

40.2

EARLY WINTER 2021

VALANCHE

INVITATION FOR CONVERSATION

REVIEW



Wyssen Avalanche Tower

Protecting Roads and
Ski Areas in the USA -
within minutes



**avalanche
control**

Wyssen USA Inc.
80301 Boulder CO
+ 1 208 891 95 43
usa@wyssen.com
www.wyssen.com



GAIA GPS

www.gaiagps.com

**Plan tours.
Navigate. Share
tracks and obs.
Analyze terrain.**

With Gaia GPS, you can track your location and use topo maps offline. Plan tours and share tracks and observations with your team. Analyze terrain with satellite imagery, satellite-topo hybrid maps, and slope-angle shading.

Available both on iOS and Android





AMERICAN
AVALANCHE
ASSOCIATION

A3 STATEMENT OF PURPOSE

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

A3 STAFF AND BOARD

EXECUTIVE DIRECTOR.....Jayne Thompson Nolan
PRO TRAINING COORDINATOR.....Erica Engle
MEMBER SERVICES COORDINATOR.....Jen Reddy
TAR EDITOR.....Lynne Wolfe
TAR DESIGNER.....McKenzie Long

EDITORS EMERITI

Steve Conger Blase Reardon
Sue Ferguson Bruce Tremper

A3 GOVERNING BOARD TRUSTEES

PRESIDENT*.....Halsted Morris
VICE PRESIDENT*.....Erich Peitzsch
SECRETARY*.....Katie Warren
TREASURER*.....Dan Kaveney
MEMBERSHIP*.....Jake Hutchinson
PUBLICATIONS.....Drew Pogge
EDUCATION.....Eeva Latosuo
GOVERNANCE.....Sean Zimmerman-Wall
AT-LARGE PRO.....Kate Koons
MEMBER AFFILIATE.....Jonathan Shefftz

*Executive Committee denoted by **

the AVALANCHE

REVIEW

The *Avalanche Review* is published each fall through spring by the American Avalanche Association, Inc., a nonprofit corporation. For a digital version, visit theavalanchereview.org. The *Avalanche Review* welcomes the submission of articles, photographs, and illustrations.

Please send submissions to:

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

Design & Production:

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

Business, Subscriptions, & Advertising:

Jayne Thompson Nolan — A3 ED
tel: (307) 360-9099
jayne@avalanche.org

Subscription: \$35 per year (4 issues). Subscription is included with membership dues to A3. For subscription and membership information, see www.AmericanAvalancheAssociation.org

Articles, including editorials, appearing in *The Avalanche Review* reflect the individual views of the authors and not the official points of view adopted by A3 or the organizations with which the authors are affiliated unless otherwise stated.

© 2021 by the American Avalanche Association.

Materials may be reproduced for research or classroom use. Permission is also granted for use of short quotations, figures, and tables in scientific books and journals. For permission for other uses, contact *The Avalanche Review*.

★ PHOTO CONTEST FINALIST



40.2

EARLY WINTER 2021

CONTENTS

CHARLES HLAVAC

6	FROM THE EDITOR
8	FROM THE PRESIDENT
9	FROM A3
10	METAMORPHISM
12	GRAUPEL
	DECISION-MAKING
14	Change Your Lenses. <i>By Amy Pertuz</i>
17	Good Terrain Selection. <i>By Steve Conger</i>
18	Applying Strategic Mindsets to Rec Courses. <i>By Colin Zacharias</i>
	FORECASTING
20	The Avalanche Forecast Quiz Project. <i>By Kevin Grove</i>
22	The Avalanche Forecast Quiz Project. <i>By Paul Diegel</i>
24	PHOTO CONTEST FINALISTS
	TAR TURNS 40!
26	Timeline of TAR
28	The Editor Who Knows Everybody. <i>By Emma Walker</i>
	RESCUE
30	Search and Rescue in the San Juans. <i>By Travis Laverty</i>
	SNOW SCIENCE
32	Deep Space. <i>By Gabrielle Antonioli</i>
33	Community Snow Observation. <i>By David Hill</i>
34	2020–2021 AVALANCHE CENTER SEASON SUMMARIES: Part 2
47	LAST LAP
	Film Review of <i>Buried</i> . <i>By Andrew Hennigh</i>

★ PHOTO CONTEST WINNER!



ON THE COVER

March 15, 2019. From the air, the East Riverside slide overtakes the humble snowshed below on Highway 550 south of Ouray, Colorado. This was one of dozens of very large slides that ran during the historic March 2019 cycle. We initially tried keeping the pass open with less drastic measures, but the snow just kept falling. Several large consecutive storms along with lots of volume on the ground necessitated corridor-wide heli mitigation. The section of Highway 550 from Ouray to Silverton was closed for a record 18 days due to storms, hazard, mitigation and then the absolutely massive amount of avalanche debris on the road. Estimated debris coverage on the highway corridor was five miles in length, with piles up to 60 feet deep.

ANN MELLICK, CAIC FORECASTER

NO EXPLOSIVES. EASIER, BETTER, FASTER, SAFER.

**GAS REMOTE AVALANCHE
CONTROL SYSTEMS**

Alta, USA
Ski Resort
4 O'BellX in operation


MND SAFETY

safety@mnd.com / www.mnd.com

Your contact in North America

northamerica@mnd.com



ROPEWAYS ■ SNOW ■ SAFETY ■ LEISURE



PHOTO CONTEST FINALIST ■ BOB RANKIN

FROM THE EDITOR

MY PEOPLE, MY MISSION: an invitation to conversation

SAW season is exciting, and especially this year, when we are able to gather in person as well as incorporate remote participation. At WYSAW, we had 250 in-person attendees and another 450+ people watching remotely. What a fabulous way to spread our messages and generate conversation! Many other SAWs have gone to some kind of hybrid form, mixing in-person speakers with remote attendance. I've been trying to attend many of them; there's so much important insight being shared on a wide variety of topics from local updates to new forecasting tools to ongoing insight into the mysterious ways of human decision-making. You'll see some of those topics in TAR later in the volume.

At WYSAW this year, as many people offered their congratulations on a smooth and interesting event, I realized a couple of points: First, these events are committee products, made better by many large brains working together. Committees, you rock! Thank you.

Second point: as I talked with friends near and far during and after the event, my mission statement became clear to me: **my people, my mission**. You're my people, snow and avalanche workers and recreationists, like it or not, and my mission is to help keep you from dying in avalanches. TAR fits under that aegis, as do WYSAW and avalanche education, as do community outreach and mentorship. It's complicated—and so rewarding. I hope to offer you, in one of those roles, some kind of tool or insight on improving your practice. In line with our theme for this issue, I am inviting you to **join our ongoing conversation** in TAR about all aspects of the avalanche world.

On offer in this issue, we'll start with the bling. We held a Cover Photo Contest and got some amazing shots that we will be showcasing the rest of this volume. Ann Mellick's East Riverside was the clear winner, however. You can almost feel the helicopter bucking in the gusts. The San Juan snowpack always demands respect, and especially in 2019. Check page 24 for the runners-up; **other editor's choice shots** are scattered through the text.

We've created a TAR timeline that shows significant dates and images along our 40-year trajectory. Emma Walker finally got me to answer some TAR questions as well (page 28).

You'll also find some useful tools to aid your conversation in the decision-making section (starting page 14), as Steve Conger presents an

BR: The avalanche was skier-triggered remotely while skiing on the "ribs" when things were spooky in the Cariboo range of BC.

LW: Super interesting how far up the lower angle ridge it reached on the skier's right. Surface hoar?

BR: Yup surface hoar 1 month old! 70-110 p slab, yikes! We knew it was lurking and were tip-toeing through the tulips so to speak! We had never seen these little bowl features slide, other than little lee wind slab pockets. The run itself is quite low angle and people ski there often in poor stability/high hazard days. I really dislike surface hoar! Of note, the crystals were well preserved and near cornflake size!

educational terrain selection mindset array, Amy Pertuz tells us how to change our lenses from Preacher, Prosecutor, or Politician to Scientist. From our friends at Canada's *The Avalanche Journal*, we are reprinting Colin Zacharias' important essay about mindset for recreational avalanche classes; personally I have already grabbed his chart for my upcoming Rec LIs.

Kevin Grove and Paul Diegel worked simultaneously on inserting quizzes into forecasts last season. On page 20 we are treated to their methods and musings. The next question to research seems to be whether promoting understanding of the forecast leads to the crucial step of recreationists actually making better decisions?

Travis Laverty tells a powerful story of two rescues in the San Juans last winter. He offers us some tools to consider if we are confronted with deep burials and multiple fatalities of our own. Thanks to Travis and all the rescue personnel out there. We appreciate your selflessness and your hard work (page 30).

A few more fun bits and pieces in this issue: In Deep Space, Gabrielle Antonioli gives us insight into her world, which is filled with snow and mountains, not many people. David Hill updates us on Citizen Science Observations, and we have part 2 of our Avalanche Center season summaries, with a recurring theme of **A Confluence of Factors**, where you will find some powerful stories and lessons in tightly packed paragraphs.

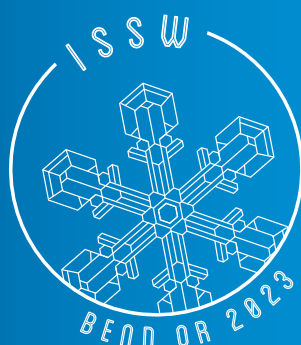
Finally, after reading Andrew Hennigh's review, I can't wait to see *Buried*, a film about the 1982 Alpine Meadows avalanche that was released this year (page 47).

