and more limited effective area, might be best used in a relatively small zone where a localized and reliable weak spot or trigger point is known.

Phase 3 testing confirmed that terrain can meaningfully alter the blast wave effects of an explosive and that current avalanche control practices making use of unique terrain features have merit. For example, data from a simulated Wyssen pentolite test shot detonated on a bamboo pole in a gully feature showed that pressure rise rates directly down the gully (the 0° axis) were approximately double those recorded in flat field testing with the same explosive. However, relatively lower peak pressures and pressure rise rates were observed in a lateral direction (on the 45° axis.) This showed that the gully terrain feature increased the directionality of the blast.

A simulated Wyssen pentolite shot detonated on a bamboo pole near a cliff displayed a slight increase in both peak pressure and energy equivalent directly downslope of the blast (along the 0° axis) when compared to flat field testing. As with the gully test, the pressure and energy equivalent values measured on the 45° axis and at 90° to the blast were relatively lower than those measured in a flat field situation. The cliff clearly enhanced the downslope directionality of the blast.

As stated earlier, however, the terrain effect portion of this study was necessarily limited to a few cases. More thorough investigations at individual sites are needed to flesh out the Phase 3 results.

The general results of this study have already been shared in numerous ways, including presentations at the Utah and Colorado avalanche workshops, meetings with device manufacturers, and communications with researchers and practitioners in the U.S., Canada, and Europe. Much of the project is well-documented in the master’s thesis compiled by Brandt Seitz, now available through the Montana State University library. **The final report was provided to the TARP team in June 2022, and equipment has already been passed along to TARP to enable additional testing.**

The information gleaned will benefit avalanche control practitioners and others in understanding the capabilities, limitations, and possibilities for implementing these interesting devices. ●



RACS Utah field testing team near O’Bellx exploders at Alta, Utah. From right: project lead **ROBB LARSON**, grad student **BRANDT SEITZ** (yellow pants), and volunteers **JAMES LESSER** (with a load of pressure sensor cables) and **SAM VERPLANCK** (orange pants.)



*We saw a need for an independent study to evaluate RACS performance and to enable comparisons between systems.*

*This story, this project*

## WHAT IS TARP?

BY JAMIE YOUNT,  
CDOT WINTER OPERATIONS MANAGER

The Transportation Avalanche Research Pool (TARP) is a partnership of transportation agencies and exists to further cooperation on research, development, and evaluation of avalanche mitigation equipment and methodologies to improve the safety and efficiency of highway transportation in mountain corridors. TARP was established in 2015 through a USDOT State Planning and Research pooled fund program and is currently administered by the Colorado Department of Transportation (CDOT).

The mission of the Transportation Avalanche Research Pool is to enhance cooperative inter-agency research that improves the safety and effectiveness of avalanche safety operations, and to facilitate communication between transportation agencies that encounter avalanche hazards.

TARP’s goals and subsequent objectives are as follows.

- To enhance collaboration in avalanche research and to identify common research and deployment needs within the group.
- To provide a means of sharing research and methods between group members.
- To improve information gathering and analysis techniques relating to avalanche hazards and risk.
- To explore and evaluate currently available and emerging technologies that could enhance TARP members’ avalanche program efforts.
- To improve the safety of avalanche mitigation operations, to both avalanche workers and the public.
- To define universal measures of the effectiveness of avalanche mitigation operations.
- To explore new avalanche mitigation methods and related technologies.
- To continually evaluate new technologies to gauge applicability to avalanche programs.
- To encourage group members to adapt new, effective techniques of avalanche mitigation and to set precedents for the rest of the country.

Current TARP voting members are the Alaska Department of Transportation, Colorado Department of Transportation, Utah Department of Transportation, Washington Department of Transportation, and Wyoming Department of Transportation. Affiliate members consist of the British Columbia Ministry of Highways, New Zealand Transportation Department, Alaska Railroad, and the Colorado Avalanche Information Center.

TARP has funded and facilitated over 1 million dollars in avalanche research in the last seven years. The following projects have been undertaken with TARP funding and guidance.

1. Assessing Gazex Avalanche Control Effectiveness with Terrestrial Laser Scanning—Jeffery Deems—University of Colorado and CIRES Snow and Ice Data Center
2. Enhanced Infrasound Avalanche Monitoring & Detection—Jeffery Johnson, Hans Peter Marshall—Boise State University
3. Terrestrial Laser Scanning with Real Time Analytics for Avalanche Forecasting—Kevin Hammonds—Montana State University
4. **Measuring Explosive Airblast of Remote Avalanche Control Systems (RACS)—Dan Miller, Robb Larson, & Brandt Seitz—Montana State University**
5. Snowshed Synthesis—Jordy Hendrix—Montana State University
6. Avalanche Performance Metric—Dave Gauthier, Zac Sala, Mark Vessely — BGC Engineering
7. Linking Measurements from a Differential Emissivity Imaging Disdrometer (DEID) to Storm Snow Instabilities—Eric Pardyjak, University of Utah



# FOCUS ON

BY MARK STAPLES

# 3

In February 2021 four people died in the Wilson Glade avalanche near Mill Creek Canyon outside of Salt Lake City. Three of the victims had been skiing a section that is 31 degrees in steepness. It was an incredibly tragic event in terrain where few thought such a deadly avalanche was possible. In fact, many locals were shocked

because they consider that area to be relatively safe during elevated hazard. Many consider it “mellow terrain,” but what does that mean? Why do people consider places like Wilson Glade safe? Because it is below treeline where it is sheltered and has less wind? Because it is not considered very steep (**see the photo with point measurements of slope angle**)? Even though slope angles are mostly in the low 30s, the entire area is steep enough to avalanche. Often ski patrollers refer to slopes like these as “stubborn terrain” because triggering avalanches is a bit harder than on steeper slopes. The UAC has recorded ten avalanches on this slope in the last 11 years, and a UAC forecaster was caught in a slide there in the early 90s but was able to grab a tree before being swept away.

People’s perception of terrain and slope steepness is very complicated. What is mellow terrain? Is it terrain easier to ride? Is it terrain safe from avalanches? Both can be definitions of mellow terrain, and all too often we see people confuse these two questions with disastrous consequences. Terrain is a complex topic with many factors besides slope steepness, including aspect, elevation, slope shape, tree cover, sun and shade. Despite these complexities, terrain is the simplest part of the avalanche puzzle to evaluate because it never changes. Instead of getting lost in the complexities of terrain, I prefer to focus on the fundamental question: Is it avalanche terrain or not?

Deciding to enter avalanche terrain requires a complicated decision-making process that is easy to screw up. For me, identifying avalanche terrain is like identifying the door to a casino. If I stay outside, I won’t lose any money. I want to have fun, so I enter the casino and begin rolling the dice. Entering the door to a casino is just like entering avalanche terrain, but the challenge is that the door is invisible. The great thing about the backcountry is that we can have a great time without going into avalanche terrain, but we have to know where that door exists.

There are many ways to teach recognizing this door. If it looks fun to ride to an advanced skier or boarder, then it is probably avalanche terrain. Another is a lack of vegetation and flagged trees in runout zones. Another is having to engage your highest heel risers when skinning. We have to teach all the parts of avalanche terrain: starting zone, track, and runout zone. Using slope steepness mainly applies to starting zones. Since we want to help people identify the door, let’s make sure we focus on 30 degrees, not 38 when we talk about the slope angles.

In the Wilson Glade accident, there were two parties involved. One group of four had skied an area 31 degrees in steepness multiple times and was skinning up through the starting zone when the avalanche happened. A group of three was in the lower-angled runout zone below. Three people in the upper group were caught and buried, all three in the lower group were buried, and four of the six died in the avalanche. One learning lesson in this accident was that being on or underneath slopes steeper than 30 degrees means you are in avalanche terrain. There are many ways to teach the public and students how to identify if terrain above them is avalanche terrain, and these ideas are outside the scope of this article which is focused on slope angles.

The challenge is that there are many different slope angles used to define avalanche terrain. A quick Google search gives a lot of results: 25–50 degrees, 30–45 degrees, 37/38 degrees, 35–38 degrees. All of which are all correct but confusing with so many numbers and ranges of values. The single number we teach at the UAC and pay attention to is 30 degrees, the door to the casino. All my field partners and coworkers pay attention

to this number, and we practice measuring slope angles more than we practice with our transceivers. Identifying avalanche terrain is as essential as transceiver practice, and I would argue identifying avalanche terrain is more important because it helps us avoid avalanches in the first place. It’s like staying out of the casino except we still have a lot of fun without the gambling.

Can people accurately measure slope angles? I believe they can, but it requires education and practice. Can people build safe climbing anchors? They can, but it requires education and practice. There are many essential skills needed to safely travel in the mountains, and they all require education and practice. As with anything, there is always room for error. This is why we never rely on a single piece of gear in climbing anchors and add redundancy. Are there risks in asking people to measure slope angles? Of course there are, but the risks of not measuring are far greater. If they do measure, the risks of focusing on a number like 38 are also far greater as well. Few can make perfectly accurate measurements, and for that reason, we should all give ourselves some margin to account for that error. Some suggest typical errors of plus/minus three degrees. Let’s still focus on 30 but build in margin from that number. In fact, many organizations and individuals already do exactly that.

It’s even more important to practice measuring slope angles because it’s easy to misjudge visually. A 30-degree slopes feel totally different in various snow conditions and modes of travel. A good example is ice climbing when a 30-degree slope feels nearly flat. An icy 30-degree slope feels steeper than one with soft snow. Mapping apps can have errors too depending on the resolution of data used to create the topo maps. There’s no substitute for taking measurements in the field, and I believe we need emphasize this skill to students and the public. It can start with learning how to measure the slope they are on. Ideally, they learn how to measure a slope near them without getting onto it. There are many ways to have errors in measurements, but let’s not get distracted the potential problems. People will almost always make better decisions and safer route choices if they pull an inclinometer out of their pocket.

Should we still discuss the meaning and importance of 38 degrees? Yes, but in the right context of understanding how slab avalanches work. Some methods like DCMR by Ben Reuter (see TAR 39.4) incorporate a range of slope angles for decision-making and route selection. These are more advanced topics and great things to learn when we decide to enter avalanche terrain. The basics of safe travel mean being deliberate when we enter avalanche terrain, and 38 degrees is not what people need to commit to memory. Let’s stick to a single number where avalanches begin: 30 degrees, the door to avalanche terrain. ●



Photo of the Wilson Glade avalanche. The numbers are point measurements of slope angle.



MARK STAPLES is the Director of the Forest Service Utah Avalanche Center. His greatest education has come from investigating avalanche accidents, walking in the victim’s footsteps, and hearing stories from people involved.



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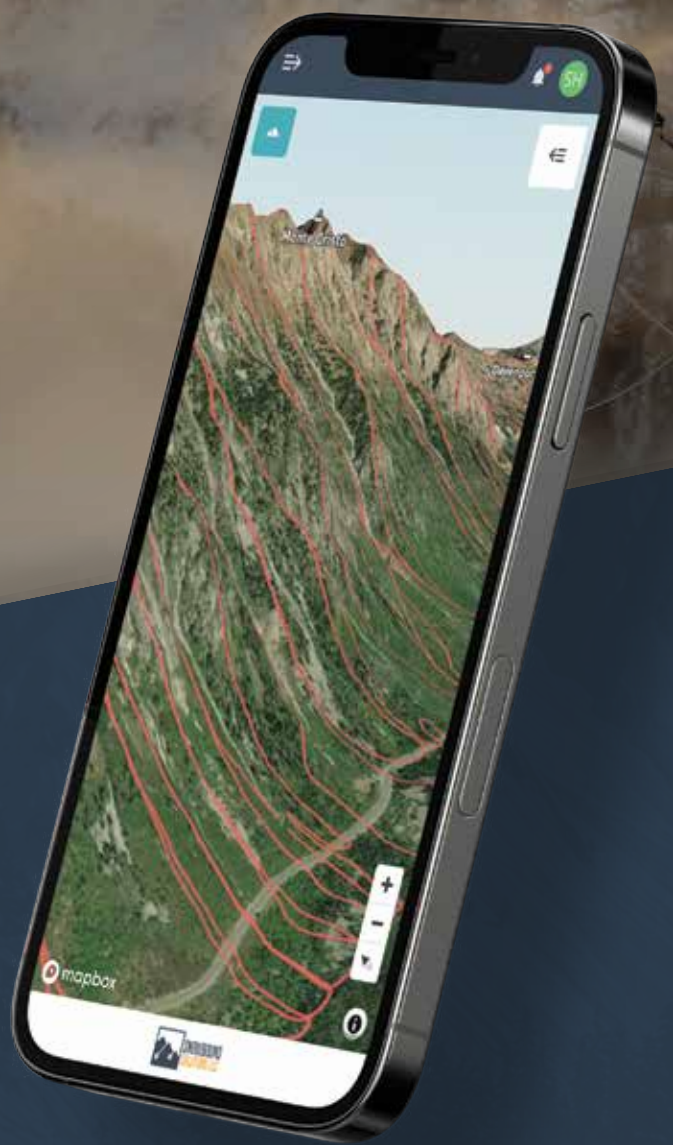
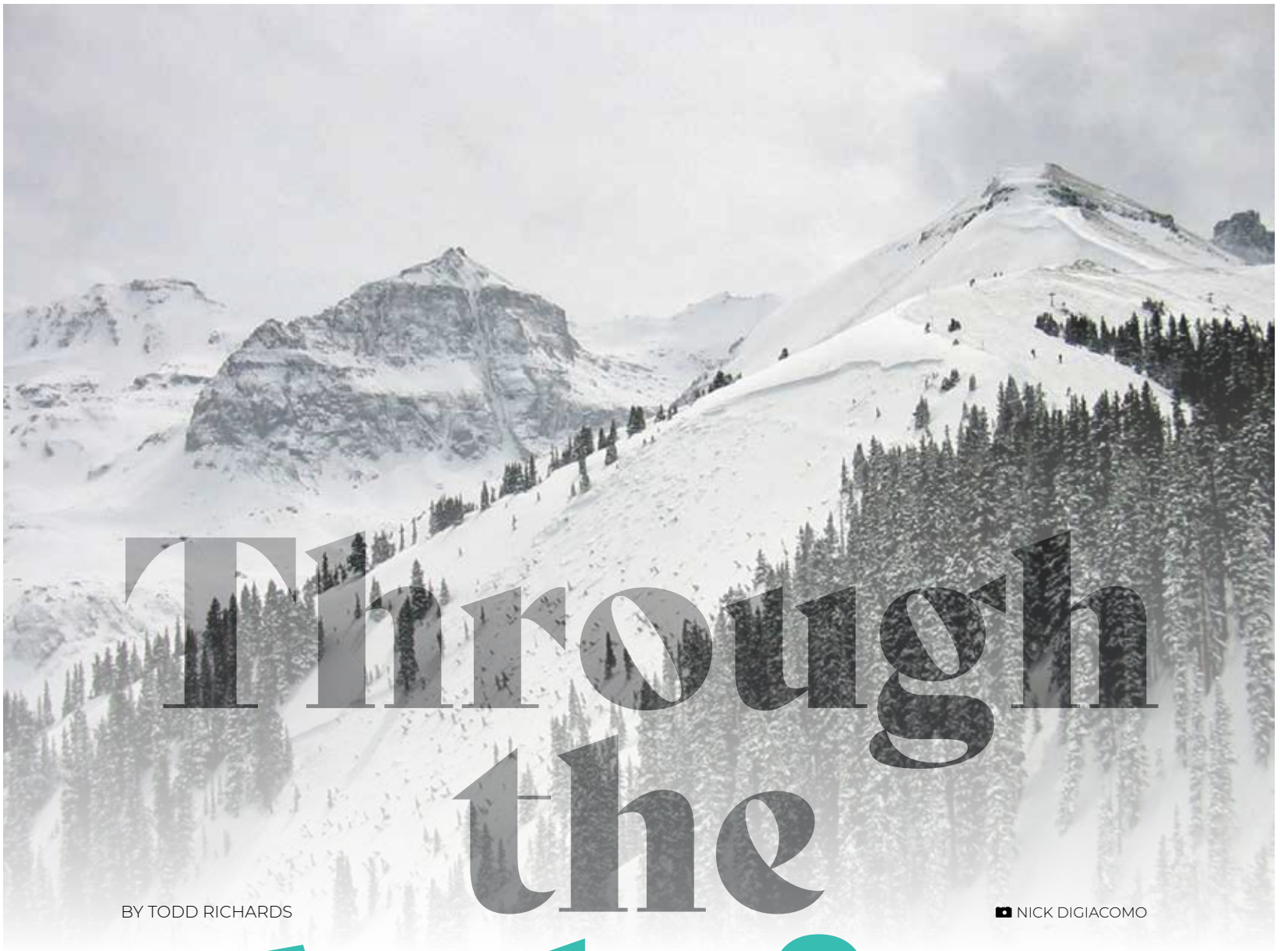


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# Through the

BY TODD RICHARDS

📹 NICK DIGIACOMO

# White



## FEBRUARY 14, 1989, TELLURIDE COLORADO, 12,227'

We rode a chairlift called The Plunge to the top and then followed the booted footprints of countless other backcountry seekers. 200 yards later we passed through the gate, a legal declaration of independence highly valued in this box canyon town. The hike was short, a small effort to access thousands of acres of untracked terrain made even more delicious by overnight snowfall. It was my day off from teaching rich people and their bratty kids how to ski. Bright sunshine, no wind, and temps barely below freezing meant relatively light clothing. Tinted goggles or sunglasses were mandatory under the brilliant high elevation sunshine.