—LYNNE WOLFE



**SAVE
THE
DATE**

**October
8-13, 2023**



**THE
AVALANCHE HOUR
PODCAST**

tap into the collective



Ski Fast, Flylow



Life goes fast. Let's slow down and enjoy it.
We make gear for long days in the mountains.



Independent
Homegrown
Mountain Raised

FLYLOWGEAR.COM

FROM THE PRESIDENT

The mastheads of the first and seventh issues of The Avalanche Review, from Hacksaw's archive.



LOOKING BACK AND LOOKING FORWARD

This issue of *The Avalanche Review* (TAR) is considered to be the 40th anniversary issue. Sue Ferguson started TAR in 1982 and eventually in 1986 it became the official publication of the American Association of Avalanche Professionals (AAAP). In 2000 the AAAP changed its name to American Avalanche Association (A3). I first became aware of TAR at the REI store in Denver back in 1983. TAR in those days was just sort of a small newspaper format, with a cover price of \$1.75 as I recall. TAR has come a long way since those days, as has A3.

When I was A3 vice president, John Stimberis, then A3 president, asked me (because I have a complete set of TAR) to put together a spreadsheet of who has been listed in the TAR masthead over the years of board positions, section representatives, and committee chairs. As it turns out it is a list of who's who over the years in the American avalanche industry. I continue to keep this list up to date.

For perspective, there have been 10 presidents of AAAP/A3 including myself, nine vice presidents, nine secretaries, 13 treasurers, seven TAR editors and seven executive directors including our current director Jayne Thompson Nolan.

Many folks over the years served in various board positions. Knox Williams and Don Bachman seem to be tied for the distinction of having served in three separate board roles for AAAP/A3. Knox was president, secretary, and treasurer and Don was secretary, treasurer and executive director. Bill Williamson served twice as vice president. Meanwhile Stuart Thompson, who served as membership chair from 1991 till 2017, holds the distinction for longest continuous service record with AAAP/A3. How many board meetings did you attend Stuart? You have to hold the record.

The list of "big name" avalanche industry leaders is very impressive : LaChapelle, Wilson, Montagne, Williams, Boyne, Kellam, Atkins, Stimberis, Armstrong, Fitzgerald, Baugher, Williamson, Richmond, Peitzsch, Ferguson, Penniman, Bachman, Gleason, Bartholow, Savage, Johnston-Bloom, Warren, Tremper, Conger, Reardon, Wolfe, Moore, Ream, Glude, Ferrari, Logan, Marler, Mace-Messina, and Thompson. These are the folks that got A3 to where it is today. I'm sure I missed someone, please don't be offended. I hope that many of them will be mentioned in Lynne Wolfe's avalanche history book. They all deserve a big thank you.

A3 has come a long way since it was first formed, and has made a real difference in the avalanche world. AAAP/A3's efforts have paid off with establishment of educational guidelines for courses, the much-needed pro/rec course split in education, numerous scholarships and research grants, publishing the SWAG book and *The Snowy Torrents* series, ISSW support, pro employment listings on the A3 website, A3's involvement with avalanche.org, the memorial list for both humans and rescue dogs, and the 40 years of publishing TAR. I'm not sure, but I would bet A3's efforts have helped to keep many people from being killed by an avalanche. These are all things that the A3 membership should feel very proud of. Without your support none of this would have been possible. But most of all **A3 has helped promote the profession and industry that we work in, and helped to build a real community that we can all be proud of.**

It's interesting to not only look back on how far we have come, but also to look forward. We have financially survived the Covid-19 pandemic thanks to Executive Directors Dan Kaveney and Jayne Thompson Nolan. Now we are looking forward to A3's future with strategic planning. Yes, for the first time in AAAP/A3 history we have engaged in doing a strategic plan. At first I wasn't sure what the strategic plan would do for us, but the membership strategic planning survey pointed out many subjects that you as members want the A3 board to focus on. I'm happy to see that strategic planning is really going to help A3 determine our next directions. Our future looks bright. Here's to the next 40 years for A3. Cheers!!



-HALSTED "HACKSAW" MORRIS



40 YEARS OF THE AVALANCHE REVIEW



AMERICAN AVALANCHE ASSOCIATION

Help us continue to publish snow industry research, news, and debate for another 40 years.

americanavalancheassociation.org

PLEASE DONATE TODAY!



Chair Peak, Washington.
Bryce Hill

A3 PROJECT UPDATE

Measuring Blast Exposure of Avalanche Mitigation Workers

BY ALLIE FREDBO, MANDY GEISLER, AND KEN THOMPSON

We are a Utah-based group of avalanche professionals with a combined 50-plus years of industry experience. In 2019 we were recipients of a grant from the American Avalanche Association to study the exposure of avalanche workers to blast overpressure. We would like to provide a bit of background, a brief update, and future goals of our project.

Explosives are a necessary tool to mitigate the threat of avalanches. Research in our industry has focused on the effectiveness of explosives on the snowpack to maximize the usefulness of mitigation efforts. In other industries where workers are in close proximity to detonation events, such as military and law enforcement, there has been a recent focus on the effects on the user. We hope to apply this same research intention to gather data on the exposure avalanche workers face during routine mitigation efforts.

Exposure to workers can be estimated at known distances for a specific type and size of explosive. However, in real world blasting environments, rocks, variation in slope angles, and snow conditions are likely to significantly influence the characteristics of the pressure wave affecting mitigation workers. We believe it will be most relevant to directly measure blast pressure levels in the vicinity of the worker during mitigation operations.

To this end, in 2020 we purchased six wearable sensors specifically designed to measure pressure waves experienced by personnel in the area of a blast event. Their small size makes them ideal for attaching to workers with minimal impact on normal operations. Data is stored and can be downloaded later for analysis. These same devices are routinely used by the military and law enforcement teams for field monitoring and ongoing research endeavors focusing on the impacts of repetitive exposure.

After receiving the sensors our team has been focusing on calibrating the equipment and refining our data collection process. We were able to test



Counter-clockwise from top: Controlled test using pressure sensors. Sensors are attached to bamboo at known distances to measure the decay of the pressure wave as it spreads out from the point of detonation.

■ ALLIE FREDBO



Close-up of pressure sensor attached to 'boo following controlled detonation.

■ ALLIE FREDBO

Pressure sensor being worn on the chest strap of an air-bag pack.

■ MANDY GEISLER

our devices in a series of control experiments with detonations at known distances. This allowed us to compare the performance of our sensors to previous studies from inside and outside of our industry. We field tested the sensors on control routes in a variety of environments to ensure their suitability. This winter we plan to expand our data collection by placing sensors on a wider variety of workers during routine mitigation operations. With the increase in volume of data we hope to gain insight into the nature of the exposure workers face during typical mitigation operations.

A special thank you to A3, the Alta Avalanche Office, and Mark Saurer of UDOT for your support of our project.

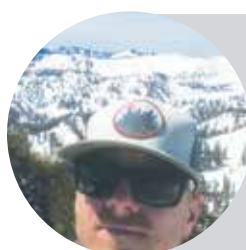
For additional details, questions, or **conversation** our emails are provided in our bios below. ●



ALLIE FREDBO graduated with a Bachelor's degree in Molecular Biology and Chemistry and worked for many years researching in the fields of neuroscience and drug discovery. She is currently a Physician Assistant student with the Yale School of Medicine, alliefredbo@gmail.com.



MANDY GEISLER was reared in Maryland and moved to Utah in 2008. She's in her 13th year ski patrolling and currently works in the snow safety department at Park City Mountain Resort. She remains elusive but she's often out with her avalanche search and rescue dog, Kiki. Amandamariegeisler@gmail.com.



KEN THOMPSON grew up skiing in Maine and likes to return to the Atlantic North East to go swimming from time to time. He has his bachelor's degree in Physics, 9 years of professional avalanche mitigation experience, and is an expert in weather stations, KenThompson.Maine@Gmail.com.

DELTALANCER AVALAUNCHER AMMUNITION

Designed & Developed by Delta K EES Ltd. in the UK. Cooperatively Distributed by Avalanche Control Logistics LLC and Accurate Energetic Systems LLC in the USA.



Key Design Characteristics:

- Safe replacement of Slip-pin ammunition variants
- Turbine controlled safe arming mechanism
- Pentolite or enhanced RDX based loading options
- Low inertial loading of blasting cap to improve safety
- RECCO reflector cast into main filling
- Advanced aerodynamic profile
- Inert and powder marker loads for ranging and/or training
- Future proof design supports ongoing product optimization



ACL • Dan Dobrowolski • dan@avconlog.com • 434-960-0558

METAMORPHISM

ALASKA WELCOMES JOHN SYKES TO CNFAIC



The Chugach National Forest Avalanche Center is thrilled to welcome **John Sykes** to the Girdwood, AK avalanche forecasting team! He will be filling a full-time seasonal backcountry forecaster role for the center.

John began his career as an avalanche professional in 2011 working as a mountaineering guide for Alaska Mountaineering School and an avalanche educator for the Alaska Avalanche School. John's first taste of backcountry forecasting was during the 2014–2015 season when he completed an internship with the Chugach NF Avalanche Center. Feeling the draw to further his education in snow science, John completed a MSc at the Snow and Avalanche Laboratory in the Department of Earth Sciences at Montana State University. His research focused on decision-making in backcountry skiers by looking at GPS tracks and survey responses. While living in Montana, John also taught avalanche courses for the American Avalanche

Institute and Gallatin National Forest Avalanche Center. Since 2019 John has been working on a PhD with the Simon Fraser University Avalanche Research Program, continuing to research decision-making in avalanche terrain by developing new avalanche hazard mapping techniques and analyzing GPS tracks of professional guides. The goal of his research is to work towards a new decision-making tool for both professional and recreational backcountry skiers based on the observed decisions of expert guides. John is currently a member of the board of directors of the Alaska Avalanche School and a professional member of the American Avalanche Association.

We are very excited to have John back in Alaska and will be taking full advantage of his various skill sets in advancing our avalanche center. We also look forward to balancing his academic interests with lots of field days on skis and snowmachines! ●



WINDS OF CHANGE BLOW THROUGH UDOT AVY

BY MARK SAURER

This fall has seen a couple significant changes to our UDOT Avy family in Little Cottonwood Canyon. Supervisor **Damian Jackson** has decided to step away from his 20 years in the canyon (and eight as part of the UDOT crew) and move back home to Puget Sound with his wife Elly to live on their sailboat. Damo still plans to stay active in the industry working seasonally for WASHDOT Avy and heli-guiding in Valdez. Best wishes to Damo and Elly and hopefully someday they'll sail around to our house on Lake Superior for a visit and a fish fry.

UDOT Avy Program Manager Steven Clark recently named **Laurie Delaney** as the new LCC Canyon Supervisor. Laurie was brought on as a part time seasonal forecaster by Liam Fitzgerald in 2014 and was promoted to full time the next year. She's proud to follow in the footsteps of our former boss and mentor Liam; as a Snowbird Patroller, resident of the famed Hilton, and now Supervisor of LCC.

And finally, also after eight years at UDOT, I (**Mark Saurer**) have taken an opportunity to move back over the Wasatch to my home resort of Park City to help run the Snow Safety Department. As I have written before, I'm proud to have been a part of the UDOT LCC Crew and in a small way, the storied history of Little Cottonwood. I'm honored to have been mentored by Liam, Garsky, Mongo, Onno, Matt McKee, and Bill Nalli along with all the current UDOT avy crew members and partners in the canyon. Laurie, Korps, Dan are a solid crew, skilled forecasters and good friends. I wish them all the best along with the yet-to-be named (at press time) new members of the team. I look forward to being a full-time patroller again and mentoring the next generation of rookie patrollers and avalanche professionals. Thank you everybody for all the support in my UDOT Avy career. Stay safe and stay healthy. ●



NWAC 2021-22 HIRING ANNOUNCEMENT

The Northwest Avalanche Center continues to grow this season as we strive to provide our community with the best mountain weather and avalanche forecasts, educational opportunities, and public outreach. With that in mind, we're excited to announce a few staffing changes as well as adding four new members to our team.

Katy Wicks will join our program as the Membership and Communications Coordinator. Katy grew up and went to school in Moscow, ID. She will focus her efforts on connecting with our community and continuing to grow our membership base.

Katie Smith began working this year as the new Outreach Coordinator. A recent transplant to the Seattle area, she will work closely with NWAC's numerous educational opportunities and community outreach events.

On the forecasting side of our operation, we have some movement within our staff and a few new faces. After several seasons serving at NWAC, **Peter Moore** (Mt. Hood zone forecaster) is changing careers. We'd like to sincerely thank Peter for all his time and hard work at NWAC serving as our first

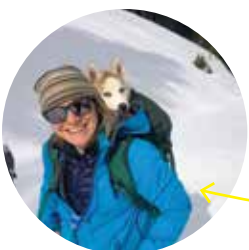
avalanche forecaster in the Hood area. We wish him all the best in his new endeavors.

NWAC forecaster **Andrew Kiefer** will be "switching volcanoes" so to speak this season. Andrew has worked in our West North (Mt. Baker) zone for the past several seasons. This year, he will be moving to the Mt. Hood area. We're excited to bring Andrew's skills to the Hood, East South, and West South zones.

Joining our forecasting crew this winter, **Lee Lazzara** will step in as forecaster for the West North and West Central zones. Lee is no stranger to NWAC and the local snow community. Lee worked from 2015–2020 as one of NWAC's professional observers and is a long-time local IFMGA guide.

We're also expanding our forecasting capacity this season in the East Central and East South zones. **Katie Warren** will join us as a new forecaster based in Cle Elum, WA. Katie will bring several years of ski patrol, DOT, and research experience to our program, serving these east-side regions.

We hope you will join us in welcoming these new faces to the NWAC family. We're excited about the new skills and opportunities they bring to our program. ●



Bruce Tremper inducted into the Intermountain Ski Hall of Fame

BRUCE TREMPER ~ INDUCTED 2021
(1953 -)



Bruce Tremper is the grand maestro in the realm of avalanche safety for developing innovative avalanche forecasts, videos, classes and books used throughout North America and the world in a career spanning more than 40 years.

A prolific author, speaker, instructor, researcher, videographer, pioneering avalanche forecaster and exceptional communicator, Tremper developed multimedia backcountry avalanche forecasts, popular avalanche classes, wrote two bestselling avalanche books translated into five languages, co-produced several prize-winning videos, and was featured in dozens of national and international avalanche documentaries and news programs. He coordinated backcountry avalanche safety for the Olympic/Paralympic Winter Games of 2002 in Salt Lake City and helped launch avalanche centers in Japan and Norway.

A native of Missoula, MT, he was a member of the Junior National Ski Team and U.S. Ski Team Talent Squad. In 1973 he was NCAA conference downhill champion. He received a master's degree in geology from Montana State University in 1982. Tremper performed avalanche control work at Montana's Bridger Bowl Ski Area starting in 1978, was director of avalanche operations at Big Sky Ski Area, then a backcountry avalanche forecaster for the Alaska Avalanche Forecast Center before his nearly three decades as the Director of the Utah Avalanche Center.

FROM THE UAC

August 2021: **Bruce Tremper**, former Utah Avalanche Center (UAC) Director for 29 years, was inducted into the Intermountain Ski Hall of Fame by the Alf Engen Ski Museum Foundation at the Olympic Winter Sports Center in Park City for creative contributions to the avalanche world. It's a prestigious and honorable recognition for one of the world's most reputable snow forecasters.

It's impossible to fully quantify Bruce's impact on the entire snow sports industry. For one, he literally "wrote the book" on avalanche safety. He pioneered many, now standard, ways to teach people about avalanches and how to create avalanche forecasts. He has been a friend, mentor, and inspiration to countless people who have safely enjoyed thousands of days of backcountry skiing thanks to his tireless work. ●



WILL and JEAN PICKETT



Announcing SlabLab.org SnowPilot Update

SlabLab is a new research organization, focusing on the experience of backcountry travelers. Through interviews, surveys and other methods we seek to understand the honest experience of backcountry travelers. We want to learn what people are actually doing, in their own words. We hope to identify common themes and lessons learned from these interviews and share them back to the community. We hope our work will benefit backcountry users, forecasters, instructors, and product designers.

SlabLab is for anyone who enjoys or aspires to travel in the mountains when there is snow on the ground. We are engaging with users of all experience levels, as both contributors to, and beneficiaries of the work we're doing.

We will share our findings publicly. We aim to share a report of our initial findings during the 2021-22 season. In addition to the report, we will be curating a content library on our website, slablab.org.

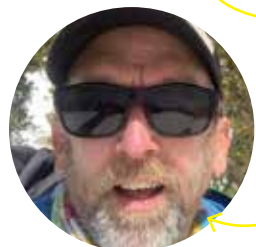
You can contribute to this effort by scheduling an interview to share your experience. If you are interested in contributing in this or other ways, please get in touch at www.slablab.org or hello@slablab.org.



SlabLab is currently a team of two; Daniel Feldman and Richard Bothwell.

Daniel Feldman is a Human-Centered designer with experience creating a wide variety of solutions, from a digital platform for community health workers in North Carolina to financial empowerment programs in rural India.

Richard Bothwell is a long-time avalanche educator and guide, guide service owner and former Executive Director at AIARE. ●



BY DOUG CHABOT

SnowPilot is growing with pits by the day and we are excited that avalanche educators are using this platform in their classes. To keep the database free from redundant pits we are reminding educators to have their students check the "Practice Pit" box under the date entry. This way we don't have a dozen identical pits in the database which could adversely effect research. Students still get to look at their pits, but it provides a way for others to easily filter them out.

Currently the database has about 37,000 snowpits available for research. **In the last 12 months over 7,500 pits were added worldwide!**

Thanks for helping to get the word out. ●



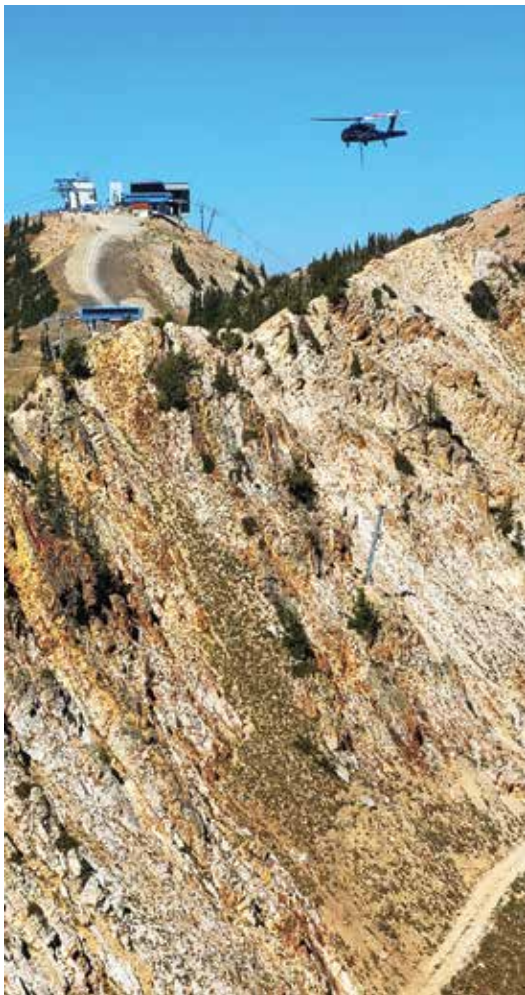
HUCKEM update

BY STEVE CONGER

In support of folks using the mnemonic HUCKEM, a website has been created to provide quick reference <https://huckem.com/>.