Moments later my feet surfed effortlessly on wide open untouched powder. Silent three-dimensional parabolic curves propelled only by gravity—as perfect as it gets. I left behind only rhythmic grooved arches, proof of accurate steering, weight distribution, and angulation skills I'd honed to precision. A gracious dance splitting time between catch and release, each one better than the last, by far the best turns I've made in my life, dozens and dozens of them.

This, more than my hundredth day in a row, made me more fit and skilled than any previous time in my 23 years and 25 days of life. Adrenaline and joy aside, I would have a heart rate near resting pace. Never had I acquired such a level of talent in anything before. I was bowling only strikes, hitting only home runs, and throwing only touch-downs without even breathing hard. I hoped my two companions would feel the ease of this time/movement but doubted it.

I descended in bliss perhaps 400 vertical feet towards a large rock outcropping I had discovered the previous day with Vaughan, a delightfully happy New Zealander. Perched on the steep slope under the deep blue sky, I planted my glove-sheathed poles uphill to retrieve my camera in hopes of capturing him as he approached from above. Alas, I again forgot to remove the lens cap in time to record his movement and glowing face of joy. He was now standing in front of me, speechless from his own experience. No matter—there would be many more chances to chronicle this wonderful day with the stunning Bear Creek Canyon as a backdrop. Paul was still above us. I raised my camera and pointed it upward to place him in the viewfinder.

Then I felt it.

A low rumble detected in my feet with custom footbeds, tight buckles, and perfectly formed liners. I'd learned to 'tune into your feet' this season; where every skiing action is both started and controlled. The entire hill vibrated. It purred like an enormous lion. I'd never felt, heard, or seen an avalanche before, but knew immediately the instantaneous change from a glorious to perilous day.

I glanced upward to see the monster, hundreds of feet wide and several stories tall. It was as defined as a thunderhead cloud containing immeasurable amounts of mass but already moving at a tremendous speed directly at us.

"Paul is in it!" in that delightful New Zealand accent was the last thing Vaughan said in his life. I still hear it with clarity in a repeatable loop with virtually no deviation even now, more than 33 years later. Paul was a tall bearded Deadhead from New Orleans with big feet. His friends called him Hoofty Woofy, resembling Shaggy from the Scoobie Doo cartoon. I knew him as one of the many resort employees that gathered at the bar nearly every day about 4:30. Vaughan invited him to join us when we were in the employee locker room earlier that morning.

I reached with gloveless hands towards my ski poles to traverse out if the way, but never touched them. The shockwave of air blasted me downhill. It ejected me from my skis, left like dinner plates when the magician yanks a tablecloth. I would later see the same shade of bruising it caused along the entire right side of my body, clearly outlined at my ski-boot's top and metal watch band.

The tumbling began. Complete lack of control from head to toe. Arms twirled and hands punched my face. Knees smashed against each other. My body was contorted and yanked in every direction. Every ligament strained. I've never considered myself particularly limber, regardless the heel of my right boot hit the back of my head.

Explosions of water and ice and everything in between. The detonations were more wet than solid; the energy inside so ferocious it had melted the medium. I instantly had no idea which way was up. Blasts mushroomed from every direction towards every direction across and through my body. Folks who study avalanches later told me the steep terrain would have propelled the slide well above 100 mph.

And then the unimaginable: the slope geography turned up the volume. Pressures increased as I entered the chute. Temptation, or as the locals call it Tempter, is a 2400' vertical mountainside shaped like an hourglass—wide open terrain at the top and bottom, with the waist perhaps 800 feet long and narrow enough to not fit jump-turned skis much more than 200 cm in the early season or low snowfall years. When viewed from uphill, this V-shaped corridor was straight unless one counted the various rock formations protruding from either side.

We'd had snow that year but not copious amounts, and by my best guess, the narrowest opening was still less than 10 feet wide. Traveling

*Trigger warning:  
explicit  
description of  
a near-death  
encounter via  
avalanche*



This is Vaughan Shelley, one of the victims, on the left, and myself on the right. I took this photo in January 1989, perhaps a month before the avalanche. ■ TODD RICHARDS

at over 100 mph hoping to pass through a 2+ football-field-long corridor with rock walls forming a narrow passage without any control was the exact opposite of what I'd just performed flawlessly only seconds before. A desperate roll of the dice with nothing but death a probability instead of the perfectly controlled descent from years of accumulated skill.

Various forms of liquid and solid cannoned down my throat, stuffed into my sinuses, and packed under my eyelids, its penetrations powered by immense pressure. I mistakenly assumed my eardrums burst when my hearing suddenly vanished; later I discovered it was because snow was packed forcefully against my eardrums. Cold slop rushed up my pant legs and sleeves. Zippers popped; seams failed; clothing tore.

My left boot hit something that shattered two buckles and pinwheeled me inside Mother Nature's Slush Puppy machine, a churning tumbling whirlpool of explosive activity beyond description. This was where both my companions died of massive injuries from multiple collisions. Neither survived the ride to the bottom. Both funerals had closed coffins.

I miraculously shot straight through the choke, but the violent tumbling continued. I was soaking wet as if I'd jumped fully clothed into the Arctic Ocean. I thought of the big waves I'd body surfed as a kid on Cape Cod with my cousin Barry. Before this day, I would have considered some of those wipe-outs 'huge.'



Here are two photos of Temptation after the avalanche. I took them from a helicopter. Vaughan's father rented it and invited me, he wanted to see where the accident occurred. The photo below shows more-or-less the top of Temptation, the photo at right shows the choke. ■ TODD RICHARDS



The tumbling then unexpectedly stopped when a strange weightlessness began. The countless flakes of snow and drops of water paused their attack against me, instead falling alongside me. We were in laminar flow, directional unison, as we went over the cliff. This was good news; it meant the horrific ride would soon be over.

I'd never gone over the cliff, nobody ever had. Its 80-foot drop is at the very bottom of Temptation. Skiers avoided it by turning left and traversing through the trees to get to the bottom of the ravine. It was then just a gentle two-mile slide alongside Bear Creek Canyon to get back into the beautiful town.

But here I was going over it with a surprisingly soft landing and a sudden slowing of speed. I thrust my left hand to the direction of light. The lower levels of the snow stopped before the upper levels, so I slowly rotated to a stop, my left hand's bare fingers on the snow's surface. I was star-fished below, a frozen position of a mid-jumping-jack.

I could not inhale. Slop filled my mouth, was well down my throat and packed up my nose. I

chewed it, tried to swallow but could not, the passage blocked by just more of the same. It slowly melted against the walls of my esophagus. I swallowed hard and the large mass descend coldly into my belly. My eyes had a similar situation—snow packed under my eyelids. I squeezed them shut and felt the jagged crystals turn soft against my corneas and run like tears down my cheeks. Snow packed into my sinuses began to melt and run out my nose.

My airways were now clear, but I was still suffocating. Inhaling only brought more of the slush. I closed my mouth and tried to suck air through a sliver between my lips without success. Frozen particles went into my nose. I left my eyes open but could only see a blurry white. The cold crystals stung against my eyeballs.

My only chance was to dig down with my exposed left hand. It was remarkably difficult as I initially could not bend my arm. I articulated my wrist and rotated my arm like a tiny backhoe, digging out my arm with my arm. I could soon flex my elbow and dug downward towards my face with the sensation of drowning.

I brushed the mashed potatoes consistency from my mouth and nose. I swallowed, spit, coughed, snorted, and screamed in rapid repeated succession, the echoes bounced off the canyon walls. I was miraculously still alive and thought I would survive, hoping my companions would do the same.

After catching my breath I thought I could just pop out of the snow but immediately discovered there was nothing to push against, nothing to pull from. I was suspended, trapped, and aware that each exhalation of my rib cage allowed the pack to settle and sink just a little more, preventing each new inhalation from being as big as the previous one.

With one hand, I dug the snow from around my neck area and tossed it out of a funnel that began to form, exactly an arm's length deep. I clawed with my knuckles because using fingers bent my nails backwards. My skin began to shred. It hurt but I didn't slow; breathing was more important than skinned knuckles. The snow grew streaks of pink. The settling continued. My lower ribs pressed hard against the firm squeezing mold.

I learned at a young age that my lungs held more than average volume, benefits of my genetically large rib cage. It served me well now. I inhaled as much as I could to resist the squeeze of the settling, trying to never fully exhale, a rapid succession of taking air in, and only exhaling until I felt the medium settle more.

In a short time the upper section of my front chest was exposed, allowing near normal breathing. I screamed for help a number of times but heard only my own echoes. I yelled my companions' names but neither answered back. A horrible thought crossed my mind: that they could both hear me, but only because they were both buried beneath me.

I started shivering which quickly grew in intensity. Prior to this moment, I would describe shivering as a fairly mild internal reaction, but now it radiated outwards. My arms shook and my legs quaked inside their molds. My hair, once wet, was now frozen in place against my scalp. No matter, there was only one thing to do: scrape, scoop, toss, repeat. I learned that a quaking single hand can toss a remarkably small amount of snow.

I dug towards my right hand which was outstretched perpendicular. Scrape, scoop, throw,

even though most of it didn't clear the rim of a funnel I was quickly forming. If I didn't toss the small handful far enough it just tumbled back to where it originated. I tried tossing it behind me only to have it fall down the back of my neck. The sun was warm on my face, but my teeth rattled uncontrollably. I kept inadvertently biting my tongue and tasted blood.

Thinking it would be my ticket to an easy escape, I continued digging towards my right hand. After perhaps 30 minutes, I moved enough snow from my right shoulder and biceps area to free my arm. I gasped with joy convinced I would exit in moments as I now had both arms to push with. I eagerly planted them on the bottom of the funnel now below my armpits and pushed.

Nothing.

Initially I was not disappointed in the complete failure; clearly I had not taken the effort very seriously. I thought of Olympic weightlifters; they don't just walk up to the bar and heave. They inhale and exhale, concentrate, and give a pause before focusing their huge effort. I smoothed an area under my armpits flat and level, I planted my elbows into the wall behind me and spread my hands against the groomed cold lower surface. I closed my eyes, concentrated, took several deep breaths, and mentally counted to 3 before pushing downward with shoulders, arms, hands, and everything in between. The strain was lengthy and fierce; the most force in a single direction I had ever generated. It sent my head spinning, my closed eyes saw stars. I'm sure my face was dark red.

Nothing. I didn't move a single millimeter.

My ski boots were anchors. The tops of my feet locked me in place. If I could somehow remove my feet, my legs could slip upwards. Once proud of how stiff and articulated my custom-fitted orange Lange boots were, I now cursed them for not being bedroom slippers.

I kept digging with both hands and figured if I could dig down far enough I would be released. Scrape, scoop, toss, repeat. My funnel's walls were too steep, the deeper I dug, the more snow tumbled in. I reached to the rim and increased the circumference. I dug down more but only another inch before having to again widen the circumference of the rim. It was a maddening function of the medium's instability. It seemed I had to move every ounce at least twice. I'd already been there over an hour. The shivering grew intensely.

My body temperature, the shivering, and wet but now re-freezing snow had formed a shell around me—a continuous hard surface ¼ inch from my exterior. It felt smooth and polished against my knees, hips, and bottom. I thought of the 'chair' I frequently made along my parents' driveway after shoveling a New England storm. I would jump backwards into the snowbank to form a perfectly-shaped recliner, comfortable as it was formed by my body. I remember even closing my eyes to enjoy the warm winter's sun.

Then I woke up.

Still in my funnel. Like falling asleep while watching TV, I could pinpoint the second I awakened, but exactly when I dozed off was a mystery. I went back to digging but with ferocity, I feared



hypothermia was setting in. I could fend it off only with faster movements. I screamed a few more times.

By now the funnel's floor was now just below my rib cage, but well above my belly button. The water created by the snowmelt during the slide had trickled downward and re-frozen. The deeper I dug, the firmer the cement was. I was no longer scraping snow; it was more a form of ice. My knuckles could do little against its hard structure. I punched it with bare fists to break it, then scooped and tossed the fragments.

The shivering had slowed and eventually stopped. At the time I thought my more-aggressive movements had somewhat warmed me, but eventually the dismal thought of severe hypothermia set in. I couldn't feel my arms past the elbows or legs past the knees. My body was sacrificing its extremities by constricting veins to save the remaining warm blood for vital organs.

My hands had balled into fists. I pried fingers open with my mouth, but they snapped shut like a sprung door hinge. I could still scrape, but fisted hands couldn't effectively scoop or toss. I removed my season/employee pass from around my neck. The credit-card-sized laminated badge now became the smallest snow shovel in recorded history. Punch, scoop, throw, repeat, one teaspoon at a time.

I missed the ability to extend my fingers, nothing I considered important until now. I thought of President Nixon when he finally left office in the Watergate years, saluting double peace signs when he last boarded the helicopter.

I woke up again.

Losing consciousness twice was an ominous indicator. Falling asleep during this truly desperate time seemed incredibly lazy. Would I wake if there was a third? I'd read about climbers on Mount Everest who sat down never to rise again, despite others pleading with them to get up, they rarely would or could, claiming they just had to rest a few more minutes to gather strength—a horrific unknowing slow path towards certain death. Many of them are now ominous permanent fixtures on the mountain. I understood them now. Despite the obvious need to work hard and fast, my body told myself only to stop and rest, to gather needed strength. I've been stuck for approximately 90 minutes.

I woke up again.

My balled fists now curled inwards and my biceps remained strangely flexed resembling a praying mantis insect. It was difficult to even hold my season pass let alone maneuver it correctly to toss impossibly small amounts of snow. I couldn't straighten my arms, so I could no longer reach the top of my funnel. My arms felt as useless as those on a Tyrannosaurus rex. My legs were equally trying to fold. My knees pressed forward. My body was coiling.

I thought of my parents, how eternally sad they would be. I wanted them to know that it was my own stupid fault, no blame placed on any other shoulders, and dying this way did not hurt. Hypothermia was merely shivering followed by a nap, a gracious way to go. To this day if given the choice I would choose hypothermia as a way to die.

I thought of my friends in the Telluride Ski School, how this would help educate them of the

dangers. I hoped my buddies back at Sugarloaf Ski School would raise a Ballentine for me at The Bag on a Saturday around 4:30.

I wondered how long it would be until, or even if, my body would be found. I hoped soon so the visual would not be painful for anybody. A week in this cold would preserve me well, but if it were months or years, the scene would be very different. I mentally apologized to whoever it would be.

Will animals eat me? Are there vultures at this altitude? I knew they went first for accessible soft tissue: my eyeballs. Could they be removed if the liquid inside had frozen into solid spheres? Perhaps they would go for my tongue instead. They would certainly skip my fingers, even though they were covered in blood, as they were already cold and rock-hard.

I pinched my season pass with the backside of my balled fists and clumsily put it back around my neck for easier identification. I didn't voluntarily close my eyes, but assume it was a short time before I again lost consciousness.

Around this time two thousand miles away both my mother and sister experienced a strange phenomenon. My sister, an actor, had just finished an audition when she suddenly broke down in tears. Unable to explain why, she later described it as a sorrow-filled sense of complete doom. My mother, walking quickly between airline flights in a crowded airport, paused to pick up a penny 'for good luck' though she'd rarely done it before, made more difficult with her arms full of luggage.

Meanwhile, my eyes were closed, but I had no strength to open them. I was shutting down, literally. A sensation of getting smaller. A campfire flame running out of wood. A shrinking ice cube in hot water. I was retreating from this world towards an enormous void that was simultaneously inward and outward. My perimeter both dissolving and becoming the lifeless abyss around me. Vacant of boundaries or direction, it was truly nothing but was enveloping me. A darkness without color or texture. It had no end and no beginning. It was lightless, soundless, and placeless, and yet it reached beyond the three dimensions. I was taking the journey, though I had no control of it.

"That was awesome," I heard, quite clearly.

Skiers. Other backcountry skiers were nearby. I yelled, but no sound came out. I tried again but nothing happened. My physical body long shut down though my thoughts still very active. I heard the clink of ski poles. Scream. Groan. Something. Anything. I tried to wake but could not, my inside banging against my outside, my tiny soul hitting the cold still walls of my exterior. An internal war between eternal sleep and life.

I had, so far, survived a series of one-in-one-thousand events, all for nothing unless I could take advantage of this last tiny sliver of good fortune. I'd beaten all the odds in the Grim Reaper's Casino only to fall asleep before cashing-out and leaving to celebrate. A ski patroller later told me being hit by the avalanche alone could have killed me. Rocketing through the chute with only the loss of boot buckles was an incalculably small possibility—both Vaughan and Paul ricocheted off the walls and had massive head trauma. Being buried relatively close to the surface and upright...close enough I could thrust my hand to the top was a very lucky thing. My companions were later found by a cadaver dog buried more than 12 feet deep.



Regardless now, my would-be rescuers were close by with me not being able to contact them. My soul shook. I internally lashed outwards, battling against the closing down of my senses, my systems, my body itself. It seemed impossible. Pushing huge logs against a swift current, nailing jello to a wall.

This was, by far, the scariest moment. Worse than being hit, carried, or buried by the avalanche by a very large margin. 33+ years later I still have the same horrific dream whereby I understand I am asleep, but I cannot jolt myself awake and it feels as if I never will. This dream comes to me several times almost every year around early February, and it always ends the same way—my silent scream slowly creeps to the surface and turns into a wild yell that awakes both me and everybody in the house. Nothing on that day was scarier. No other event brings me a sense of dread like those last few moments. I was physically well into the process of dying, and yet part of me was very much alive and fighting, though so far, failing. My thoughts were firing red hot while my limbs were frozen logs.



*The old saying  
'Hindsight is 20/20'  
is completely false.  
Looking back in time  
does not give a clearer  
understanding, it only  
skews and distorts.*

And then it finally happened. I don't know why, I can't describe the path, but the connection between my thoughts and body finally occurred. Light sensed as my eyes opened simultaneously with my mouth. Out came undoubtedly the loudest and longest sound I've ever made. A wild rabid moan of countless vowels varying in pitch that stopped only when there was no more air in my chest to propel it. The echoes bounced off the walls of the Bear Creek canyon. I listened for a reply. Was I already too late? Had they already left? Desperate for a response. This was it. If a human responded, I would live, if not I would die. Period.

"Where are you?" I heard in a speaking, not yelling voice that was clearly very close by. The volume changed as if the person was rotating their head as they spoke.

"HERE!" I yelled in a voice that cracked midway. I tried throwing any ounce of snow from my hole. The paired click sound of ski bindings being released and stomping feet approached. "Jesus," he said while peering over the rim of my funnel. I was blue.

#### AFTERWARDS

Physically, I was a wreck for many months. I was lucky to not lose any fingers from frostbite, and the skin I tore from my knuckles when digging eventually grew back, though the scars are still very prominent. But for a long time, everything just hurt. All my joints and ligaments were strained from the ride. It took a few weeks before I could comfortably walk and doing anything requiring coordination was absolutely out of the question.

Mentally of course things were much worse. I saw a therapist less than three months after the accident, and only now I know that I quit very quickly because I was just too scared to discuss it, the emotions were overwhelming.

In the summer of '89, five months after the slide, I was more or less living on my parent's couch, sleeping late, eating a lot and drinking even more. I spent the day watching TV where I discovered NBC sports coverage of the '89 Tour de France. I learned of Greg LeMond's near-death experience from being shot by his brother-in-law when turkey hunting, and literally cried like a baby when he won the three-week race by just eight seconds. He proved to me that anything is possible if I truly wanted to do it. I got off the couch and bought a bike the next day. I trained hard and years later won a few bike races myself. I still ride to this day.

One of the more difficult aspects of the accident was the admission to myself that I was the better skier of the three of us, and though I certainly did not have a lot of experience in the backcountry, my companions had even less. I was certainly not 'the leader,' and it was not my sole decision to ski there that day. Vaughan had skied Temptation Chute the day before, and we'd shared a beer soon after it and planned to go the next day. I honestly don't remember how Paul ended up joining us, and I didn't know him very well. Regardless, as a ski instructor (on my day off) many of

the locals were angry and quite vocal that I had somehow been the principal of our group, and it was my fault that the accident occurred.

It didn't help that the Colorado State DA contemplated pressing two charges of involuntary manslaughter. If found guilty I could easily spend the rest of my life behind bars. I appeared in court in Gunnison for the charges of Federal Trespassing. I plead guilty and offered to the court my hopes to work with local schools and the U.S. Forest Service to help educate. I ended up traveling to Denver and sat for a video recording to tell my story. The film was later edited and distributed to many ski areas who used it to train employees before each ski season. To this day I have friends who are forced to watch it each year.

I'd taught skiing at Sugarloaf in Maine before I moved to Telluride and returned to Sugarloaf to teach again. It was good, my friends understood what I'd been through and were supportive of me coming back to the sport. I eventually moved away from Alpine and into Telemark as a new challenge, and even made it up the PSIA ladder to become a Telemark Examiner.

Perhaps 15 years after the accident I found myself growing increasingly depressed each winter as the anniversary (Valentine's Day) approached. I finally got the courage to find a therapist. At the time a new method of treating PTSD was coming out called EMDR (Eye Movement Desensitization and Reprocessing). In a nutshell, the therapist asked me a series of questions that when I answered were always somewhat negative. Example: "Of the three of you, who was most at fault for the accident?" was always answered with a tearful "me." Then the therapist performed a rhythmic tapping on my knees (while seated) and asked the same question. It is a strange format whereby the input of the knee tapping occupies a part of your mind so the other part can contemplate the question without just falling into the same repetitive rut it previously had. When she asked, "Of the three of you, who was the most at fault for the accident?" I started to giggle with joy, finally able to honestly say "nobody, we all made the same exact mistake."

Above all perhaps the most important lesson I learned is the old saying 'Hindsight is 20/20' is completely false. Looking back in time does not give a clearer understanding, it only skews and distorts and results in 'what if-ing' yourself literally into a form of insanity. I've tried to teach this aspect to dozens of people I've met over the years who have done something that resulted in injury or even death to others. I feel it's the best I can do to relieve their pain. ●



**TODD RICHARDS** now lives in Bristol, Maine, married for 27 years to his wife Sarah, where they own a small gallery and run a website of his wife's art (SarahRichards.com) Their 20-year-old son Sam goes to Brandeis University.

■ BRIAN WEDGE



Ski areas across the northern hemisphere closed, or severely limited, operations in the latter half of the 2019–2020 season due to the SARS-CoV-2 pandemic (COVID-19). In the US, the National Ski Area Association reported that the American ski industry suffered a \$2 billion estimated loss when 93% of US ski resorts closed operations in March, 2020. This continued into the 2020–2021 ski season, with limits on ticket sales and skier capacity. In Europe many resorts were shut down, despite an excellent snow season. As a result of this turmoil and these restrictions, many resort skiers looked to the backcountry as a way to continue their sport.

# COVID 2020

## How Covid Affected Backcountry Skiing In The 2020–2021 Season

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Although minuscule in scale when compared to resort skiing, backcountry skiing has been the most rapidly growing snow sport, increasing 8-fold from 1995 to 2017<sup>1</sup>. There is concern that many of these newcomers may not have the requisite gear and training to safely enter the backcountry. The American Avalanche Association defines education standards for avalanche safety and rescue courses and recommends purchasing relevant safety equipment, such as an avalanche beacon, probe and shovel, and obtaining at least Rec 1 education before entering avalanche terrain<sup>2</sup>.

Following the onset of the Covid-19 pandemic, there had been many anecdotal and media reports of a surge in backcountry use and concerns of a commensurate increase in backcountry avalanche incidents and fatalities [Mander B. Ski in the Wild. *Wall Street Journal*. November 28, 2020; Branch J. Virus rules may factor into avalanche deaths. *New York Times*. February 10, 2021. B:8]. This study was undertaken to help quantify that perception, and to assess how those first entering the backcountry during the pandemic differ from experienced backcountry skiers.

### METHODS

Methods are described in detail in “Perceptions of Backcountry Skiers During Covid-19” in WEM December 2022 (online ahead of publication October 2022).<sup>3</sup>

In summary, the data collection instrument was an anonymous cross-sectional online questionnaire with 29 items incorporating multiple choice, numeric, Likert-type items, visual-analog scales, numeric sliders, and free text entry responses.

Participants were recruited via online postings by regional avalanche centers, avalanche education providers, winter sports news sites and storefronts, and personal social media including Facebook and Instagram.

The instrument assessed several target areas of our study, including the participant’s self-reported skiing/riding ability level, the impact of Covid-19, level of avalanche education, comfort with risk, and confidence in assessing avalanche terrain. These questions, where applicable, were modeled after items in prior studies, which have demonstrated a high degree of content validity<sup>4,5</sup>.

For brevity, the term ‘skier’ was used throughout the text to refer to both backcountry skiers and snowboarders.

### RESULTS

The survey produced a total of 5,674 raw responses over the survey period of March 1–31, 2021, with n=4,792 responses after eliminating 882 early drop-out participants. By recruitment source, the largest group of responses (49%, n=2338) was from organizations in backcountry

and avalanche education, followed by avalanche centers (31%, n=1494), and media or social media websites (16%, n=746). Most responses were from the United States, with only 21 participants reporting Canadian postal codes. Respondents were predominantly young males, as visualized in Figure 1, and mostly established backcountry skiers (84%), with over 10 years of resort experience and 4–6 years of backcountry experience. They reported spending an average of 15 days in the backcountry and 20 days at resorts in a “typical season.”

Since the onset of the Covid-19 pandemic, survey participants reported spending a significantly higher proportion of their time in the backcountry instead of at resorts (Figure 2). Overall, since Covid-19 began, participants reported spending 17% more of their ski days in the backcountry.

In addition, during Covid-19 19% of all participants reported spending almost all (95% or more) of their time in the backcountry, substantially higher than the 8% who did so before Covid-19.

When asked about their perceptions of overall backcountry use, 81% of established skiers reported noticing more people in the backcountry during Covid-19 (n=3898). Established skiers were also surveyed on changes to their own habits due to Covid-19. The majority (97%) reported entering the backcountry with the same number of partners, with none reporting fewer partners



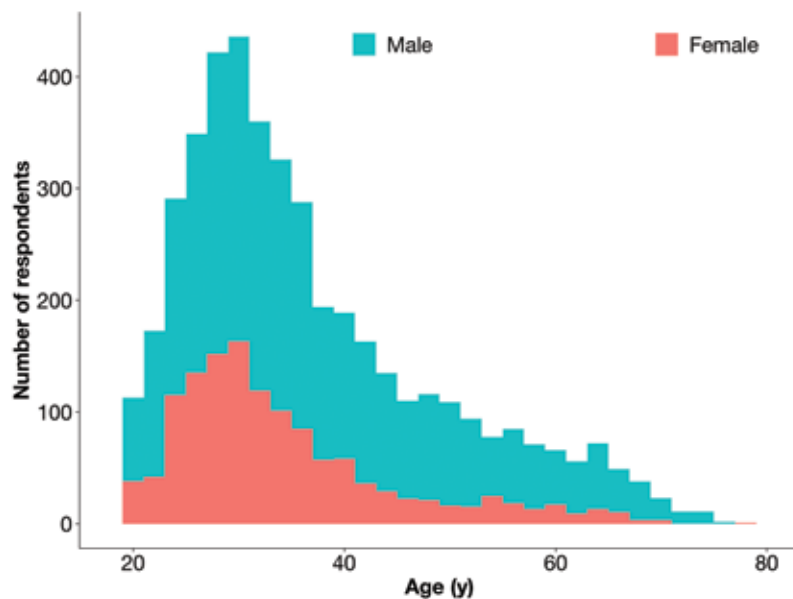


Figure 1: Age of respondents by sex and age

The age distribution of survey respondents by male or female sex and study cohort. Vertical lines within each category denote quartiles with respect to age ( $n=4558$ ). Those respondents reporting a gender neither male nor female ( $n=30$ ), or with an age above 80 years ( $n=4$  males) are insufficiently numerous to be meaningfully visualized and are omitted for clarity.

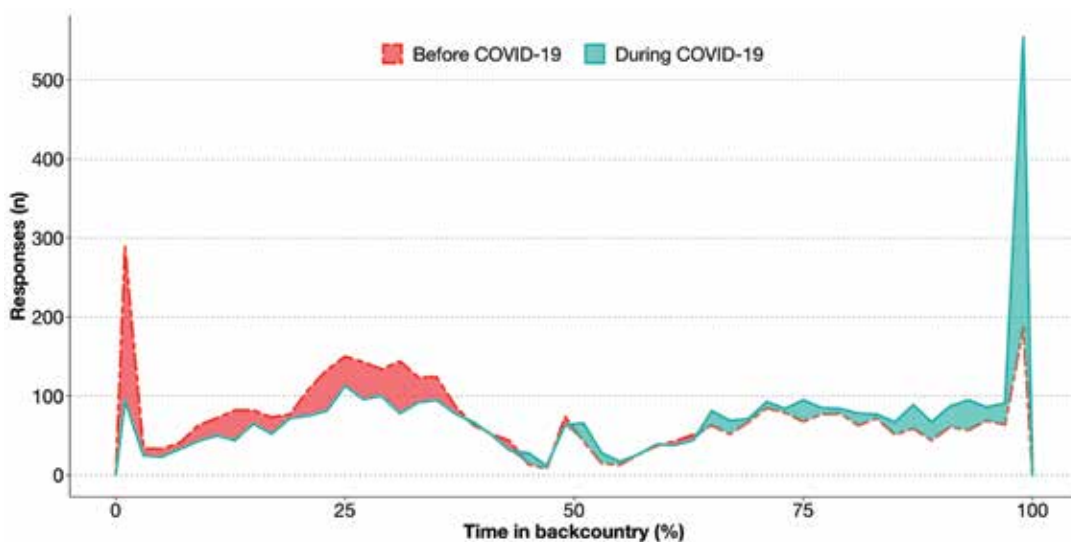


Figure 2: Increase in backcountry versus resort days during Covid-19

Percentage of ski days spent in the backcountry versus in resorts, before and during Covid-19. Participants reported spending a higher percentage of their ski days in the backcountry since the beginning of the pandemic.

( $n=2632$ ). No respondents reported changing the distance they toured from the trailhead ( $n=3125$ ). When surveyed on whether Covid-19 had influenced the frequency of their backcountry use, 27% reported more frequent use, 56% no change, and 17% less frequent use ( $n=4026$ ).

Newcomer cohort respondents ( $n=572$ ) were surveyed about whether certain consequences of Covid-19 were important in their decision to first enter the backcountry. Those factors which participants agreed or strongly agreed were important included resort closures (27%), uncertainty about resort operations (26%), and limited resort access (35%).

All participants were also surveyed on their perceptions of the relative risks of sustaining injury, and of getting Covid-19 in the backcountry compared to a resort. The majority (91%) of respondents felt that they had a higher chance of getting Covid-19 at a resort ( $n=4224$ ). Conversely, 72% of the newcomer cohort felt that they were more likely to get injured in the backcountry, a significantly higher proportion than the 56% of established skiers who shared this belief.