Additionally, die-cut stickers are available. Through the rest of 2021, the simple cost of a sticker is a \$10 donation to either the A3 or the Avalanche Canada Foundation. Information can be found here <https://huckem.com/put-it-to-use/>. ●





NEW TECHNOLOGY FOR SKI AREA AVALANCHE MITIGATION



Clockwise from top: Tower being flown onto foundation at Snowbird. Ischgl, a ski area village in Austria, employs numerous RACS to protect its pistes. Construction of Wyssen Tower Foundations at Snowbird. ■ MATT RISLEY

BY ROZ REYNOLDS

Technology is always progressing in our modern world in all fronts. The new technology on the block for ski area avalanche mitigation is in the area of RACS (remote avalanche control systems), bringing benefits of greater efficiency and a larger separation of people from detonations.

Ski areas in the United States have used RACS for quite some time now, but recently there has been some new technology on the scene. Gazex and O’Bellx have been utilized by some ski areas around the country and have been in use for a while. These systems use gas explosions as a trigger for avalanche mitigation. This upcoming winter season will see the first use of Wyssen Avalanche Towers at ski areas in North America, using explosives for detonation. Alta Ski Area of Little Cottonwood Canyon just installed four Wyssen Towers this summer. Additionally, Snowbird installed four towers in Mineral Basin as well.

The progression of RACS installations comes from a variety of reasons, but one of them is pressure by the military to decrease howitzer rounds used by civilians. The howitzer has traditionally been an exceptional tool for avalanche mitigation in the American West, introduced by Monty Atwater after World War II. With accuracy and power, howitzers are very effective at triggering avalanches preventatively, but they do spray shrapnel across the mountainside. What is unique about RACS as a tool compared to howitzers is that they are systems specific to avalanche mitigation with no other purpose.

Hand charges are also deeply integrated into avalanche mitigation at ski areas. Their use is not as statistically dangerous as one would think, but it does not come without risk. There are a lot of moving parts with handheld explosives in mountainous terrain and in often adverse weather conditions. But, just like the howitzer and other methods of avalanche mitigation with a long history, they are effective at what they do. RACS will probably never completely replace the need to use hand charges. Ski areas need to control terrain for skiers and even a small avalanche posed a threat. Hand charges are very effective at mitigating specific terrain features like gullies in undulating terrain.

RACS have been used in Europe on ski areas for quite some time. Ischgl and Samnaun ski areas, in Austria and Switzerland respectively, are a prime example of this as they employ over 100 RACS for use at the ski areas. Because of this, they are able to open up pistes to skiers in a timelier manner than before the use of RACS. There are many other examples of RACS at ski areas in Europe and more and more are installed each year.

RACS are also used to protect roads and other infrastructure in the United States. Departments of Transportation (DOTs) in some places have their

hands full with hazard to roads via avalanches. UDOT, CDOT, CalTrans, WSDOT, ITD and WYDOT are among the DOTs that have teams specifically assigned to avalanche mitigation for the protection of roads and to do their best to keep certain roads open during the winter. Many of these DOTs, including UDOT, CDOT, CalTrans, and WYDOT, have installed RACS to benefit their avalanche mitigation program.

As RACS become more integrated into our society, we must play our part to educate our community on what they are and how they work. One point that is important for the outdoor community to know is that RACS mitigate avalanches but what they are NOT designed to do is protect backcountry skiers. In fact, the word ‘backcountry’ indicates lack of infrastructure. If you are skiing in the backcountry and you come across a structure designed for avalanche mitigation, do not assume the area around it is safe. You might not know how these systems are being used. RACS are often used to protect roads and the size of avalanches that affect roads are very different than those that can affect backcountry skiers. As a side note to that, at ski areas, RACS can be used to protect skiers. But the same judgment applies, do not assume that these systems provide proof of safety. One must follow the guidelines of the avalanche professionals at the resort.

At Snowbird and Alta Ski Area this summer, construction for installation of the Wyssen Avalanche Towers was completed in August. Foundations were built at the locations determined to target the desired avalanche starting zones. The four towers at Alta Ski Area and four towers at Snowbird were successful installed in the terrain. Now the next step is snow. It will be interesting to see what this winter brings and how these systems impact the efforts of the ski patrol team. These towers are the first of their kind at ski areas in the United States, but the Wyssen Avalanche Tower and other RACS will likely be utilized more and more at ski areas. ●



ROZ REYNOLDS, lives in Boulder, Colorado, where she works for Wyssen Avalanche Control promoting safer avalanche mitigation installations and detection systems. She has worked for Wyssen since 2017 when she was tasked with kick starting operations in the United States. She is an avid skier, white water rafter, and climber.

KNOW BEFORE YOU GO

A Framework for Avalanche Awareness

BY CHAD BRACKELSBURG

Not many snowstorms get their own Wikipedia page, but this was no average storm. (https://en.wikipedia.org/wiki/2003_Utah_snowstorm). Alta received 87 inches of snow in the six days from Dec 25-31, 2003. On December 26, the storm raged on, trees were knocked down by heavy snow and strong winds, and local power companies attempted to keep the lights on throughout the Salt Lake Valley. Meanwhile, at Sundance Resort located in Provo Canyon, hurricane-force winds, dense heavy snow, and intermittent power outages had forced the resort to close early. The Utah Avalanche Center (UAC) had issued a High avalanche danger, and to those with avalanche knowledge, the danger was obvious. (<https://utahavalanchecenter.org/sites/default/files/archive/advisory/print/advisory/salt-lake/20031226.html>).

The Aspen Grove Trailhead, east of Provo at the base of Mt Timpanogos, teemed with people eager to take advantage of a day off from school or work to play in the fresh snow. With the resort closed, several groups of people, most of whom didn't know each other, hiked up the Elk Point apron under one of the largest avalanche paths in Utah when a massive avalanche released from 4,000' feet above the parking lot and slammed into 14 people. Six people were buried with three teenagers being completely buried. The debris covered an area the size of 22 football fields with a depth ranging from 10-25 feet. One body was recovered two days later but the other two remained buried until the snow melted in the spring.

None of the people buried knew that they were in avalanche terrain and none were carrying avalanche rescue gear. The UAC had issued an Avalanche Warning for that day, but those in the path had not gotten that message. This tragedy made the UAC realize that something had to be done to ensure that those growing up in mountain regions learned about avalanches, just like those growing up next to the ocean learn about rip currents. Work began that season on a revolutionary new kind of avalanche awareness program and in the fall of 2004 the Know Before You Go (kbyg.org) program was released in Utah. While the "Know Before You Go" phrase is now used by countless other organizations who want you to check local information before doing something, we like to think that avalanche awareness was the first use.

To be successful, KBYG had to be exciting, high-energy, compelling, and simple. Long lectures about snow science weren't the answer. We decided that KBYG would be based on teaching people three simple things:

1. Avalanches present a serious risk to anyone in the backcountry
2. There is something you can do to decrease your risk
3. You need avalanche education if you are going to be in mountains in the winter

The program accomplishes this by using five simple steps each which help teach avalanche knowledge:



Another key aspect to make the program successful was the presentation style. Just like the program, the presenter had to be high-energy, enthusiastic, and be able to relate to the students. We leveraged Craig Gordon's energy and trained other avalanche professionals and those aspiring to be to deliver this program. With 8th-grade students as the target audience, KBYG was

taught to almost 100,000 Utah school kids in the first five years. KBYG continues to reach close to 10,000 Utahns each season with about half of these being school-age kids. We have delivered the program to about 250,000 Utahns (and many other non-Utahans) since 2004!

The current version of the program was released in 2015. The feature film was one of the first dedicated avalanche awareness production films and was produced by the UAC with video footage provided by Red Bull Media House, Sherpas Cinema, and others. The video was the first public safety film to ever be named a finalist in the Banff Mountain Film Festival in 2016. To increase the reach of the program outside of Utah, the 2015 version was developed in collaboration with several other avalanche centers, avalanche educators, and some members of the outdoor industry.

KBYG has become the North American standard for teaching avalanche awareness. The program has expanded and is now used in 35 countries and has been translated into 11 languages. With limited free online avalanche education focused on North America, in November 2018, the UAC released the KBYG online learning courses (learn.kbyg.org). Who would have predicted that two years later a pandemic would make online avalanche education essential.

What's next for KBYG? In January 2021 the UAC, in partnership with Colorado Avalanche Information Center and Avalanche Canada, launched an 18-month project to rebuild the KBYG program with new videos, presentation content, website, and online learning courses. We are partnering with Sherpas Cinema for video creation. Northwest Avalanche Center, Mammut, Backcountry, KUHL, and RECCO have also joined the partnership. Watch for the release in October 2022.