Although most respondents reported having formal avalanche training (Level 1 or higher), 24% of the newcomer cohort lacked any formal avalanche training, compared to 14% of the experienced skiers. Almost all participants reported carrying appropriate avalanche safety equipment (avalanche beacon, probe, and shovel) while in the backcountry, with 97% carrying all three, and only 2% of people carrying none (total  $n=4621$ ).

When surveyed on their willingness to accept risk in the backcountry on a 1–10 scale (from completely unwilling to very willing to take risks), the newcomer cohort reported a willingness of  $2.8 \pm 1.7$  to take risks, compared to the established cohort at  $3.4 \pm 1.9$ . As shown in Figure 3, the newcomer cohort also reported feeling less comfortable assessing avalanche risk in various conditions and terrain than the established cohort, but 73% of newcomers reported confidence in assessing “simple conditions and terrain” with another 23% reporting confidence in “moderately complex conditions and terrain.” In comparison two thirds of the established cohort were confident in complex and all conditions and terrain.

## DISCUSSION

The Covid-19 pandemic had a direct and severe impact on ski operations starting with resort closures in March of 2020. This study attempted to assess how the changes in ski area operations affected backcountry skiing. Key findings of this study include confirming that there was an increase in backcountry skiing by both new and experienced users; changes in ski area operations and concerns about Covid-19 fueled at least some of this increase, new backcountry skiers were less confident in their ability to assess avalanche terrain (but probably greatly overestimated this ability) and were less comfortable taking risks, both groups felt the risk of injury was higher in the backcountry than at resorts (with newcomers judging this risk higher than established users), and lastly, almost one-quarter of newcomers did not have any formal avalanche training.

Our study confirmed what many backcountry users already suspected, and as reported by the media: there was a large increase in backcountry use during the pandemic. 81% of our experienced respondents reported seeing more people in the backcountry and 17% of these respondents reported increasing their own percentage of ski time in the backcountry. This was also reflected by the fact that the proportion of our respondents who spent nearly all their time in the backcountry had doubled. Although a majority of the new backcountry skiers did not report that Covid-19 was a main motivating factor for getting into the backcountry, one-quarter reported resort closures and over one-third reported limited resort access were major factors.

New backcountry skiers reported feeling less confident about their ability to assess avalanche terrain than experienced skiers, but given their lack of experience, they still seemed surprisingly confident. This may reflect the Dunning-Kruger effect, where they just don’t know what they don’t know, and overestimate their ability. The very high confidence in assessing terrain of the established cohort also merits attention, especially in light of the fact that this cohort seems to be over-represented in avalanche fatalities.<sup>6</sup>

The winter of 2020–21 was unique not only due to Covid-19, but also because of the persistent and widespread unstable snowpack across the wider US Mountain West. This, unfortunately, was reflected by a historic number of avalanche fatalities<sup>7</sup>. Contrary to popular belief, the US Forest Service notes that most of these recent avalanche fatalities (amongst all types of backcountry users, including snowmobilers) were experienced



recreationalists<sup>7,8</sup>. This may be a reflection of the self-described differences in ability and risk perception reported by the more experienced established cohort.

Another interesting finding of our study is that both new and experienced backcountry skiers felt that the risk of injury is higher in the backcountry than at ski resorts. While accurate injury rates in backcountry use are notoriously difficult to obtain, one prospective study of ski tourers (which did not include cross country skiing) in the Alps reported an injury rate of 2.2 injuries per 1,000 tours, excluding minor “injuries” such as blisters<sup>8</sup>. This is very similar to the rate of injuries at ski areas of 2–3.7 per 1,000 skier days<sup>9</sup>. Concerning fatalities, we have better information on the numerator (number of fatalities) in both the backcountry and resorts, but the denominator in the backcountry (number of ski/tour days) is still very unclear. Tackling these uncertainties, Niedermeier, et al, estimated that the risk of a fatality is between five and six times greater from ski touring than at resorts, primarily due to avalanche accidents in the backcountry.<sup>10</sup>

The final point from our study that merits discussion is that nearly one in four new backcountry skiers did not have any formal avalanche training. Many avalanche safety course providers reported being overwhelmed with clients during the latter half of the 2019–2020 and the entire 2020–2021 season, which likely contributed to this issue. Looking forward, if this cohort continues to ski without this training, their risk-taking behaviors are likely to increase with more comfort in the backcountry environment, and positive reinforcement from each run completed without consequences—despite having made potentially dangerous choices<sup>11</sup>. It will be important to determine if those who continue backcountry skiing will seek out the appropriate training.

## LIMITATIONS

This study has several limitations, including those common to all survey-based studies, including such biases as; sampling, selection, non-response, social desirability, acquiescence, anchoring, and recall. Additionally, we recruited most respondents through avalanche educators (49%), and avalanche forecast centers (31%). This likely biases responses towards persons already engaged with avalanche safety, with the expectation that this likely causes our estimates and conclusions to substantially underestimate skiers with little to no avalanche education, and those who are not aware of avalanche danger. Lastly, our study was only intended to assess subjective changes in backcountry use and perceptions and was not designed nor able to assess the quantitative growth, or exactly how many new backcountry skiers Covid-19 has created compared to baseline.

## CONCLUSIONS

With over 4,000 responses, we found support for the media reports that backcountry use increased substantially during the Covid-19 pandemic, and that Covid-19 was influential in some people’s decision to first enter the backcountry. We also found that while backcountry novices were less willing to take risks in the backcountry and (appropriately) had less confidence in their ability to assess avalanche terrain, both newcomers and experienced backcountry skiers may have overestimated these abilities. Lastly, it is concerning that

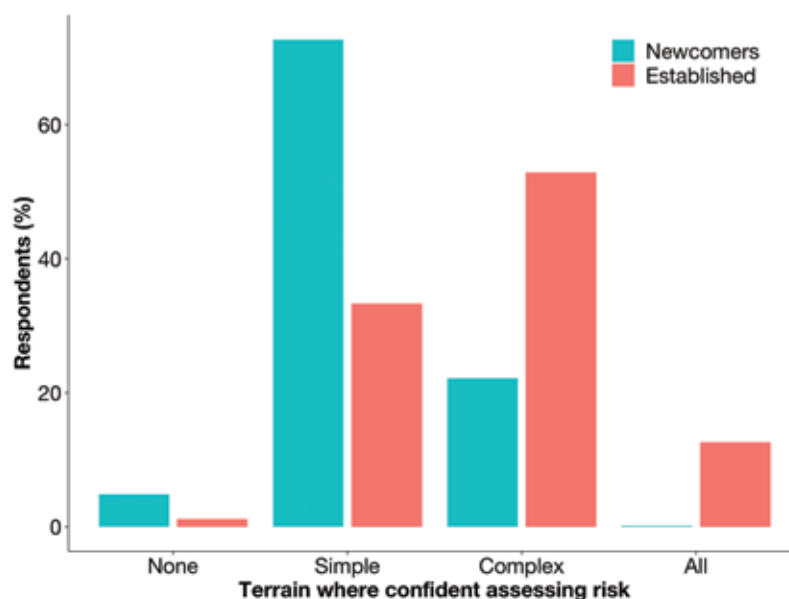


Figure 3: Confidence in assessing avalanche risk in various conditions and terrain

Participants in the newcomer cohort reported a median confidence in assessing avalanche risk in “simple” conditions and terrain, which was significantly lower than the established cohort who felt comfortable assessing risk in “moderately complex” conditions and terrain (n=4566). “None”=Not confident at all; “Complex”=Moderately complex.

one quarter of new backcountry skiers did not have any avalanche training. Ongoing research should be undertaken to determine if this is a trend, and if so, how to reach these newer backcountry skiers.

## ACKNOWLEDGMENTS

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## AUTHOR CONTRIBUTIONS

Study concept and design (all authors); data acquisition (EV, AC, ST, DF); data analysis (EV); drafting of the manuscript (EV, AC, ST, DF); critical revision of the manuscript (EV, JH, JJ, DF); and approval of final manuscript (all authors).

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## DISCLOSURE STATEMENT

We report no conflicts of interest. Our principal investigator, David Fiore, MD is a volunteer board member and medical advisor of the Sierra Avalanche Center. His involvement with this research is independent of that appointment, and the Sierra Avalanche Center has not endorsed or otherwise supported this study other than hosting our survey URL on their webpage. ●

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# CRITICAL REFLECTIONS

## 2021-2022 AVALANCHE CENTER SEASON SUMMARIES PART 2: ALPHABETICALLY, F TO W

### FAC

Flathead Avalanche Center

Atmospheric Rivers bookended the 2021-22 season with dramatic but warm storms that dumped sometimes astounding amounts of precipitation at upper elevations. The November ARs that pummeled Washington and British Columbia sideswiped the Flathead Region, bringing several inches of rain to mid elevations and jump starting snowpacks at upper elevations. We saw a similar event in May. These seemed like powerful storms until mid-June, when a late-season AR reset our understanding of what “powerful” can mean. Over a five-day period, Snotels in the region recorded 8 to 11 inches of precipitation, including eight inches in one calendar day at the Noisy Basin Snotel. Snow heights jumped 20 to 40 inches over the period. No longer will a few inches of SWE look like a big storm.

Between these end-pieces, the Flathead region saw roughly average snowfall but often cold temperatures, thanks to several episodes of Arctic air pouring south. The persistent weak layers that formed were short-lived. Most of the season’s avalanche activity involved small to large avalanches, with the most active period in early March. The largest reported slides were a natural D4 hard slab in January and two D4 natural wet slabs in late March.

Over the season, we had seven reported incidents and near-misses. That tally is half of 2021’s and more typical of most seasons. Five people were caught, with two partially buried and one injured. The last incident was reported May 20th.

Cool temperatures and late season storms prolonged the transition to a summer snowpack. After the staggering mid-June AR, snowpacks in the region remained at 180 to 340% of median, with 40-80 inches of snow still on the ground above 6000 feet.

The FAC issued forecasts on 126 days this winter, from Dec. 6 to April 10. Two forecasters collaborate to produce each morning’s products, often aided by interns. We published 177 total products (conditions

reports, daily forecasts, and weekly conditions blogs) between Nov. 10 and May 27. Other highlights from FAC and its critical partner, the Friends of the Flathead Avalanche Center:

- Observations submitted by FAC staff (forecasters, observer and interns): 150
- Observations submitted by the public: 350
- Individuals submitting public observations: 97
- Day with the most reported natural avalanches: March 1 (74 of which were D2 or larger)
- Days with D2 or larger slides reported: 30
- Reported incidents: 7, with 5 people caught, 2 partially buried (non-critical), and 1 person injured
- Days with high avalanche danger: 5
- Miles on this season’s loaner sled (thanks, Dream Marine and BRP!): 759
- Cost of repairs to loaner sled: \$733
- Cost of repairs for damaged coolant system on FAC snowmobile: TBD

- Injuries to FAC and FOAC staff: bruised knee (vehicle accident).
- Avalanche safety classes and community workshops hosted: 37
- Students: 1,133
- Youth participants: 584
- Total webpage views: 284,805
- Forecast Page Views: 61,945
- Date with most single views: January 8, 2022, 1,157 views
- Unique visitors: 31,723
- Audience growth across social media platforms: 14%
- Instagram reach: 98,237
- Facebook reach: 66,972
- YouTube views: 5,393

Behind these numbers is a team of Flathead National Forest personnel and the staff of the Friends of the Flathead Avalanche Center. The FAC team consisted of me and returning forecasters Clancy Nelson, Cam Johnson, and Mark Dundas, with Mark in his first season as Lead Forecaster. Guy Zoellner returned one to two days a week as our reliable field partner and observer. Three interns supplemented the team at various points: Rick Ziegler, Christina Marie Salzmann, and Megan Guinn.

The FAC team couldn’t devote as much time to field work and forecasts without the invaluable work of the FOAC staff—Emily Struss, Clare Menzel, Meg Killen, and a team of capable, engaging instructors. They expanded their sponsors and granting partners this year and were able to enhance engagement with our community with two new initiatives, a weekly forecast quiz and monthly community chats.

The weekly engagement quiz was the brainchild of FOAC’s Clare Menzel and Emily Struss. Each Friday, Forecasters wrote three questions that were posted on Instagram. The answers could be found in the weekly conditions blog published earlier that day. We had surprisingly high participation—5,398 engagements—during the seven-week pilot period. It’s a project we’ll continue next winter, as it allowed us to reinforce key points from our products in a new venue and drive users to our conditions blog and weekly videos.

**FAC:** The third skier down the slope triggered this soft slab avalanche. She was carried and pinned against a tree by the debris, but uninjured. ■ BURKET KNIVETON



The Fireside Community Chats focused on near-misses and accidents. They included a forecaster, a rider involved in a near-miss or accident, and local skier/psychologist Sara Boilen. She facilitated conversations between the participants and an online audience. The three sessions had 69 digital attendees. We hope to conduct these sessions in person next season.

The Avalanche Alliance awarded FAC and FOFAC funds for a new weather station that we plan to install in the Whitefish Range in July. A second grant from Yamaha supplemented that award. The Link Mountain station will fill a massive data gap in our largest forecast zone, in an area that's seen the second highest concentration of fatal accidents involving motorized riders. A big thank you to the Avalanche Alliance and Yamaha for their support this key project.

For next winter, FAC plans to continue its established forecasting and fieldwork efforts. A fifth forecaster will help us keep tabs on conditions in our 1800-square-mile forecast region. FOFAC plans to launch an in-person, State-of-the-Snowpack series. The 30–40 min discussion of the snowpack is scheduled for every other Friday starting in December and will be hosted by local breweries

and distilleries. The goal is to reach riders who haven't attended avalanche classes in a long time.

The FAC and FOFAC forecasting and education efforts are made possible by USFS and Glacier National Park, a grant from Montana Fish, Wildlife and Parks, and donations and grants to FOFAC.

—Blase Reardon



Snow began to accumulate in our forecast area in early October. On October 12 there was enough snow on the ground for us to issue our first early season bulletin. Warm dry weather through October eliminated much of the snowpack at low elevations and on sunny slopes. We issued our second early season bulletin a month later, on November 7. That day we had the first reported



**GNFAC:** Crown of the avalanche that killed a snowmobiler on Lionhead Ridge on February 6, 2022. ■ GNFAC



**GNFAC:** Burial location and debris of slide that killed a rider near Cooke City on February 19, 2022. ■ GNFAC

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avalanche of the season which was a skier-triggered dry loose avalanche in a steep couloir. The skier was caught but uninjured. Through November we issued snowpack updates 2–3 times per week as snow slowly stacked up. Small storms added no more than 6–12” each week, and warm temperatures slowed the growth of the mountain snowpack.

Avalanche activity in November and early December was limited to small wind slabs and wet loose avalanches. There were a couple avalanches on persistent weak layers near Cooke City where it was cold enough to grow weak facets at the ground and have enough snow to drift into a slab.

We issued our first daily forecast with danger ratings on December 10, with a moderate danger throughout the area. Through December, steady snowfall and wind kept danger at Moderate to Considerable. We issued two consecutive avalanche warnings for the mountains near Island Park when they were favored

with heavy snowfall in mid-December. These would become the only warnings we issued this season.

On December 27 two snowmobilers were killed in an avalanche on Scotch Bonnet Mountain near Cooke City. The avalanche broke 3–5 feet deep under a slab of wind-drifted snow on a layer of facets 1.5 feet off the ground. The area had received 7–9 feet of snow equal to 8.9” snow water equivalent (SWE) from December 6 through 27.

January started with the season's first forecasted Low danger in parts of our area. On January 6, danger was elevated to at least Moderate through the entire area before extended dry weather allowed danger to drop to Low throughout the area from January 15–20. During this period, the January drought layer began to form. We anticipated avalanches to fail on this layer with each storm that followed its formation, but snowfall amounts were underwhelming with almost every storm. Danger bounced between Low and Moderate through late



February, and slabs of new snow and wind-drifted snow seemed to quickly facet into another weak layer on top of a weak snowpack.

On February 6 a snowmobiler was killed in an avalanche on Lionhead Ridge near west Yellowstone. Danger was rated Low in that area for the 23rd day in a row, and the area had received only 1" of SWE over that time. The avalanche was a slab of snow that formed after steady strong westerly winds drifted a few inches of recent new snow. It broke 4-12" deep and 75 feet wide, failing on weak facets or surface hoar that formed during dry weather in mid-January.