If you have questions or want to learn more about the KBYG program, email info@kbyg.org and follow us on Instagram (@kbyg.avy) and Facebook (KBYGavalanchesafety). 🍎



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




**Professional
Snow Avalanche Expertise**

Hazard mapping	Risk assessment	Avalanche modelling
Engineering design	Protection structures	Avalanche safety plans
Worker training	Avalanche forecasting	Risk control

Revelstoke, Whistler, and Kimberley BC

250.837.4466 | info@dynamicavalanche.com | www.dynamicavalanche.com

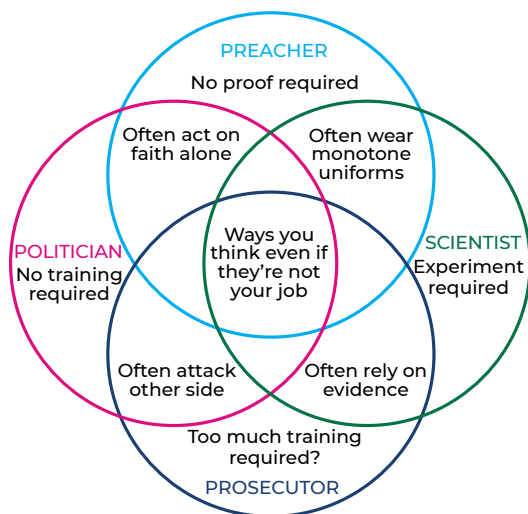
CHANGE YOUR LENSES

A strategy for cultivating intellectual humility in avalanche terrain

BY AMY PERTUZ

Have you ever put on a fresh pair of goggles or switched into better lenses and realized how poorly you had been seeing? The mindsets we bring to our interactions can function as lenses through which we view situations and choosing the ones which help us see best can improve both our communication and our decision-making.

In his book *Think Again*, organizational psychologist Adam Grant argues that when we discuss our beliefs with others, we often engage in the modes of Preacher, Prosecutor, Politician, or Scientist— the four ‘lenses’ through which we approach our choices. There is good evidence to suggest that strategically using Scientist lenses more often can help us cultivate a rethinking mindset which brings us to more reasoned choices when in avalanche terrain.



PREACHER

Preacher lenses convince us that we know the Truth, and we intend to convince you of it, too. Our beliefs are based on faith more than facts, but we are quite certain that we are right.

PROSECUTOR

When we are Prosecuting, we are convinced that you are Wrong, and our aim is to tear apart your beliefs rather than use our curiosity to find out about them. The facts may be on our side, but the alienation inherent in prosecuting means we quickly lose any platform.

POLITICIAN

Wearing Politician lenses, we want to get along, can see both sides, and might even change our position, but that change is typically based upon wanting harmony, and not upon examination of evidence. Politicians often fail to offer any real opinion.

SCIENTIST

When we apply Scientist lenses, we move into the realm of questions. We ask what we don't know, what's the basis for what we believe, and what might change our minds. As Scientists, we aren't threatened by saying, "I don't know." With those lenses on, we embrace uncertainty and use probabilistic language when communicating. Scientist lenses importantly help us to interact with our group members in a more inquisitive and open-hearted way. "Tell me more about why you think that is the case," "keep going with that," and "What evidence would you need to change your mind?" are the heart of the Scientist toolkit. They ask these questions of themselves as much as of their peers, with "What am I missing here? How might I be wrong?"

Let me illustrate this with a story.

Four friends go out for a ski tour. They all work together on snow, but they have never toured as a group. Chris and Alex have sleuthed out a sweet new spot, skied it twice, and today Iggy and Terry are joining them to check it out. After an easy but long skin up a well-packed summer trail, they arrive at treeline. There is moderate snow and wind, mostly obscuring visibility and the alpine terrain above them.

Chris, in front, stops and addresses the group, gesturing to the left, "Ok just about ten minutes over that way, and we are there."

"Hmm, I think we are wanting to go <that> way, but yeah we are close!" says Alex, gesturing in the opposite direction. Statement, not question.

"No. It's to the north. It's right there." Chris replies, flatly, gesturing again towards the left.

"Didn't you guys say this starts right at treeline? I mean all of this looks pretty good to me..." offers Terry, uncomfortable but wanting to be helpful.

Alex sounds annoyed now, "Yep; it does. And it is north of here, which is THAT way." Alex is gesturing emphatically towards the right.

Iggy is pulling out a compass,

"Wait, so you guys both agree that it's north of here and starts at treeline? Ummm, that seems easy enough. Am I missing something?..." Alex is muttering, "I have a compass, too, but don't need one to know where NORTH is."

Iggy confirms north, to the right. Alex skis off towards the line. Chris chuffs but says nothing. Terry shuffles awkwardly. The group finds their objective—glorious powder filled open slopes in the trees—and takes a few laps, but the day is understandably soured. This is one of those stories that is so stupid it simply must be true, and it is. Arguing about true north....really?

Hopefully it is clear that Iggy is the Scientist hero of our story. Chris, arguing from faith, not facts, is wearing Preacher lenses. Terry, as Politician, hopes to make some peace. Alex, correct but bull-headed, is not being helpful wearing Prosecutor lenses. It may seem obvious, but there are real reasons why trying to spend more time wearing Scientist lenses can foster better experiences for us in avalanche terrain. When in doubt, gather more information.

INTELLECTUAL HUMILITY AND THE VALUE OF RETHINKING

When Grant writes about the value of adopting Scientist lenses and rethinking our positions, he is describing intellectual humility, which can be defined as recognizing that our beliefs may be incorrect. Basing the certainty of our view upon the evidence supporting it distinguishes intellectual humility from low self-confidence or lack of knowledge on a topic. Grant's research shows the benefits of adopting a **rethinking mindset** across numerous domains. For instance, studies of successful hostage negotiators show that they have a much higher question-to-statement ratio than that of less skillful negotiators. These expert negotiators are also more likely to seek common ground and are less likely to engage in 'defend-attack spirals' (which are exactly what they sound like). In the book *Superforecasters*, Philip Tetlock explores the habits of the highest performers in long term forecasting competitions. The consistently successful forecasters rethink and update their views twice as often as others, and frequently establish in advance what criteria it would take for them to change their minds. Put in ski language, Doug Workman, a ski guide with no shortage of complex and consequential descents, offers, "we all know that if you're not turning around, and if you look back at the last ten years of your life and you've never backed off an objective, that there's a problem there, and you're fooling yourself into thinking you're using any kind of judgment if you've never turned around. Aside from whether your judgment's good or not, you're not even practicing the skill."

KNOW YOURSELF

You can probably recall times in the past where a coworker or touring partner was arguing on faith, was wrong but not in doubt, was right but being a jerk about it, or was unwilling to offer an opinion ahead of time but quick to offer a “I knew that would happen” after the fact. You may even remember moments when you have acted similarly. Can you also think of when you successfully donned Scientist lenses? Were there situational factors that may have contributed in either case? In the same way that **Personal Disaster Flags** encourage us to identify our problem tendencies, it is also worth taking the time to think about what your dominant lens tends to be: Preacher, Prosecutor, Politician, or Scientist? I experience my best interactions and choices while wearing Scientist lenses, but in my less-evolved moments, I slide towards Prosecutor. My favorite coworkers and partners are the folks who want to peek around the next corner, who will make small wagers about what they expect to see in the field, who have an idea for what they want to check out before they leave the house, and who are constantly updating what they think as they get more info. Put simply, they are curious hypothesizers, without a lot of ego attached to being “right.” As one partner once remarked, “I’ve learned something from every person I’ve ever gone touring with.”

precise communication. The Conceptual Model of Avalanche Hazard, the Avalanche Problems framework, checklists like ALPTRUTH, SOPs, and the Danger Rose are all cognitive tools we use in our craft. Employ ALPTRUTH enough, and you internalize the questions it contains. If you are used to thinking of the avalanche hazard in terms of distribution, sensitivity, and expected avalanche size, the top-of-slope discussions you have are more likely to consider these variables individually: “I haven’t seen signs that this storm slab is sensitive to triggering,” conveys more precise information than, “I think the storm snow is good to go.” Remembering to ask ourselves what lenses we are using is the hard part, but once we put on our Scientist lenses, we have concrete strategies to employ.

STRATEGIES WHICH CULTIVATE INTELLECTUAL HUMILITY

What are the strategies which will help us improve our rethinking? David Dunning, psychology researcher behind the ‘Dunning-Kruger effect’ offers, “I think it’s important to come in with the idea that you don’t have conclusions, you have ideas, you have hypotheses. You’re going to act on them, but you’re going to identify the possibility that you might be wrong.” It’s ok for us to still have and share opinions when wearing Scientist lenses, it’s just that we are not afraid to also subject them to scrutiny.

PERSONAL DISASTER FLAGS

Look at the intersection of human factors and our own personal tendencies. If you think back to the instances in your life when you have been your own biggest obstacle, are there themes that show up? Do your mishaps stem from repeated behaviors, such as impatience, goal-oriented-mindset, hanger, competitiveness, or poor time management? These would be your Personal Disaster Flags (PDFs). You can’t fight them if you haven’t identified them. Knowing the PDFs of your partners matters, too.



STOP FOCUSING ON BIASES AND START FOCUSING ON USEFUL BEHAVIORS

The work of Ian McCammon helped us see how heuristic traps are commonly found in avalanche accidents, and avalanche workers have understandably focused a lot of attention on this topic along with the cognitive biases which commonly plague decision-making. McCammon, however, never intended his work as a strategy to guide our actions. We need to focus our efforts on the “do this” side of the behavioral equation, since “watch out for that” is not a strategy. Luckily, research shows that cultivating intellectual humility is itself a strategy to counteract common decision-making biases. If we can create a habit of noticing how our interactions are frequently shaped by the lenses through which we view a situation, we can increase the chances that we employ the best lens for the situation and, hopefully, nudge our minds towards intellectual humility, more reasoned choices, and improved communication.