Dry weather persisted through February, and most of the area had low danger when there was no new snow. Cooke City was the exception, where enough snow piled on top of the January and early February drought layers to maintain a heightened danger for a persistent slab avalanche problem. In Cooke City danger was Moderate or higher every day except one from February 5 through March 30.

On February 19 a snow biker was killed in a large avalanche on Miller Mountain near Cooke City. Two snow bikers were high on a slope; one stopped on a small ridge while the other climbed higher and triggered the avalanche. He was carried through a gully and over a cliff where he was partially buried with his arm and airbag visible and head one foot under the surface. Danger was Moderate and the area had received about a foot of snow equal to 1" SWE over the previous week along with strong westerly winds. The avalanche likely broke on facets that formed in January in an area that was thinly covered and recently wind-loaded.

Through March we dealt with the standard mix of spring avalanche problems. Enough new snow and warm sunny days warranted Moderate danger most days. A few storms were large enough to bump danger to Considerable. At the end of March, the snowpack was hit with above-freezing temperatures for seven days in a row and not freezing most nights. Danger quickly rose to Considerable for wet snow avalanches and eventually was rated High for a day on March 28. Due to a shallow snowpack we did not see huge wet slides, but activity was widespread during this period with many D2 Wet Loose avalanches and a few large wet slabs.

Following the late March warmup, cold temperatures froze the snowpack and danger quickly dropped to low to start April. A few spring storms the week of April 5 created a period of dangerous avalanche

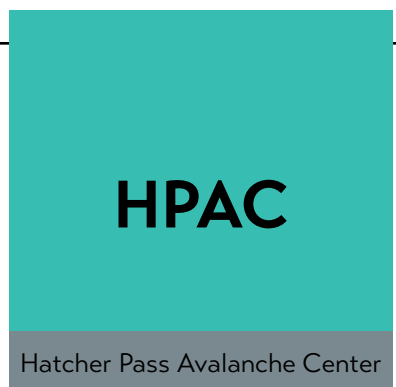
conditions. Danger subsided for our last forecast on April 10.

Through the end of April we issued avalanche and weather bulletins every Monday and Friday. After we culminated daily forecasts, frequent wet cool storms through May were the biggest of the season. These storms created dangerous late season avalanche conditions and provided a much-needed increase to our snowpack.

Despite having frequent Low danger and few days with High danger, we still had an average number of accidents, fatalities, and close calls. The nature of avalanche activity was relatively smaller slides in higher consequence terrain or less frequently traveled areas. It was a mellow winter in terms of snow, but enough snow fell for an average number of people to be out in the mountains near avalanche terrain.

The GNFAC team of four full-time avalanche specialists included Doug Chabot, Alex Marienthal, Dave Zinn, and Ian Hoyer. Hannah Marshall was our intern and joined us for many field days. The Friends of the Avalanche Center and the GNFAC worked together to teach avalanche classes. We ran field classes and lectured both in person and online. In total we offered 82 classes to 3,349 people, including 391 kids under 18 and 283 snowmobilers.

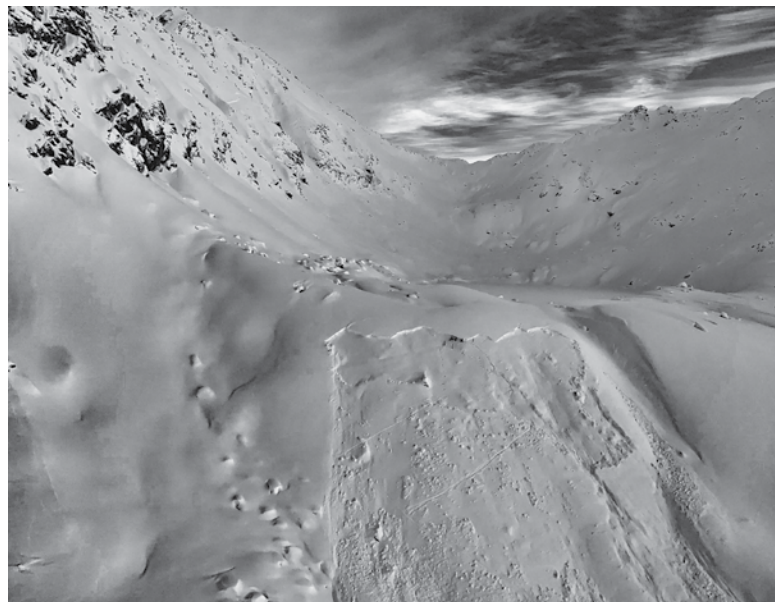
—Alex Marienthal



**Another successful season accompanied by challenging weather events.**

HPAC has been forecasting since 2009 and transitioned to an independent non-profit in 2019. Our organization has grown but still remains small, grassroots, and locally supported. Highlights for this season include new forecasts on Thursdays in addition to the Saturday weekend forecast, additional forecasts on all days with a Considerable or higher avalanche danger, professional observations, a huge leap in our education outreach in local schools, and successful grant awards.

Some challenges this season were related to long term weather



**HPAC:** Gold Cord Lake natural avalanche on January 25th. Small loading events produced avalanches of this magnitude throughout the season. RYAN VAN LUIT

changes. Over the last several seasons our snowfall comes later and lasts longer into the spring and summer. Our region has been considered continental for as long as the old timers can remember but the last several seasons we've observed significantly warmer weather with more rain events, as opposed to the previously predominant persistent slab problems. More rain on snow

events have formed problematic buried rain crusts that persist until the spring shed cycle.

Our season started off like the old days, cold with 0 to -20° for six weeks, turning the shallow Oct snowpack into our famous square powder, and creating a setup for PWLs.

October, November, and the first half of December were rather

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boring with little precipitation, mostly green light conditions, low danger days, and forecasting for dry loose. Around December 25 our weather patterns shifted, bringing more precipitation, unusually warm rain events, and lots of wind.

Earlier in the season, widespread persistent weak layers consistently failed numerous times with small loading events of 4–8” of snow.

A February fire hose eventually buried the eight-foot-tall snow stake at the Marmot weather station (3550’), overloading the snowpack and resulting in numerous and voluminous avalanches that crossed and covered the road system. This historic storm occurred from February 15 to 22, and brought 50” of snow and 8” of water to Hatcher Pass. We not only reached 100” on the Marmot snow stake but buried it. We forecasted High Danger with Avalanche Warnings three consecutive days and four of five days that week. The term 100-year-cycle has taken on new meaning; we will have to recalibrate after having two 50–100-year cycles in consecutive years.

Austin Hart from NRCS compiled data showing February 2022 breaking records for snow accumulation at the Independence Mine Snotel. He did a second study comparing snow course data against Snotel data in the same area, which showed an October 2019 storm breaking that record. This was a linear model of Snotel data to snow course data. This model brought the February 2022 storm in as the number two record for the period of 2000–2022.

Impressively, last season’s Easter cycle and this season’s Valentines cycle both resulted in unusually large avalanches crossing the road system. The Valentine’s cycle was similar to last season’s Easter cycle but produced more and larger avalanches. Both produced numerous D2–D4 avalanches that crossed the road and resulted in road closures for two weeks in 2020–21 and two months in 2021–22. The Valentines cycle produced even larger avalanches that crossed the upper and lower road, as well as the road between Marmot and the Hatcher Pass lodge, with avalanche debris from south and north paths meeting in the Little Su river. We documented paths never recorded before in our 100 yrs of historical data. 10 paths crossed the road in various locations. Due to lack of state resources, the road stayed closed for over two months.

Road closures have increased the use of snowmachine access to the area, increased the remote nature of the area, and increased potential response times for any emergency response. Thanks to the AMDS

loaner snowmachine program combined with grants, HPAC was able to use snow machines to regularly access terrain to continue forecasting throughout the closure and the entire season.

Cold temps persisted long into spring, so long that we finished forecasting mid April and never saw a wet slab cycle until the beginning of June.

**Takeaways:**

- 1” of water used to be considered a lot of SWE in a storm at Hatcher Pass
- Buried rain crusts persist and have large continuity and produce large to very large avalanches.
- Long term cold temp events necessary to facet out buried crusts are not as reliable anymore
- Less precip/SWE/ snowfall is producing larger avalanches more frequently when the snowpack has buried rain crusts, compared to our historically continental snowpack with buried facets and DH weak layers

—Allie Barker and Jed Workman



A welcome lack of avalanche accidents defined the 2021–22 Idaho Panhandle Avalanche Center (IPAC) season. Meanwhile, both the Forest Service and nonprofit Friends of the Idaho Panhandle Avalanche Center (FIPAC) made critical strides in program development. Strong cooperation between the Forest Service and FIPAC produced a very successful year.

After a slow start, winter roared in with a big storm December 10. We issued a special avalanche bulletin for the isolated but rapid increase in avalanche danger and watched terrain start to fill in. Regular avalanche forecasts began on December 17. Another powerful storm prompted the first High avalanche danger and avalanche warning of the season on Christmas Eve.

January quickly checked our December optimism for an old-fashioned snowy and cold winter. A rain event around January 12 produced

a prominent crust. A little snow accumulation above the crust paired with many clear cold nights to promote surface hoar and near-surface facet development for the remainder of the month. A storm finally buried this well-developed crop of surface hoar February 1. Relatively small accumulations above this buried weak layer produced few and small avalanches. We waited for a larger storm and avalanche cycle, but instead received spring-like weather that culminated in a Valentine’s Day gift of a robust melt/freeze crust. Our Kootenai forecast zone, especially the relatively colder Purcell mountains, escaped this warming and kept persistent weak layer on the avalanche problem list until March.

March did indeed come in like a lion. Heavy snowfall accumulated quickly and slowly turned to rain everywhere, even the high peaks of the Cabinet Mountains. We issued successive avalanche warnings and expected widespread natural wet avalanches. While a few large wet slab and wet loose avalanches were observed, this cycle reminded us that the snowpack adjusts well to slow change, even if that slow change is a significant and prolonged warming event.

All this early March wetness refroze and produced the second widespread crust of the season. When snow returned, facets and generally poor bonding to the crust kept us on our toes through most of March. Warming late in the month brought many wet loose avalanches and stabilized the persistent weak layer on that early March crust. A few more storms and an overall cold April rounded out the forecast season. We issued the final avalanche forecasts of the season on April 9.

IPAC issued regular avalanche forecasts each Tuesday and Friday through the forecast season with general avalanche information statements issued the day following each forecast. A total of 35 forecast cycles across three forecast zones resulted in 104 total avalanche forecasts and 109 total general avalanche information statements. We issued a combined total of 11 avalanche watch, warning, and special avalanche bulletin products.

Several developments on both the Forest Service and nonprofit Friends of the Idaho Panhandle Avalanche Center (FIPAC) sides continued incremental growth for the program. Friends of IPAC hired Jon Totten as Education Coordinator and Danica Gilbert as Membership and Development coordinator, filling these two paid positions for the first time. Jeff Thompson returned in a forecaster and educator role, and many local instructors helped with avalanche classes, rounding out our Friends group paid staff. Friends of IPAC also added a few new and valuable board members.

The Idaho Panhandle National Forests filled a full-time IPAC Director detail for the winter. Though temporary, this marks the first season for IPAC with a full-time Forest Service Director. Ryan Matz, from the Mt. Hood National Forest and formerly of the Mt. Washington Avalanche Center, filled this role. We made progress towards a permanent, full-time version of this position and are optimistic that the Idaho Panhandle National Forests will support IPAC by filling this crucial Director position soon.

Many part-time forecasters and our full-time director make up the IPAC avalanche forecast team. Full-time Idaho Panhandle, Kootenai,



**IPAC:** One of many wet loose avalanches produced by late March warming. ■ RYAN MATZ



and Lolo National Forest employees Ben Bernall, Mikey Church, Kevin Davis, Liz Figgins, Grant Golden, and Eric Morgan all contributed by producing and publishing avalanche forecasts this season. Friends of IPAC rounded out our forecast team by continuing to fund Jeff Thompson as a forecaster. This team of excellent individuals makes regular IPAC avalanche forecasts possible as we work towards additional full-time forecast staff.

Friends of IPAC increased avalanche education offerings to reach over 300 students in the 2021–22 season. 16 total courses included avalanche awareness, rescue fundamentals, Level 1, and Level 1 refreshers. Our education coordinator, 12 instructors, and 7 volunteers all contributed to this effort. Public demand for Level 1 courses continued, with 127 students completing a Level 1 with Friends of IPAC this season. Progress towards insurance for motorized avalanche courses will hopefully allow the addition of motorized-specific Level 1 courses in the 2022-2023 season.

Motorized and non-motorized use continues to grow across the three IPAC forecast zones. Motivated and skilled snowmobilers, snow bikers, skiers, and snowboarders push deep into our remote mountains. While escaping significant accidents this season, we observed countless bold tracks from all user types. We think that backcountry users in north Idaho and northwest Montana are trending towards greater collective avalanche awareness and ability to choose appropriate terrain for given snowpack conditions. We know that a few more mistakes or a little less luck could result in many more accidents. The Idaho Panhandle Avalanche Center is working to continue growth of avalanche information and education offerings for the greater Idaho Panhandle area, helping our increasing users stack the odds in their favor.

—Ryan Matz

## KPAC

Kachina Peaks Avalanche Center

Short, very windy, challenging, and mostly stable conditions could briefly describe the 2021–22 season

for the Kachina Peaks Avalanche Center (KPAC) of northern Arizona. Wind stripping, warming periods, and prolonged dry spells resulted in a below average snowpack. The most unstable period occurred when the “George Washington’s birthday storm” deposited 2” of SWE over NSF’s that had formed in late January and early February. Despite this, no avalanches larger than D1 were reported the entire season. Most backcountry recreationists visited the San Francisco Peaks and Kachina Peaks Wilderness between late December and early April. By mid to late April, winter transitioned into fire season.

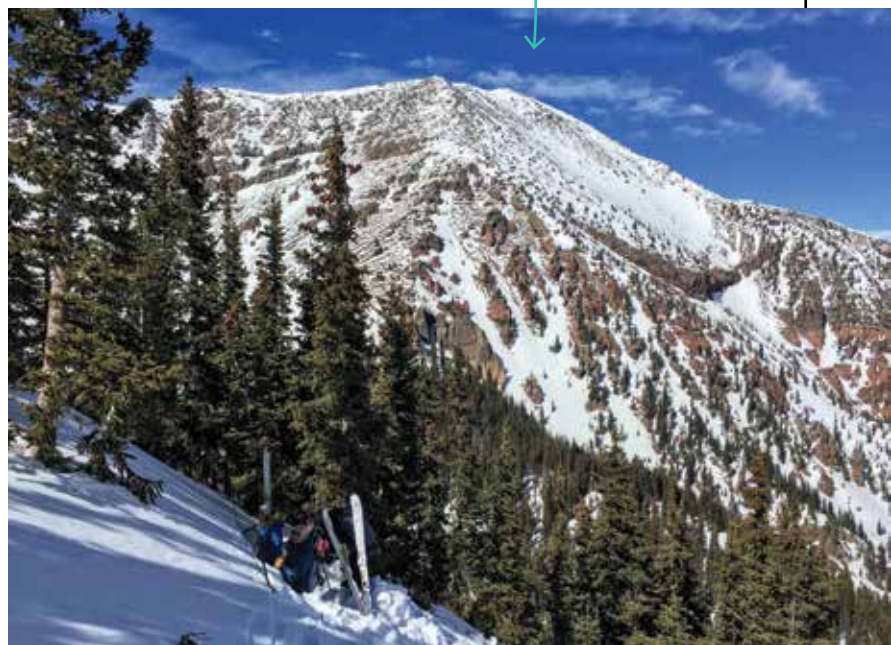
Between October and November, several events deposited minimal snow. The first significant snowstorm arrived on December 9th when 14” of new snow was measured at 10,800’. On December 14–15, approximately 7” of high density (30%) snow accumulated near treeline, accompanied by strong southwesterly gusts up to 67 mph. Southwesterly slopes had noteworthy rimming. The snowpack was still too thin for safe backcountry ski travel, but at that time the consensus was that the few inches of early season snow (from Oct. and Nov.) had faceted, creating a weak base that was buried by denser accumulations and wind deposits during December. Most slopes of the KPAC forecast zone generally need 36” of base to safely tour. At that time the backcountry base was approximately 20” and thin coverage hazards prevented us from gathering conclusive observations during this period.

Between December 23rd and 29th, a series of storms resulted in 44” of accumulation and our winter backcountry season began. Investigations revealed some early-season basal facets but they had no propagation potential, were not widespread, and in general were well below the tops of boulder anchors. There was no precipitation for the first three weeks of 2022. The winds were relentless and wind slab was the only listed problem in our summary. Many above-treeline slopes became scoured to the ground. Despite this, some good touring was found in sheltered terrain. No instabilities nor avalanches were observed, but thin coverage made approaches and egresses challenging. Between January 19 and 23, 8” of snow accumulated resulting in our first observed instabilities of the season. Fortunately, these were only small natural and human triggered releases where new and old snow was not well bonded. On January 26th we were very close to 100% of normal snowpack, based on Snotel data (site 927) back to 1997. Wind,

wind slab, and variability remained the theme for the next two weeks.

By the middle of February, prolonged drought and cool nighttime temperatures had created mature NSF’s on northerly slopes near/below treeline. Finally, after a twenty-five-day dry spell, 5” accumulated near treeline on February 17th. Strong post frontal winds blew 50 mph from the northeast. The result was a small (R1D1) cycle, but the NSF’s remained mostly dormant. The five-inch refresh and NSF’s provided good touring and teaching opportunities for the **KPAC recreational 2 course**. On February 22–23 the “George Washington’s birthday storm” deposited 28” (2” of SWE) near treeline. The February 23 KPAC storm update stated that “human triggered wind slab and persistent slab avalanches are likely,

natural avalanches are possible. For the next 48 to 72 hours, conservative decisions and cautious routes will be essential to avoiding avalanches.” Low-scoring propagating test results, cracking, and collapsing were observed. Several groups backed off their intended lines. The instabilities were limited to northerly slopes between 10,400’ and 11,500’. The excitement continued into early March as several storms deposited 49” of snow near treeline. From February 23 through March 11, wind slab and persistent slab were the problems listed in KPAC’s summaries, with the February/January NSF’s being the primary cause for concern. Fortunately, no large avalanches were observed. It appeared that the NSF’s had no good bed surface to slide on. The late-winter snow was



**KPAC:** Great conditions for teaching the KPAC recreational L2 class on February 20th, 2022. Easterly and southeasterly slopes of Humphreys Peak in the background. ■ TROY MARINO



**KPAC:** Small penitentes on northeasterly slopes of Abineau Canyon. May 15, 2022. ■ RORY T GOFORTH



## PROUD SUPPORTER OF THE AMERICAN AVALANCHE ASSOCIATION



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welcome, but southern and western slopes remained thin and hazardous below 10,500’.

Winter mostly yielded to warm days by the spring equinox. Loose wet was the only problem published in April. Two windy storms dusted the mountains during April, and most of the snowpack melted from southerly and sunny slopes by April 15. Spring quickly transitioned to fire-season when the Tunnel Fire started on April 17, destroying homes and livestock. Fire closures blocked some backcountry access. By mid-May the snow surface had metamorphosed into suncups and small **penitentes**.

Total snowfall was 191”, amounting to 83% of the recently recalibrated thirty-year average of 229”. No large avalanches were observed. KPAC issued 20 weekly summaries and two storm updates. Between December 1 and March 31, the snowpack summary had 9,425 pageviews by 3,968 users, with 2,428 of those users originating within Arizona. Thirty-seven students were taught in four recreational courses. Due to thin coverage in our traditional lower-elevation terrain, alternative terrain was utilized for the courses. Thirty-two applicants were offered course scholarships and 12 were redeemed.

—Troy Marino

### MSAC

Mount Shasta Avalanche Center

It started with snow, as winter should. Heaps of it. Big, fat flakes, smashing down the brush, covering the rocks, preparing us for a back to normal, bountiful, beautiful, cold, frosty winter. A white Christmas, powder in the face, the Avalanche Center off and running. All those things mentioned...lasted for a month. That’s it. Can we just skip the rest of the season? January through March was the driest period on record in 127 years. Low avalanche danger plagued the website. We ran out of green ink.

It was another dry winter in Northern California with far below average snowfall, but a few big storms in fall and early winter set us up with a usable snowpack that provided winter recreation for most of the season. Forecasts were issued

daily, December 1 through April 3. Due to the stable weather and snowpack midwinter, there were many climbers on the mountain and avalanche forecasts reflected this in targeted messaging. Much to our chagrin (because avalanches are cool when nobody gets caught in them), we had zero notable avalanches to report this winter. Also a result of that...zero avalanche accidents involving humans, always good news.

The Mount Shasta Avalanche Center completed its 24th season of operation. For the 6th season in a row, the MSAC had three full time employees. Nick Meyers returned for his 13th season as MSAC director, forecaster, and 20th year as a climbing ranger. Aaron Beverly worked his 6th season as a professional observer, forecaster, and web master. Ryan Lazzeri joined the team in September as a permanent avalanche forecaster and climbing ranger. Prior to joining the MSAC, Ryan was a climbing ranger at Mt Rainier National Park and a ski patroller in Telluride, Colorado. The USFS funds portions of Nick and Ryan’s salaries, while the Friends of the Mount Shasta Avalanche Center (FMSAC) funds some of Aaron’s.

“

**IT STARTED WITH SNOW, AS WINTER SHOULD. HEAPS OF IT. IT LASTED FOR A MONTH. THAT’S IT. CAN WE JUST SKIP THE REST OF THE SEASON?**





**MSAC:** Mt Shasta and the surrounding forecast area have been plagued by high northwesterly wind over the past years. This has contributed to near and above treeline terrain remaining scoured for much of the winter on the mountain. ■ NICK MEYERS

The remainder of their salaries are funded through the Department of California State Parks OHV Program. The MSAC has been successful for many years (since 2012) in receiving OSV grant funds that contribute to the success of the center.

A full round of weather station upgrades from last season have allowed the MSAC's stations to run well all season, providing critical real-time data to avalanche forecasters and the public. A weather station manual, the magnum opus, was developed over the winter by Aaron, to function as a guide in understanding and maintaining the MSAC's station network for future employees. It's amazing, and if anyone ever wants a copy, shoot us a line.

The spirited MSAC provided 16 educational programs over the winter. These include KBYG Avalanche Awareness and Companion Rescue Clinics to the general public, school groups, motorized users, search and rescue teams and Forest Service personnel. The programs took place both on Zoom and in person.

### MSAC By The Numbers:

The website experienced steady use this season. For the 2021–22 winter (December 1st, 2021–April 12th, 2022), [www.shastaavalanche.org](http://www.shastaavalanche.org) received 75,835 total visits, of which 31,704 were unique users. The average session duration was 2 minutes and 29 seconds. Of website visitors, 23.6% were returning while 77.4% were new.

### Website

- 2021–22 MSAC Avalanche Advisories: 121
- Unique Website Users: 31,704 (-15% [change from last year])

- Total Website Visits: 75,835 (-21%)
- Mobile Users: 43,030 (+111%)
- Average Session Duration: 2 minutes 29 seconds (-3%)

### Social Media / Email

- Facebook Followers: 7,050 (+27%)
- Instagram Followers: 4,601 (+98%)
- Advisory Email Subscribers: 216 (0%)

### Education

- People Reached: 210
- Avalanche Presentations Delivered: 16

### Avalanches 2021–22 Season

- National Avalanche Fatalities: 15
- Fatalities in the MSAC Forecast Area: 0
- People caught in avalanches in the MSAC Forecast Area: 0

**The Bottom Line:** Our audience is increasing, particularly on social media, but website visits have decreased. This decrease can likely be attributed to a season of mostly low avalanche danger.

—Nick Meyers



**Snowpack:** Winter in New Hampshire arrived early beginning with a cold November that delivered

49 inches of snow, 15 inches above the average of 35.6 inches. Although limited to just one or two runs, skiers willing to hike the 2.8 miles into Tuckerman Ravine were rewarded with generally thin but good dry snow from several small snow events. On December 5, skiers triggered a wind slab from five days of continuous snowfall in Left Gully, Tuckerman Ravine. Two people were caught and carried with one person's injuries severe enough to require a rescue from MWAC bystanders on scene. It's worth noting that the two people carried in the avalanche were not in the same party. A skier high in the terrain triggered the avalanche onto a skier ascending from below; neither knew of the other's presence. Unfortunately, having several people exposed in an avalanche path at the same time is becoming increasingly common in the White Mountain National Forest as

the number of backcountry skiers steadily increases.

December, January, and February were dry overall with 21 percent below average precipitation for the period. Snowfall was down almost 27" from average. As a result, it wasn't until January 16 when snow fields were filled in enough to warrant the start of daily five-scale avalanche forecasts. Cold temperatures in January produced some wonderfully dry low-density snow, which unfortunately couldn't stand up to subsequent high winds after each storm scoured much of the snow out of avalanche terrain and down into trees at lower elevations. Many of the storms during this period produced some brief but very active natural avalanche cycles on east-facing terrain with some aspects running, refilling, and running again.

Towards the end of January, a shallow snowpack and very cold temperatures drove the formation of facets throughout the range at elevations up to 3500 feet. Warmer temperatures in February worked to reduce the effects of the faceted crystals at low elevations and at mid elevation locations capable of producing a larger avalanche, dense wind packed snow provided bridging protection from the weak layers below. These same periods of warm temperatures in late February and March also resulted in several soaking rain events at all elevations, some acting as the catalyst for a few natural D2 wet slab avalanches.

At the end of February and the beginning of March, 25 inches of snow were recorded over a 10-day period. Early in the cycles of one period of localized snow events, calm wind allowed a low-density weak layer to set up beneath a higher-density wind slab. On March 4, a skier in Tuckerman Ravine triggered



**MWAC:** Solo skier triggered an avalanche from the Sluice (in the center) on a sensitive day and it propagated widely towards the center headwall of Tuckerman's Ravine. Skier was ejected towards the top without injury. ■ MWAC STAFF



a D2 sized avalanche which failed on the above-mentioned weak layer. The solo skier was carried around 300 feet in the debris and avoided injury as the debris poured over a field of boulders.

In March and April, the snowpack finally began to fill in. Precipitation was close to average for the time period and above average snowfall helped “build more base” as we say in NH—all the way to spring. In May, a nearly complete lack of new snow and record-breaking warm temperatures brought a quick end to the snow season. Overall, the season ended with 13.4 inches less snowfall than average (-8.47” SWE). In total, MWAC produced 99 daily Avalanche Forecasts and 27 General Information products.

**Rescues:** At MWAC we do our best to advise and inform, but inevitably people make mistakes and rescues are necessary, mostly due to the nature of our easily accessible very steep terrain. From December 1 to January 1, MWAC managed 12 significant rescues requiring 205 person-hours to complete. We were assisted by the Mount Washington Volunteer Ski Patrol and local SAR teams filling in 132.5 of those hours. Most of the incidents involved trauma from falling, trauma from

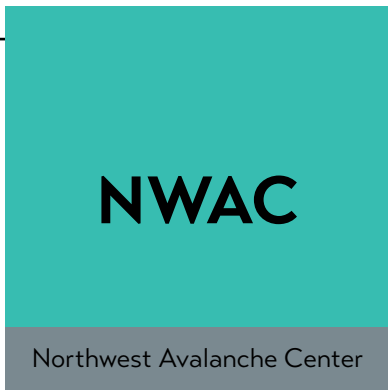
triggering an avalanche, and a couple of steep frozen snow roped pick-offs thrown in to keep us sharp.

**New:** A donated BCA Wireless Beacon Training Park was a huge success. Despite the lack of deep snow to adequately keep the targets buried, the training park was frequently used by both the public and the many avalanche courses which run throughout the season.

**Staffing:** Jeff Fongemie stepped in as interim Director for the season when Frank Carus left to become Director of the Bridger-Teton Avalanche Center. With Ryan Lewthwaite returning, we rounded out the team with veteran avalanche forecaster Jeff Lane, and added strong new talent with Patrick Scanlan, Kate Moynihan, and Nathan Delmar.

**Volunteer Support:** The Mount Washington Volunteer Ski Patrol assisted MWAC every weekend in Tuckerman Ravine from March to June, assisting with countless injured skiers and long litter carries. The Friends of Tuckerman Ravine and the White Mountain Avalanche Education Foundation are continuing with their merger to create one entity supporting MWAC in the future.

— Jeff Fongemie



While many here in the Pacific Northwest may remember the 2021–22 season for its prolonged mid-winter stretches of limited snowfall, this by no means tells the story. In truth, the season saw periods of banner precipitation, marked by enormous region-wide avalanche cycles, and a wintry spring that further built the season’s snowpack well into May. At NWAC, we continued to grow our staff, expanding our capabilities in programming and forecasting. This allowed us to widen our reach to underserved and underrepresented communities both demographically and geographically. Ultimately, the success of this winter continues to emphasize the incredible support of our community and partners here in the Northwest.

Early season snowfall in October and the promise of another La Niña winter left most backcountry travelers eager and optimistic. Sadly, a series of warm atmospheric rivers in November would wash away these hopes. Instead, our season wouldn’t start until December 9. In typical Northwest fashion, a pair of impressive winter storms built the snowpack seemingly overnight and set the tone for what would become almost a month straight of near-daily precipitation. Sadly, the kick-off to the winter also brought with it a major avalanche accident where six backcountry tourers were caught and carried. Three members were fully buried, and one did not survive. This accident highlighted many points, but the influence of terrain traps and well-executed companion rescue rose to the top.

As 2021 ended, the mountains were in the full grip of winter. Many locations had already received 150+ inches of snow over the preceding weeks. While avalanche conditions typically hinged on the next storm, several weak layers lingered in the snowpack. A series of storms from January 3–9 would bring these problems to a head and cause one of the most widespread avalanche cycles in recent memory. Over the course of a few days, Snoqualmie Pass (3000’) would receive 9.1 inches of water with warming temperatures. The city of Leavenworth picked

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**LEAVENWORTH SAW 40+ INCHES OF SNOW, THE MOST IN ONE STORM IN 30 YEARS. AVALANCHES ABOUNDED. WSDOT RECORDED 376 AVALANCHES THAT BLOCKED AT LEAST PART OF A ROADWAY.**”

up 40+ inches of snow, the most the town had seen in one storm in nearly 30 years. Not surprisingly, avalanches abounded. During this period the North Central Region WSDOT (including Stevens Pass) crew recorded 376 avalanches that blocked at least part of a roadway. All of the Cascade Passes closed for at least four days, with White Pass (US 12) remaining closed for an impressive eight days. While road closures are common in the Cascades, this event stood out for its region-wide and long-lasting nature. In the aftermath, backcountry travelers discovered numerous D3 slides that expanded natural trim lines, and several D4 slides that removed sections of forest.

Like much of the West, following this cycle we entered a period of relatively warm and dry weather. While occasional storms passed through the region, we slowly watched our snowpack dwindle. This all changed the last week of March when the storm track returned to the PNW. What were once below-average season totals quickly flipped, with many monitoring sites reaching 110 percent of average by April 15. Even as I type this article in late May, we remain in a very wintry weather pattern with snow continuing to fall at mid and upper elevations.

Much like the Cascade snowpack in April and May, our operations at

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**Snow Profiles in Seconds**  
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**NWAC:** These two photos are from an impressive D4 avalanche that is believed to have failed sometime on January 7, 2022 and encompassed nearly the entire west face of Kendall Peak at Snoqualmie Pass.

■ DALLAS GLASS

NWAC continue to grow. During the 2021–22 season, we hired four new staff at NWAC. Katy Wicks and Katie Smith joined our team to work on communication, outreach, membership, and educational programs through the non-profit. Katie Warren and Lee Lazzara began working with the forecasting operations. By adding to our team across the organization, NWAC was able to continue and grow programming across our user base with an emphasis on underserved and underrepresented communities.

With additional staff capacity, we were able to add a forecaster location in Cle Elum, WA to serve the East Central and East South zones. For the rural mountains near Yakima, WA this was the first time we were able to focus on and create a full daily forecasting product combined with dedicated field observations. For this largely motorized access zone, this was a welcomed and exciting change.

This season, NWAC worked alongside PNW-based nonprofit Climbers of Color to develop a program that would prepare BIPOC individuals to teach as part of our extensive avalanche awareness program. Nine individuals completed this inaugural program and went on to teach 18 avalanche awareness classes, with six of those programs directed specifically to BIPOC communities.