IMPLEMENTING LENSES AS A TOOL

If acting more like a scientist sounds nice but hard to implement, perhaps the important question to incorporate into our practice is “What lenses am I wearing right now? Am I operating as a scientist, or am I preaching, politicking, or prosecuting?” A cognitive tool is any device or framework that helps us think with more clarity on a topic and which might allow us to continue to benefit even after we cease to use the tool. Benefits of this clearer thinking are improved decisions and more

Increase your Question-to-Statement Ratio

Experiment with asking more questions and making fewer statements, especially in challenging situations. The results may really surprise you.

Use Challenge Networks and Devil’s Advocates

Creating a “challenge network” among our peers and partners is another tool which can help set the group tone that it’s ok to ask someone to state the evidence supporting their beliefs, and that you value having yours scrutinized. Adopting a tone of inquiry versus inquisition in conversation can go a long way towards preventing defensiveness when we ask what someone’s reasoning is based upon. This might be especially critical to honest dialogue if there is a large power distance between two partners. Offering proactively that we don’t think we have all the answers and sharing times when we have been wrong can make others more willing to state their own opinions and can help to create a culture of psychological safety where this kind of communication can happen. Some touring parties may choose for one member to play Devil’s Advocate for the day, lessening the threat that questioning the rationale will be seen as disagreeable.

Focus on the Uncertainty

Embracing uncertainty with both our thoughts and language is another fundamental Scientist strategy. Focus on the gaps in our understanding in order to target and gather new evidence. Remain humble; we don’t know it all.

Employ Prediction and Use the Language of Probabilities

Speaking in terms of probability is another strategy which can reinforce the idea that uncertainty exists in avalanche terrain. “I think that wind slab will pull out with that air blast, but I’m just barely

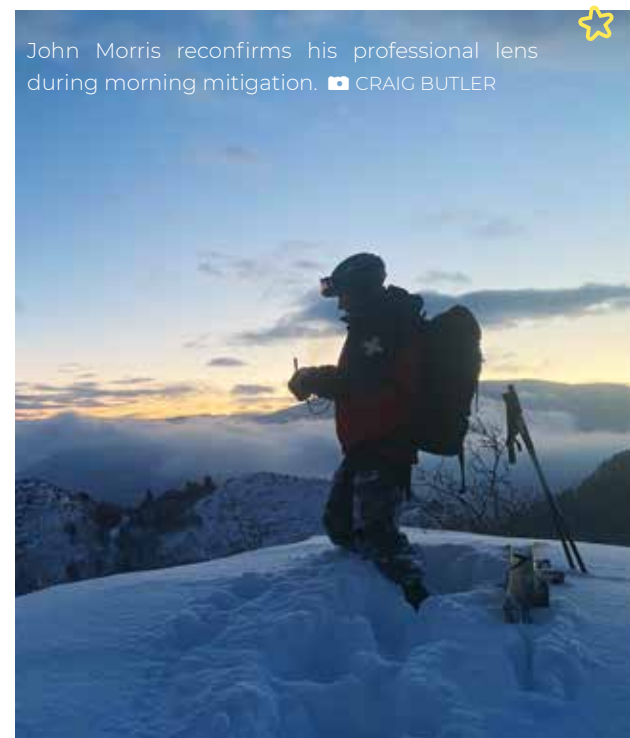
THE RETHINKING SCORECARD

		Decision Outcome	
		POSITIVE	NEGATIVE
Decision Process	SHALLOW	Luck	Failure
	DEEP	Improvement	Experiment

above 50-50 on that,” conveys more information than “I bet this shot will pull out that wind slab.” Either is better than offering no prediction, as we actually learn better when incorporating prediction. Including terms of probability into our predictions also gives the opportunity for differing views to surface. “Oh really, you think there is a chance it won’t? I’m curious why? I’d put 95 cents on the dollar on that air blast triggering a wind slab. I’m thinking it came in cold and didn’t bond well.” Even if we don’t use numbers, employing likelihood terms from the Conceptual Model of Avalanche Hazard such as “possible” or “almost certain” can add clarity and increase consistency.

Question Assumptions

Another habit of the Scientist is to question the implicit assumptions that make up the basis of our explicit conclusions. Do you think that the east aspect is fine with today’s new snow on top because it escaped a sun crust yesterday? Ok, but have you actually checked to verify the absence of that sun crust? Ground truthing our assumptions



John Morris reconfirms his professional lens during morning mitigation. CRAIG BUTLER



Bill Nalli tests his hypothesis that prior strong winds had rearranged coverage on alpine slopes, despite even-looking coverage. Friendly wagers about depth were made before probes came out. Five minutes later we had confirming evidence that this theory was true in our location. ■ AMY PERTUZ

helps us figure out if they are any good. More accurate assumptions make for more accurate predictions. Ask yourself if you're also making assumptions about the thoughts and goals of your partner.

Analyze our Decision-Making Process

Finally, improving our intellectual humility requires us to employ meta-cognition, to think about our own thinking and analyze how we are making our decisions. Says Dunning, "I've come to recognize that every decision is really two. There is the decision we come to. And then there is the second decision about how sure we are... The key to that second decision is 'should I be sure of that decision, or should I have some doubt?'" As Annie Duke points out in *Thinking in Bets*, in environments of uncertainty, we are prone to "resulting"—judging the quality of the decision-making process by the quality of outcome. We know that the avalanche realm is a wicked learning environment where feedback is poor; that we can make a sketchy choice but still have a good outcome. The asymmetry of this environment means we might only get clear evidence when we are "wrong," and the slope avalanches, but when no avalanches occur we can't be certain we were "right." We will never know if we were skillful or lucky when we only look at results. Metacognition helps us be honest about this reality and look instead at the process. Questions like, "Am I making this decision in a data-driven way? Have I sought out disconfirmatory evidence? Which flaws might be in my logic? What emotions or goals might be in the mix?" serve us more nutritious thoughts than the questions like "Why am I right?"

Back to our ski buddies Chris, Alex, Iggy, and Terry...

Many years have passed, and Chris, Alex, Iggy, and Terry are all (still) working in the avalanche industry. Iggy, an IFMGA guide, laughs and says these days the plan gets reviewed before leaving the trailhead. Terry continues utilizing politician skills as a ski patrol director. Chris admitted a tendency to get lost, has bought a book about navigation, and has tightened up. And Alex—well, that was me. I have considered other moments where I showed up wearing Prosecutor lenses, but I've also pondered how I would handle that same situation differently were I to get a do-over. I would like to think that I spend a greater percentage of time wearing Scientist lenses now.

When the reward is more palpable than the risk inherent to a decision, cultivating impeccable habits is our best strategy. Try to up your intellectual humility. Think in ideas not conclusions. Up your question-to-statement ratio. Create a challenge network. Think and speak in terms of probability and uncertainty. Get comfortable with being wrong. Ground-truth your assumptions. Employ meta-cognition. Try a little experiment this winter: see if you can remember to consider which lenses you are wearing, and whether it might be time to put on a fresh perspective. Look at situations after the fact to see how your group's lens choices affected the outcome. Hopefully it will help you cultivate some good questions and some more thoughtful conversations along the way. ■

"Getting rid of a delusion makes us wiser than getting a hold of a truth."
—Ludwig Borne

REFERENCES

Duke, A. *Thinking In Bets* (2018) Portfolio
 Grant, A.M. *Think Again* (2021) Viking
 Interview with Daniel Kahneman (2021) Kahneman Doesn't Trust Your Intuition, Taken For Granted Podcast with Adam Grant
 Interview with Daniel Kahneman (2019) Putting Your Intuition On Ice, The Knowledge Project Podcast #68 with Shane Parrish

Interview with David Dunning (2020) Why You Think You Are More Competent Than You Are on "What Got You There" with Sean Delaney
 Interview with Ian McCammon (2019) Utah Avalanche Center Podcast with Drew Hardesty
 Interview with Todd Simkin (2021) Making Better Decisions, The Knowledge Project Podcast #119 with Shane Parrish
 Johnson, J. et al (2020) Rethinking the heuristic traps paradigm in avalanche education: Past, present, and future, *Cogent Social Sciences* 2020 Volume 6
 Krumrei-Mancuso, E.J. et al (2020) Links between intellectual humility and acquiring knowledge, *The Journal of Positive Psychology*, 15:2, 155-170,
 Leary, M.R. et al (2017) Cognitive and Interpersonal Features of Intellectual Humility *Personality and Social Psychology Bulletin* 2017, Vol. 43(6) 793-81
 Leary, M.R. (2018) The Psychology of Intellectual Humility *Publication of Department of Psychology and Neuroscience*, Duke University
 McKay, R., Langdon, R., Coltheart, M. (2006) Need for closure, jumping to conclusions, and decisiveness in delusion-prone individuals *J Nerv Ment Dis* 2006 Jun;194(6):422-6.
 Moreno-Fernández, M.M., Blanco, F., Matute, H. (2021) The tendency to stop collecting information is linked to illusions of causality *Sci Rep.* 2021; 11: 3942.
 Pakdaman-Savoji, A. et al The Conceptualization of Cognitive Tools In Learning And Technology: A Review *Australasian Journal of Educational Technology*, 2019, 35(2)
 Presentation by David Dunning (2015) Cognitive Habits of Intellectual Arrogance and Humility, The Intellectual Humility Capstone Conference, Catalina Island, California, USA
 Shafer, G. (2021) Testing by Betting: A Strategy for Statistical and Scientific Information, *Journal of the Royal Statistical Society: Series A (Statistics in Society)* Volume 184, Issue 2 p. 407-431
 Sanchez, C., Dunning, D. (2021) Jumping to conclusions: Implications for reasoning errors, false belief, knowledge corruption, and impeded learning *J Pers Soc Psychol* 2021 Mar;120(3):789-815
 Tetlock, P.E., (2002) Social Functionalist Frameworks for Judgment and Choice: Intuitive Politicians, Theologians, And Prosecutors *Psychological Review* August 2002 109(3):451-71
 Tetlock, P., Gardner, D. *Superforecasting* (2015) Broadway Books



AMY PERTUZ lives in the San Juan mountains of Colorado, sniffing out large facets as a ski patroller, forecaster, guide, and educator. When she is not skiing, Amy loves warm, sunny rock climbing, but she doesn't understand why people climb rocks during ski season.