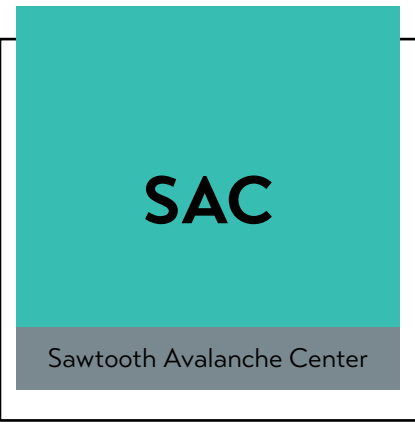
Our Women’s Mentorship Program ran for the 3rd year in a row with the aim of providing women educational opportunities, mentorship, and professional connections for those seeking careers in the outdoor and avalanche industry. This season four women completed the program. Similarly, we ran our second annual Women’s Professional Workshop, with over 100 participants from all over North America. This virtual conference aims to connect women just starting their careers in the avalanche industry with those who have

had decades of experience. Its success is due to enthusiastic information sharing and a willingness to spend the extra time to become a mentor or “friendtor” to those needing support.

After two years of entirely virtual events, NWAC held its first in-person event in late March. Don Sharaf joined our professional community for an evening of seeing old friends and making new ones. Don spoke about the importance of community amongst professionals and how each segment of the industry is stronger because of our friends and co-workers. After two years, it was great to see so many smiling faces.

With yet another busy winter in the books, we are continually reminded that the strength of our operation depends on our community. Our professional partners provide consistent and reliable information, and the ever-growing recreating public supports NWAC through membership, field reports, and volunteer hours. Without the efforts of individuals and operations working together, we could not hope to meet our mission here in the PNW to increase avalanche awareness, reduce avalanche impacts, and equip the community with mountain weather and avalanche forecasts, education, and data.

—Dallas Glass



So many of us have been experiencing strange winters that “abnormal is the new normal” has become a buzz phrase. Cliche or not, there’s little doubt that the 2021–22 winter was one of extreme feast or extreme famine. Near record-setting snowfall during the first part of the winter was followed by one of the driest periods in memory, only to have winter return with a vengeance just after we published our last daily Avalanche Forecast. But I’m getting ahead of myself—let’s start at the beginning.

For the 4th season running, we had the same all-star four-person forecasting team: Scott Savage, Ethan Davis, Ben VandenBos, and Chris Lundy. Due to Covid complications, it was our second season without a forecasting intern. Like most centers, we spent the

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# SAVE THE DATE

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fall working on projects, attending SAWs, and prepping for the upcoming winter.

A new focus this winter was our Spanish-language outreach to our growing Hispanic community. Many Spanish-speakers work as snow removal and maintenance workers, occasionally adjacent to avalanche-threatened homes. We began publishing bilingual Avalanche Warning information via recorded messages on social media and local radio. Through a translator, Ethan presented an Avalanche Awareness class to Spanish-speaking snow removal workers. A project to produce and distribute an Avalanche Awareness video in Spanish is well underway.

We continued refining our web-based products. Building on last winter's additions to our Observation Platform, we made it easier for users to view and search Field Reports, Avalanche Occurrences, and Media. In addition to improving the organization of the data, we added "Visualization" views to display graphs and plots of data. Especially for the Avalanche Occurrences, the visualizations make it easier to tease out patterns and trends from the data. We also added more powerful filters to help users sort data. The Sawtooth AC continues to be heavily involved in developing and testing national-level IT platforms in partnership with the National Avalanche Center.

With a resurgence of Covid this fall, we made the difficult decision to once again present our educational programs in a virtual format. This included our popular bi-weekly Digging Deeper series as well as the Friends of the SAC's Know Before You Go and Intro to Avalanche classes. By the latter portion of the winter, we saw a strong drop-off in participation in our online programs due to "Zoom fatigue," the dismal snow conditions, or both. Our fingers are crossed (again) to be presenting in person next winter.

Fall projects were put to bed a bit early when a warm storm near the

end of October provided a supportable 2-3' snowpack. The next month delivered a few small storms interspersed with both very warm and cold spells. Particularly dry weather during late November and early December produced a widespread layer of facets sitting atop a hard crust—at least where the snowpack survived the early season thaw. This facet/crust layer became the season's primary weak layer when it was buried on December 11th.

Snowfall finally returned—with a vengeance. December 11 to January 7 was one of the snowiest periods in memory. An estimated 100" (on Bald Mountain at the Sun Valley Ski Area) to 200" (Vienna Mine Snotel—western Smoky Mountains) of snow fell in less than a month. Most Snotel stations were sitting at 70-80% of normal snowpack prior to this period and were 140-150% of average when the atmospheric rivers stopped flowing on January 7. Not surprisingly, these large storms falling on a well-developed weak layer produced dangerous avalanche conditions. We issued our first Avalanche Forecasts of the season on December 13 with HIGH danger in three out of four zones. An Avalanche Warning was issued the next day. Avalanche activity during this period was fairly extensive, including several slides triggered remotely from lower angled terrain.

Up until this point, the winter was a forecaster's dream: a well-developed persistent weak layer, major storm cycles, numerous avalanches, and no close calls that we heard about. But like many good things, it wasn't to last. The next three months were extremely dry, producing only a small fraction of the snowfall that fell during the first half of winter. The drought conditions created plenty of weak snow but few occasions where enough loading occurred to produce avalanche activity. Late March brought the warmest temperatures of the winter, and upper elevation temperatures stayed above 0° for five consecutive nights. Fortunately, clear skies allowed for a light freeze

most nights and prevented a major wet avalanche cycle.

Once the snowpack froze hard on March 29, we returned to relatively stable conditions. We issued our last (and 119th) daily Backcountry Avalanche Forecast on April 10. Owing to the three-month-long drought from January 8–April 9, we issued twice as many LOW danger forecasts compared to the previous two seasons. Our snowpack had dipped to 60-80% of normal by early April.

In a turn of events that should no longer surprise us, the proverbial faucet turned on shortly after publishing our final daily Backcountry Avalanche Forecast. From April 10 (our last Forecast) through May 9 (our last General Information update), the mountains received from 3.5" to over 7" of SWE—significantly more than what had fallen during the preceding three months! During these storms, experienced skiers and snowmobilers triggered four persistent slab avalanches in an eight-day period. Three skiers (including two snow professionals) were caught in two separate avalanches, and a snowmobiler was able to outrun a large slide he remotely triggered. In early May, a D3 avalanche was triggered remotely by a party digging out a stuck snowmobile. The slide broke over 1,000' wide and the debris was an estimated 30' deep. It failed on the same late-season weak layer—nearly a month after burial.

Despite April's close calls, we're grateful to finish our operating season with no avalanche fatalities or injuries in our forecast area. With the Covid situation seemingly improving, we look forward to much of our operations going back to normal next season. But any hope for "normal" winter weather seems to fade each season!

—Chris Lundy and the SAC Staff

## SAC

Sierra Avalanche Center

### Long Fall, Short Winter, Long Spring

After a brutal fire and smoke season during summer of 2021, with active fires within our forecast region, we had a fire season-ending atmospheric river storm in late October that brought up to 10" of rain and up to 3+ feet of high elevation snow to our area. There was a scramble early season with the thought that forecasting may need to begin earlier than our normal starting time in early to mid-November. Turned out winter was not quite ready and warm temperatures, sunny skies, and a dry November brought back fall and mountain biking season. We began forecasting on December 1 with limited early season snow only on the higher elevation northerly aspects.

December was a month of contrasts, with a dry start to the month then two large storm systems. By mid-month, a large storm impacted our area finally opening some usable terrain for backcountry recreation. The first storm dropped five feet of snow along the Sierra Crest. After a short break, a larger storm brought up to eight feet of snow during the holiday break. This December 23–27 storm had a string of five High avalanche danger days essentially shutting down infrastructure and lasted well into the New Year. Storm totals for the month of December were 163", making this month the fifth wettest December on record.



**SAWTOOTH:** 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. Photographed on December 24th, it likely failed the night before. ■ SCOTT SAVAGE





**SIERRA:** Skier triggered wind slab avalanche from late spring storm on Andesite Peak April 15, 2022. Two skiers were partially buried. ■ SAC PUBLIC

After December, the dreams of large Sierra storm years like in the past were on all our minds. How big could this winter get? Then the dry spell hit, and we kept waiting for winter to return. We set a record of 38 consecutive LOW avalanche danger days between January 8 to February 14 with zero precipitation during that time. That beat the previous record of 34 days from January 2 to February 5 in 2015—one of the worst drought years in recent history. An inside slider pattern developed in February and continued through March bringing many dry or precipitation-starved fronts through our area. This inside slider pattern also brought large wind events on a regular basis. These wind events scoured ridgelines down to dirt and destroyed snow surface conditions. The January-February-March timeframe turned out to be the driest on record.

Spring conditions started in January and the snowpack slowly started to disappear on southerly aspects. The snow cover remained good on shaded aspects, even at lower elevations through most of the winter. By March, that started to change dramatically as we experienced two heat waves that brought temperatures 15 to 20 degrees above average. Mountain bikers and trail

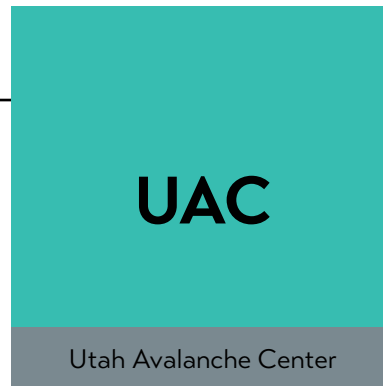
runners started to outnumber snow travelers as the lower elevations melted out quickly. A series of late season storms came through just in time before closing the avalanche center with the most significant precipitation event for 2022, far exceeding the January-February-March total snowfall. In a two-week period, another six feet of snow fell on the Sierra Crest adding to our snowpack and prolonging an early spring melt out. Total average snowfall ended the year at 270" putting us at 58% of normal for the Central Sierra Nevada. We had a large range in snowfall totals within our forecast area with the northern part far out producing the southern part of the forecast region. This winter season led to four reported avalanche incidents with six people involved.

Operations and personnel at the Tahoe National Forest forecasting program remained the same as previous years. Director/lead forecaster was Brandon Schwartz; Andy Anderson and Steve Reynaud served as avalanche forecasters. On the nonprofit Sierra Avalanche Center side, Travis Feist continued at his position as Professional Observer and Education Coordinator. David Reichel continues as SAC's Executive Director and Professional Observer, and Jason Bilek continued

as a Professional Observer. We are very fortunate to have an experienced and dedicated group of talented individuals who have been long-term members of the team. SAC issued 144 daily avalanche advisories and nine early season snowpack reports for the 2021–22 winter season.

The Sierra Avalanche Center functions as a partnership between the Tahoe National Forest and a volunteer Board of Directors with 501(c)(3) non-profit organization status. David Reichel continues as Executive Director for his second term. The SAC board continues with successful financial support and vision for our growing avalanche program. We continue to expand our avalanche education scholarship program, motorized avalanche education programs, and avalanche outreach education to help reach and message our local users and visitors to our area. The non-profit SAC and the Tahoe National Forest continue to work together successfully to inform and educate the public about backcountry avalanche conditions in the greater Lake Tahoe area.

—Steve Reynaud



The winter of 2021–22 was unlike any other. It started with early snowfall in the latter half of October that pushed the snowpack above normal, and then it basically didn't snow during all of November and the first week of December. The October snow became weak and faceted on northerly facing slopes, while it melted away on southerly facing slopes. In most areas, snowfall returned around December 8 and didn't stop until the first week of January. Many of these storms came from the south with strong southerly winds that loaded northerly facing slopes where the faceted October snow existed.

When the storms stopped after the first week of January, avalanche activity began to subside. By the second week of January, many slopes had either already avalanched or the weak layer was buried so deeply that it was no longer a concern. By January 17, the avalanche danger throughout the state

had dropped to LOW on all aspects and elevations.

No snow fell across nearly all of Utah during a six-week period from about January 9 to February 16. Mid-winter dry spells are not uncommon, but what was remarkable was such a prolonged period with zero snowfall. Graphs of precipitation across the state were dead flat during this time. In many parts of the state during this dry period, riding conditions on northerly facing slopes remained good where winds hadn't destroyed the powder. As dry weather continued, the snow surface began to weaken and

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**BETWEEN FEB 19 & MARCH 19 IN THE CENTRAL WASATCH, 47 AVALANCHES WERE REPORTED, MOST OCCURRING ON MID-ELEVATION SLOPES. AT UPPER ELEVATIONS, THE WEAK LAYER AT HAD BEEN DESTROYED BY WINDS. THE SITUATION WAS COUNTERINTUITIVE BECAUSE MANY MID-ELEVATION SHELTERED SLOPES PEOPLE RIDE TO AVOID DANGER WERE IN FACT THE MOST DANGEROUS.**

facet. Eventually, the combination of old tracks, wind effects, and warm weather that created melt-freeze ice crusts, making soft powder very hard to find. One area that maintained decent snow conditions for the longest period of time was the Manti-Skyline where there had been less wind and more faceting of the snow surface. This area had great skiing and riding conditions for much of the dry spell due to this faceting. Between February 16 and 23, all parts of the state began receiving small amounts of snow. As more snow accumulated and bigger storms began arriving, a growing slab of new snow sitting on top of the dry spell facets began producing



more and more avalanches that grew larger with each storm.

In northern Utah, the avalanche danger spiked near the end of the first week of March. **Between Feb 19 and March 19 in the Central Wasatch, there were 47 avalanches reported. What was interesting is that the majority of these slides occurred on mid-elevation slopes.** The weak layer at upper elevations was less widespread because it had been destroyed by winds while mid-elevations generally have more wind-sheltered slopes where the weak layer was preserved. The resulting situation was counterintuitive because many of the mid elevation sheltered slopes people ride to avoid dangerous slopes were in fact some of the most dangerous ones.

Also of note was that many of the people who triggered these slides, including some who were caught, were people that anecdotally seemed to be more experienced. There were several close calls. Most notable was a guide who was buried six feet deep for 23 minutes and survived.

In Central Utah, on the Manti-Skyline, the weak layer was much more widespread. During the same time period, there were 32 avalanches; an unprecedented avalanche cycle for this area. Further south near Moab, the avalanche

activity and the avalanche danger had two peaks following snowfall around February 21 and March 4.

Throughout the winter there were periods of warm weather that created wet avalanches; however, the last weekend of March stands out as the peak of wet avalanche activity with many wet slabs occurring on the Jan/Feb faceted layer. Spring didn't go down without a fight with several storms through April and May including one over Memorial Day weekend that provided great powder riding. Unfortunately, snowfall in those last three months wasn't enough to bring the snowpack back to average.

Most importantly, the season ended with zero avalanche fatalities. Despite several avalanche cycles mostly during storms around Christmas and early May, close calls that did occur had happy endings because the people involved seemed to be prepared, were generally knowledgeable about avalanche conditions, and had a little bit of luck on their side. This is the third season in five years with no fatalities in Utah.

Our forecasting program:

- Issued 1,100 forecasts.
- Had 700,000 page views of the forecasts.
- Logged 444 field days.



**UAC:** This natural avalanche on March 10th was typical of many during that period. The facets on which they broke were most prevalent on slopes sheltered from sun and wind. ■ UAC

- Collected 1,300 public observations.

In terms of avalanches, many go unreported, but there were 219 reported human-triggered avalanches, 38 unintentionally triggered, 42 people caught, 10 partially buried, 3 fully buried, and zero killed.

The UAC continues to grow our awareness and education programs reaching more people each year. This year we were excited to introduce two new programs, community transceiver practice and the Backcountry 201 course. We also continued the Trailhead Awareness program that reached over 1400 people. The 14th Utah Snow & Avalanche Workshop in November had over 3,000 pros & recreationists. In January 2021, we kicked off a project in partnership with CAIC, NWAC, NAC, and Av Can to rebuild the entire Know Before You Go program and we launched this program in October with all new films, presentations, online content, and a new KBYG website. Read more in an article about the rebuilt KBYG program on page 15 of the October TAR, 41.1

The education program:

- Taught 60 avalanche classes.
- Educated 600 students.
- Used a pool of 30 instructors.
- Provided 4000 hours of instruction.

The awareness program:

- Delivered 83 KBYG talks.
- Had 5,500 in-person attendees.
- Had 10,000 virtual attendees.
- Reached 3000 people with the e-learning course.

We have been working on a long list of summer projects and look forward to helping everyone stay on top of The Greatest Snow on Earth.®

—Mark Staples & forecasting team

**WAC**

Wallowa Avalanche Center

The winter of 2021–22 was characterized by some very unpredictable weather in the mountains of Northeast Oregon. After very little early season snowfall, winter decided to arrive with gusto during the month of December. The lack of our normal high elevation snowfall during the fall months left us with less uncertainty of a poor basal snowpack. By the end of December it seemed like we could be off to a banner year, but then the jet stream headed up north for most of January through March. Winter made a strong comeback during April, and we ended the month above average in the SWE column.

This was our 11th winter of operation and we have continued to make significant improvements as an organization. One of our biggest accomplishments this winter was doubling our weekly forecasting and writing avalanche advisories with danger ratings Thursday–Sunday. Over the course of the winter, we produced 63 avalanche forecasts and 20 general bulletins. As a Type 2 avalanche center we are required to post a general bulletin following the expiration of our last advisory. This allows the public to have a sense of what to expect over the next 72 hours until the next forecast is published.

One of our greatest challenges over the history of our small



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**WAC:** AIARE motorized Level 2 course taught by the Wallowa Avalanche Center. ■ VICTOR MCNEIL

avalanche center has been fundraising. We do not receive any funding from the state or federal government. Traditionally we have a handful of small fundraisers annually, but the Covid-19 pandemic has made in person events challenging for all of us. Four winters ago we became an AIARE provider, as there was no formal avalanche education in our region. As the backcountry industry has exploded, the attendance in avalanche courses has soared. We had 170 participants this past winter take either a recreational Level 1, Level 2 or 1-Day companion rescue course. Participation in our motorized specific courses has continued to grow, which we feel has been a huge success. This March we hosted our first Motorized Level 2 course in Halfway, OR, with 11 participants. Jeff Hambelton, the Motorized Coordinator from AIARE, joined us as the course leader. Offering these high-level avalanche education programs has really helped provide a stable financial foundation for our organization.

Regarding our snowpack and avalanche stability, this was one of the most stable winters I can remember in our regional mountains in the last decade. We typically have a persistent slab problem of some sort in the early part of the winter. There were times when the forecasting team envisioned moving into adding a persistent slab to our problem list, but fortunately we mostly dealt with storm and wind slabs this winter. We had far more melt freeze crusts in our snowpack, but the lack of consistent cold weather kept the formation of facets above and below these crusts to a minimum. This winter we issued fewer avalanche

warnings than the past several years.

The Wallowa Avalanche center received two grants totaling \$24,500. One of the grants was through the Recreation and Trails program, which will allow us to purchase three BCA beacon training parks for this coming winter. The second grant was through the Avalanche Alliance. Money from this grant was used to purchase 10 avalanche transceivers, shovels, and probes. This rescue gear is used when we teach an AIARE course or offer a training with our local SAR teams and snowmobile clubs. We also used some of this grant money to subsidize avalanche courses for a new Motorized Ambassador program that we started this winter.

Over the past couple of winters one of our biggest projects has been increasing the avalanche awareness and training with our local motorized community. This winter we selected a total of 10 men and women to become our Motorized Ambassadors. All these individuals have taken a Motorized AIARE 1, and a handful took our AIARE 2 course this past spring. These ambassadors have been great advocates within their local riding circles, snowmobile clubs, and friends. From an educator perspective we've found many of the participants in the motorized courses have already spent 10–20+ years riding in avalanche terrain. This group is significantly more experienced than our average AIARE 1 non-motorized participant. It's been really fun working with this group as they have so many aha moments connecting the dots.

Our largest traditional fundraiser, the Eastern Oregon Backcountry

Festival increased attendance this February. We also brought in a record \$10,000 over this multi-day event. Our friends at Anthony Lakes Mountain Resort graciously hosted us for two days of free avalanche awareness clinics, the Kip Rand Memorial Uphill/Downhill race, and a disco party.

This winter we worked with the National Avalanche Center and continued to use the Avalanche Forecasting Platform. Our relationship with the NAC has been excellent and we can't thank Simon Trautman enough for his long hours to help out small avalanche centers like ours. Kudos to Chris Lundy and all of those who have made the AFP work so fluidly. The forecasting platform, avalanche danger maps, and weather station platform have worked great and are a great tool for our end users.

I would like to thank our avalanche forecasting team which included myself, Michael Hatch, Tom Guthrie, Caleb Merrill, and Kelly McNeil. Our Board of Directors also put in countless hours of free labor helping to keep the ship on course. We are looking forward to next winter and the opportunity to serve those who live in NE Oregon and visitors to the area.

—Victor McNeil

# WCMAC

West Central Montana  
Avalanche Center

During the 2021–22 operating season, the West Central Montana Avalanche Center (WCMAC) maintained the thrice-weekly avalanche forecast schedule of previous seasons and issued fifty-seven forecasts. The season included six high hazard days, three avalanche warnings, one special bulletin, twenty-four considerable ratings, seventeen moderate, and ten low danger days. Additionally, six general avalanche information bulletins were issued. The WCMAC issued the season's first forecast on December 30, 2021, and the final forecast on April 9, 2022.

In contrast to the previous two years, when deep slab instabilities created season-long problems, facets played a minor role and rounded out quickly during the 2021–22 season, except for two short-lived

## 22.23 Winter Public Pro Schedule

### Bozeman, MT

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

### Jackson, WY

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

### Salt Lake City, UT

Pro 1 Dec 11-16  
Pro 1 Jan 9-14  
Pro 1 Feb 20-25  
Pro 2 Jan 30-Feb 5  
ProAvSAR Jan 17-21

### Estes Park, CO

(alpine guide specific)  
Pro 1 March 5-10

### Seven Utes Yurt, CO

(meals and lodging included)  
Pro 1 Feb 21-26

### MT. Baker, WA

Pro 1 Dec 9-14  
Pro 2 Dec 16-22

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and isolated deep slab problems in the Bitterroot. Wind slab was the predominant problem type, making an appearance 75% of the time. Wet problems regularly appeared with rain to upper elevations in January, February, March, and April. Temperatures well above average in late March resulted in a widespread wet slab cycle with slides to D4 in size.

The winter season started late and suddenly. In early December, we recorded 12" of unconsolidated base. The snowpack grew to 40+ inches by December 10th, and forecasting began. It was nice to find a stable, uniform base underlying the snowpack. Snowpack hovered around 100% for most of the season but dropped below average during the late March warmth. April and May brought winter back, and the snowpack climbed to 110% by May 1st, 2022. Cold temperatures and continued snowfall through May brought SWE to nearly 500% of average by June 15th, 2022.

Personnel changes from the previous season included the retirement of Travis Craft from the Director position. Forecaster Jeff Carty was selected and welcomed as the incoming Director, and Ryan Sorenson, previously of the Mt. Shasta Avalanche Center, was hired

as a Forecaster. Returning from last year, five Professional Observers were employed to gather field observations throughout the forecast area. One hundred eighteen Professional Observation days were logged, providing increased coverage of the forecast area. Public Observations stayed on par with the previous two years at 125 observations.

The WCMAC transitioned to the National Avalanche Center (NAC) dashboard and website platform after using the previous website for over a decade, bringing increased functionality to and receiving consistently positive feedback from the community. In addition to the new website, the WCMAC defined three forecasting zones to represent conditions more accurately throughout the area. On February 12th, 2022, the WCMAC updated the forecast areas, indicating the Seeley Lake zone, the Rattlesnake zone, and the Bitterroot zones. This welcome change resulted from recognizing the growing needs of the user base and helping to deliver more accurate and specific forecasting products for west-central Montana.

The West Central Montana Avalanche Foundation (WCMAF) education program kicked off the season with free avalanche awareness sessions for all backcountry travelers.

Four avalanche awareness events occurred as online webinars and three as outdoor motorized education events. Collectively just over 300 people attended the awareness events. This winter also marked the return of the Know Before You Go (KBYG) program, with classroom and field sessions. The KBYG program spent significant time with school groups and reached over 200 students. Weekly Level 1 courses began in January and ran through March. All non-motorized Level 1 courses were led by American Avalanche Association (A3) Pro instructors and delivered within a hybrid format that included virtual classroom sessions and a 4-to-1 student-to-instructor field ratio. For the fourth consecutive season, the WCMAF partnered with the Mountain Riding Lab to provide AIARE's motorized curriculum to mountain riders throughout the region. Overall, Level 1 course offerings reached 144 students this season. With the education team focused on weekly course offerings, WCMAC Forecasters expanded educational program capacity and outreach by delivering an Avalanche Rescue course for Missoula County Search and Rescue and on-snow training for regional Forest Service staff.

When we reflect on the 2021–22 season, it reminds us that the ability to provide avalanche information and education is made possible through the continued support of dedicated avalanche professionals and the communities we serve. Operating in the mountains, we observe continuous changes in weather and snowpack. Similarly, the backcountry community is constantly changing, growing, and diversifying. As an organization striving to equip communities with the tools needed to recreate safely in a dynamic environment, our responsibility is to change, grow, and evolve. **As we prepare**

“  
**REFLECTING ON THE 2021–22 SEASON, WE ARE REMINDED THAT THE ABILITY TO PROVIDE AVALANCHE INFORMATION AND EDUCATION IS MADE POSSIBLE THROUGH THE CONTINUED SUPPORT OF DEDICATED AVALANCHE PROFESSIONALS AND THE COMMUNITIES WE SERVE.**

for another busy winter season, our focus remains on community engagement, staffing, partnerships, and educational resources.

—WCMAC Staff



**WCMAC:** Ryan Sorenson gathers field observations and assesses the snowpack following the mid-December storm cycle.

TRASK BAUGHMAN





During the holiday week of December 2021, the “**Santa Slammer**” single-handedly delivered almost half of our entire season’s snowpack in just 9 days. Schofield Pass recorded 14” of SWE—the most intense 10-day loading period since its installation in ‘86. The storm produced a prolonged and destructive cycle, starting with a widespread cycle below treeline early on, and shifting to extensive deep D3 to D4 activity from alpine late in the cycle, some of which expanded historic runouts. Here are a few of the avalanches that we documented after the storm cleared.

—ZACH GUY, CRESTED BUTTE AVALANCHE CENTER



## CORRECTION

The article *Snowpit Scoring: Strength Structure Propagation* on pages 36–37 in TAR 41.1 was published with an inaccurate figure representing the discussed scoring model. Here you will find the **correct figure** to provide clarity.

Please contact the editor at [avalanche.review@avalanche.org](mailto:avalanche.review@avalanche.org) if you would like an updated electronic copy of the complete *Snowpit Scoring* story.

	Rating	Description	Score
Strength	Difficult	Tap score 21-30	3
	Moderate	Tap score 11-20	2
	Easy	Tap score 0-10	1
Propagation	ECTX	ECT provided no results	3
	ECTN	ECT provided no propagation	2
	ECTP*	ECT provided full propagation	1
	ECTPV*	ECT fails with full propagation on isolation	0
Structure	Good	Weak snow on top of strong snow, lacking a weak layer	3
	Fair	Strong snow on top of weak snow, greater than a meter deep and lacking a PWL	2
	Poor	Strong snow on top of weak snow, PWL is present	1
	Very Poor*	All lemons or PHD factors are present	0

Total Score =



ON  BACKCOUNTRY

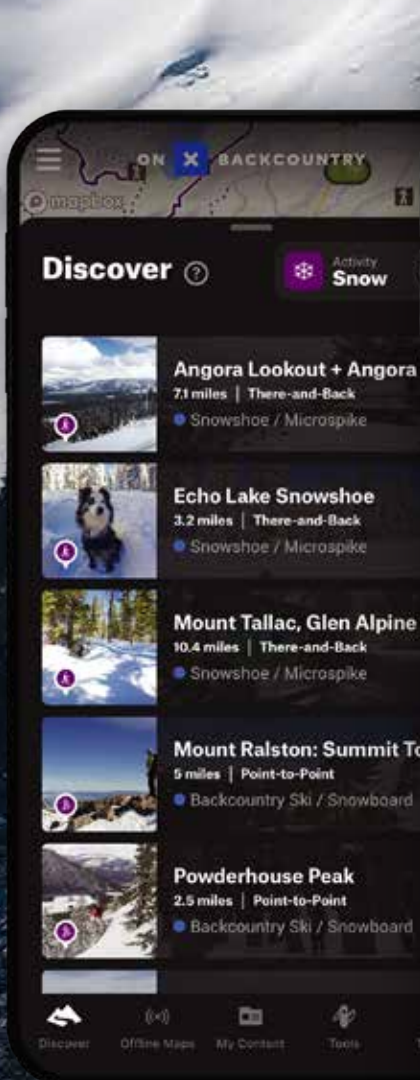
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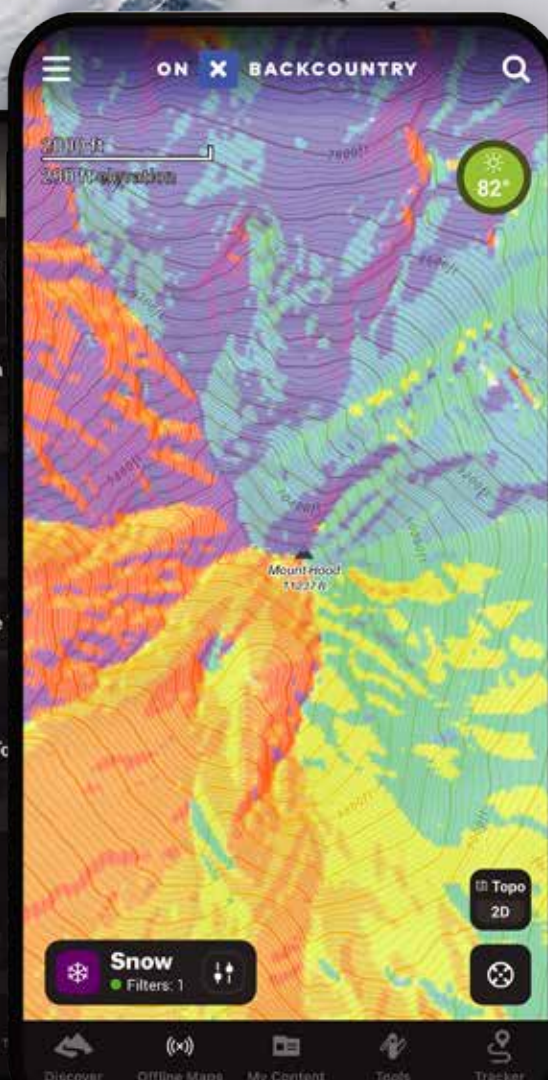
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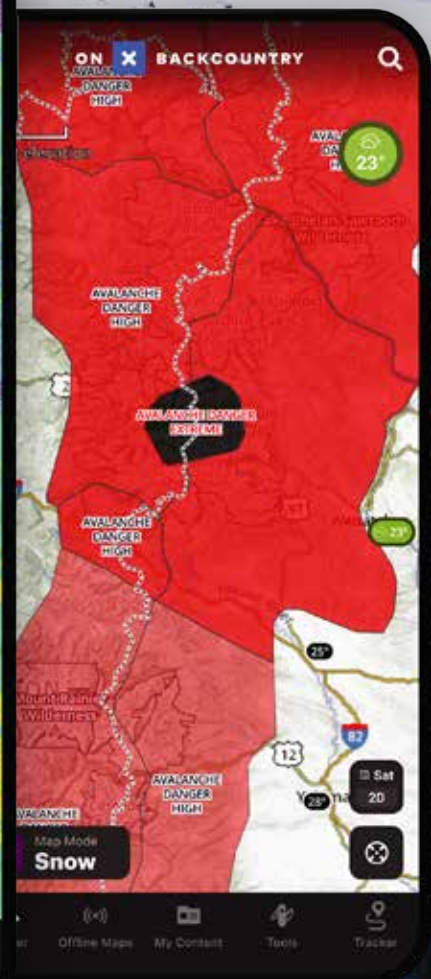
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