SKI GUIDE PANT

Hardwearing Most Rugged GORE-TEX PRO with large pockets and removable knee pads. Designed for work.

ARC'TERYX PROFESSIONAL

GOOD TERRAIN SELECTION

for avalanche instruction, making the best of the situation

BY STEVE CONGER

In the snow avalanche risk management process, establishing the context includes determining the scope and situation. Scope includes the objectives and risk criteria (in our lexicon, the operational risk band or ORB). The instructor manages learning objectives versus risks present in the learning environment. When it's avalanche instruction, risk of harm must be balanced with access to education.

Terrain selection to meet these learning objectives can look very different from terrain selection by a guide for a day of adventure.

An example of ORB for an avalanche program might be that students will travel and study in avalanche terrain but not be exposed to scenarios where human triggering of the avalanche problem is likely or greater; or natural triggering of avalanches is possible or greater.

Situation is the three-way intersection of the element(s) at risk, scale, and the hypothetical sequence of events where exposure to the avalanche hazard occurs. This article describes a tool that those delivering avalanche education can use to acknowledge the situation for which they are making their field trip terrain selection.

The education extension intentionally combines goals of Roger Atkins's strategic mindset (establishing a background context, deliberate de-biasing and communication strategies). The extension is meant to be used in conjunction with the terrain or strategic mindset during pre-field trip planning.

There is a common thread in the four education extensions: opportunities combined with a strategy. Opportunities for mis-step (student or instructor) are connected to the choice of destination and route.

Destination and route are selected:

- a) For a semi-stationary exposure period and to minimize learning roadblocks such as cold or over-exertion and maximize available time on site; OR,
- b) To inherently provide adequate margin from consequential exposure during practice of skills with any avalanche terrain being observable / viewable / verifiable in the field without the need to be exposed; OR,

MINDSET EXTENSION FOR EDUCATION	DESCRIPTION	OPPORTUNITY FOR MIS-STEP	STRATEGY
INSTRUCTIONAL	The learning objective requires skill or knowledge typically with adherence to a set of guidelines or standards. Demonstration, practice, and repetition occur while semi-stationary.	Here an opportunity for mis-step would be in skill practice such as poor craftsmanship or mis-reading a compass.	<ul style="list-style-type: none"> • A lot of location planning results in minimal location assessment during travel by the instructor. • Destination is chosen for extended exposure period. • Route is chosen to minimize learning roadblocks and maximize available field lesson time.
DRY-RUN	The learning objective is met through coaching of a students' practice or and feedback on demonstration of intellectual or physical skill.	Opportunities are limited or restricted to minor consequence outcome potential through robust terrain margins.	<ul style="list-style-type: none"> • Destination and route are chosen pre-trip to meet specific learning objectives and to inherently provide restriction to exposure. • Avalanche terrain where the class might be exposed is observable and verifiable regardless of conditions. • Terrain assessment exercises can occur without the need to be exposed.
VALIDATION	Intellectual or physical skills are confirmed or assessed through monitoring in a simulated situation or scenario.	Real or simulated opportunity for mis-step without the immediate threat of hazard.	<ul style="list-style-type: none"> • Destination and route provide appropriate scenarios or simulated situations that vary based on the curriculum and course objectives. • Opportunities for mis-step are identified by instructors as part of their planning to ensure the group is managed such that instructor can step-in at any time.
PRACTICUM	A student has the mentored opportunity to practice skills in real-world environment and conditions.	Same opportunity for mis-step and same consequence as real-life situations.	<ul style="list-style-type: none"> • Under Practicum a student applies skills under direct supervision of an appropriately competent mentor in a highly structured relationship using established protocols and skill expectations. • Established protocols might be organization or sector standards, desired learning outcomes described in a curriculum, or specific skill expectations.

- c) From alternatives providing appropriate validation simulation without immediate threat of hazard in case of mis-step; OR,
- d) Where direct supervision and established protocols are compulsory.

Just as the strategic mindset works to align desires with choices, the education extension works by articulating types of educational scenarios in a similar manner. It provides an opportunity for a common language.

Lastly, some musings about future practice: the education mindset extension could go beyond use just by the instructor team. If the situations that go with each of the mindsets become widely recognized and communicated, they might help overall quality and risk management on an avalanche course. For example, course marketing could include that it contains elements of instruction, dry run, and validation. With an understanding of what those terms refer to, a potential student would better know what to expect. If during the pre-field trip planning, the instructor states that today's learning objective includes dry run, students would have a mental picture of what opportunities for mis-step may be present, but it might also bias them to be less watchful. ●



- Ultralight, 4.5 oz including teeth protector
- Performance snow saw made of 7075 Aluminum
- Crust buster teeth in front, snow teeth in back
- 2mm thick, specs of Propagation Saw Test
- 30cm mark to measure out small column tests
- Option for engraved ruler marks on top edge
- Made in Washington State



PRIMO
SNOW & AVALANCHE

www.primosnowavalanche.com @primosnowandavalanche



STEVE CONGER is a regular contributor and emeritus editor to *The Avalanche Review*. He works as a consulting scientist, avalanche professional, and senior instructor for the CAA Industry Training Program, and as of fall 2021, is AIARE's Technical Director.

APPLYING THE STRATEGIC MINDSET TO RECREATIONAL AVALANCHE COURSES

This story first appeared in the Canadian Avalanche Association's publication The Avalanche Journal, volume 127, and is reproduced by permission.

BY COLIN ZACHARIAS

This past January, Powder Cloud published *Terrain Tips #4: Know Where Not To Go*. This was the fourth of five terrain articles I have written for the avalanche education site and arguably the most important. Its premise encourages the backcountry rider to conduct a pre-trip plan that emulates—in a simpler way—our professional hazard and risk analysis. To encourage a strategy of choosing terrain that reduces risk, the article highlights the two most important decisions backcountry riders make on any given day: 1) adopting a terrain mindset that reflects both an analysis of the risk factors and a willingness to limit exposure; and 2) agreeing on slopes to avoid (see Figure 1).

As a part time educator, I've worked with others developing curriculum for both the CAA and the American Institute of Avalanche Research and Education (AIARE). The latter specializes in developing recreational curriculum accompanied by yearly instructor training. During my tenure with AIARE we saw instructors readily adapt and engage students in field book trip planning checklists, complete with prompts that promote teamwork, ensure consensus, reflect on goals and risk tolerance, preview terrain, identify route options and reduce exposure, and have an emergency plan. But while instructors employed Roger Atkins' strategic mindset at the workplace and on each American Avalanche Association professional avalanche course, there wasn't a lot of buy in to apply it at the recreational learner level. Instructors preferred to keep the discussion to preferred and alternate routes that matched conditions, and offered a basic terrain narrative such as, "Avoid convex slopes and slopes over 30°," combined with ATES-style terms.

When trying to apply an Atkins-style mindset, most struggled to simplify what seems a little esoteric outside workplace operations. "What do you mean, strategic mindset?" This was a common student refrain echoed back to me by the instructors when we beta tested an early proposal. As a result AIARE took several years of convincing prior to applying a terrain mindset to the daily



Figure 1: The four key stages of a pre-trip plan, with the terrain selection process in #2 and #3.

trip plan. The initial preference was to avoid the mindset phrasing in favor of a "plan to limit exposure" similar to the ATES strategy. This meant previewing terrain at a drainage and mountain scale and describing the options available to reduce or eliminate exposure. For me, this line item of the daily trip plan worked, but this didn't quite provide the same decision-making support that we had when we applied the strategic mindset in the workplace.

However, the idea of applying Atkins' mindset to the recreational course never went away. Paul Rogers, publisher and Editor-in-Chief at Powder Cloud, encouraged us on several occasions to find ways to better apply the concept to the Level 1 student (the U.S. equivalent of Avalanche Canada's AST 1). He and others recognized the mindset was more than a plan to limit exposure. In *Terrain Tips #4*, I described why mechanized guides have always applied some sort of mindset when choosing and describing their terrain use strategy:

After reviewing weather, snowpack, and avalanche hazard factors, it was apparent that most guides would already have a morning mindset that would frame the team run-list discussion and operational plan.

This mindset was a mental attitude or disposition that would evolve from each guide's hazard assessment, local knowledge, and personal level of risk acceptance. The mindset defined an unspoken, internal dialogue that illustrated each guide's perception of conditions, ter-

rain, and level of uncertainty and confidence. "Today, I'm a bit uncomfortable. I'm choosing a drainage with straightforward options, keeping it mellow, and staying out of harm's way."

Importantly, the mindset informed our team's decision to open or close ski runs and helped to subdue habit and desire—two semi-automatic processes that could bias our daily terrain choices. (Even prior to Atkins' terms each guide had a personal and at times cryptic way of expressing their mindset (and terrain use strategy). A phrase such as, "Now is not the time to roll the dice," might reflect uncertainty. "Drop off low and pick up high," may indicate one's strategy to manage poor visibility and high freezing levels. "Stay on line only," could mean to only ski the most conservative, risk-free runs in each drainage. "Take a look, but take it easy," could urge a plan to get the guests out for a few safe runs, make some important observations, and come home early.

As pros, when we agree that we are "stepping back"—to use Atkins' term—it doesn't only help define our terrain choices prior to departure, it also serves as a mnemonic device that carries our pre-trip choices into the field and supports each decision we make that day. This simple strategy may be missing from the recreational decision-maker's daily checklist. The moniker "stepping back" heightens our situational awareness and promotes team field discussion.

We knew it was important to somehow translate this essential decision-making tool to the recreational learner. We followed a few key strategies to better apply the mindset to the backcountry user's daily trip plan:

1. To be consistent we wanted to come up with a set of similar terms and definitions that were self-defining, that reflected both the user's analysis of conditions and terrain use strategy, and that was simple enough to apply. We agreed to keep it to four mindset options. Howie Schwartz, Bruce Jamieson, and I brainstormed and edited a number of versions. Paul Rogers, Brian Lazar, and Terry Palechuk also provided key input.
2. The application of a terrain use mindset had to be an integral part of a four or five step pre-trip plan. We didn't want it to be a literary sidebar (see Figure 1).
3. Each mindset describes today's preferred plan. For example, "time it early," identifies today's most suitable strategy. The accompanying one sentence descriptor in bold type provides a key message that defines how you reduce your risk: "**Prior to incoming storms or during spring-like conditions, travel when the hazard is low.**" We felt that the mindset and brief descriptor would be memorable even if the



ADOPT A TERRAIN MINDSET

Choose one mindset for today

Did we choose the right mindset for the day? First day of high pressure after a five-day storm in the Alaska Range. We went out to assess conditions. On the first track of the day, a few small soft slab releases confirmed our decision to stick to mellow terrain. We then proceeded to lap the lower angle slope on looker's left. As the first skier dropped over the edge on slightly steeper terrain, he remotely triggered the avalanche in storm slab that stepped down to a PWL from which we had observed collapses both before and after the storm. ■ ZACH LITTLE

bulleted paragraphs describing related conditions and uncertainties were not. Importantly, these defining paragraphs employ language that encourage consensus. (i.e. "We agree to build in a margin of error by starting early and returning early, and be out of harm's way with time to spare.")

4. Make the trip plan available online at thepowdercloud.com for the 2021–2022 season, and ensure it includes an offline function. The 2021 publication of *Avalanche Craft* by Jamieson and Palechuk employs the same trip plan steps and mindset terms. The goal is to provide a simpler trip planning checklist that will develop into a post course habit.
5. Test drive the strategy and incorporate feedback. Schwartz, Palechuk, and myself all had the opportunity to test drive the strategy with recreational learners prior to publishing the final version.

During the day end debrief students can review the decisions made relative to the mindset they adopted. Importantly this informs how the student uses the mindset on subsequent days. Adopting a mindset prior to selecting a drainage, routes, and slopes has become an essential decision-making support tool and should be a part of recreational level curricula. ●

REFERENCES

Rogers, Paul, Editor/Owner, *Powder Cloud* (thepowdercloud.com). Site providing educational information and online mentorship

The AIARE Education Committee, 2019, *The AIARE Backcountry Decision Making Guide* (field book and manual).

Atkins, Roger, 2014. *Yin, Yang and You*. Proceedings International Snow Science Workshop, 2014, Banff

Jamieson, Bruce, Palechuk, Terry. 2021. First ed. *Avalanche Craft: Strategies for Reducing Risk in the Backcountry*. Published by Snowline Associates, Calgary AB

Cut out and paste somewhere convenient to review and select a mindset before a trip. Ping the editor if you'd like an electronic copy.



COLIN ZACHARIAS is an IFMGA/ACMG Mountain Guide who has worked in the guiding and avalanche industry since 1980. He also works as a mountain safety consultant and an avalanche instructor with the CAA.

MINDSET	TEAM ATTITUDE PRIOR TO SELECTING YOUR ROUTE
CHECK IT OUT	<p>Observe but avoid today's avalanche problem</p> <ul style="list-style-type: none"> We have low familiarity and confidence in either the terrain or our team, and/or we have high confidence that the conditions are dangerous. Our goal today is to increase our confidence through careful, targeted observations without exposing ourselves to avalanche risk. We agree to select a zone that offers several options to eliminate exposure to avalanche terrain. Our choices include low angle and primarily forested terrain. We agree to avoid big overhead slopes, and on days with higher avalanche hazard we also agree to avoid or minimize the risk of travel through runout zones.
KEEP IT MELLOW	<p>Limit exposure by avoiding steeper slopes, wind loaded start zones, and trigger zones</p> <ul style="list-style-type: none"> We have moderate confidence in both our assessment of the hazard and our team's skills and knowledge. We can identify the avalanche problems and uncertainties that may cause issues. We will create a plan with a range of options that allow us to gather relevant information while maintaining a large margin for error. We are hyper-aware that good decision making is paramount to avoid avalanches big enough to injure, bury, or kill. We know that managing exposure requires experience and plan to select a zone where options exist to reduce exposure with careful route finding. When the avalanche problems are difficult to target, we will choose slopes <30°, avoid overhead hazards and terrain traps. Also, we plan to employ travel techniques such as spacing, timing, and strategic regrouping that further reduces risk.
STEP IT UP	<p>Consider steeper options mindfully during periods when human and naturally triggered avalanches are neither expected nor reported</p> <ul style="list-style-type: none"> We have relatively high confidence in our assessment of the terrain, conditions, and team members, and we have the training and experience to make good terrain decisions in this familiar situation. This mindset assumes a low chance of avalanches, with no persistent slab or wind slab problems. We are aware that these factors, combined with a forecast for good visibility, are fundamental to managing avalanche risk on steep, open terrain, and on complex terrain with multiple avalanche slopes and terrain traps. We know this type of terrain may have limited options to reduce exposure once committed. Our team members agree that it is appropriate today to venture out into more exposed avalanche terrain. We are mindful of the potential consequences that comes with increased exposure and we are prepared to back off and/or use alternative terrain options.
TIME IT EARLY	<p>Prior to incoming storms or during spring-like conditions, travel when the hazard is low</p> <ul style="list-style-type: none"> We anticipate low hazard early, but that conditions will significantly deteriorate during the day. Our plan considers that rain or radiation/warm temperatures—and alternatively incoming snowfall and wind—can quickly increase the hazard and result in unstable snow. We recognize that it can be complex to predict the interaction between weather and mountain slopes. We agree to build in a margin of error by starting early and returning early, and be out of harm's way with time to spare.

How do we obtain feedback as a backcountry enthusiast?

- A** Ask your buddy after a few drinks.
- B** Wait until you make a catastrophic mistake, and learn from it.
- C** If nothing bad ever happens, you are doing it right!
- D** Feedback? What's feedback?

How do we obtain feedback as a backcountry enthusiast? Take a minute and think back on your backcountry career and that of all of your peers, friends, and colleagues. What were all the ways you obtained feedback? What feedback actually caused you to change your practice?

For this article and study, we are going to focus on the recreational backcountry user, who most likely has taken one or two recreational avalanche courses. The A3 guidelines call for a minimum of 24 hours for each course, but compared to a journeyman electrician who must complete 576 hours of study and 8000 hours of experience, these 24-48 hours of avalanche education seem light. Recreational riders can also obtain feedback from peers, mentors, or guides. They can also further educate themselves by attending annual SAW events across the country or other workshops. Most recreational and professional enthusiasts consult the avalanche forecast regularly.

Pascal Haegeli and his group at the Simon Fraser University Avalanche Research Program have

making it difficult to develop expertise and intuition. Repetitive learning through low stakes and high frequency quizzing can have a direct impact on improving user knowledge, understanding, and application of material presented in an avalanche bulletin.

Feedback and repetitive quizzing also may help delay or improve the forgetting curve, hypothesized by Hermann Ebbinghaus in the 1880s. He found that after obtaining knowledge, the percent of information retained declines exponentially over

difficult each weak testing knowledge—week 1, understanding—week 2, application—week 3, and synthesis—week 4. This repeated each month throughout the season. I issued sixteen total quizzes from December through March. I developed the quiz myself and issued them on the COAC website's bottom line as part of a sabbatical project for COCC.

The Google form quiz format allowed me to embed videos in both questions and feedback responses. I also could embed images, topo

THE AVALANCHE FORECAST QUIZ PROJECT

Experience in the backcountry does not necessarily result in expertise.

been studying avalanche forecast users and learning more about their backgrounds, experience levels, and expertise. A finding from their research is that forecast readers are hungry for more interactive tools to be included in a forecast, providing them with immediate feedback on knowledge and understanding. They found recreational users to be diverse with a wide range of knowledge, skills and abilities. St. Clair classified five user groups; each gathering and interpreting different parts of the forecast in different ways. Each group also has very different abilities in terms of utilizing this information. Perhaps a more interactive bulletin providing feedback could be an additional educational tool to help move the B and C user classification in their study to the next level of D? Perhaps we can help the E users to apply and synthesize forecast information and think more critically when making decisions in avalanche terrain.

WHY IS FEEDBACK SO IMPORTANT?

Hogarth, et. al. reference wicked learning environments where there is little to no feedback on decision-making skills, making mental model and intuition development extremely difficult. Kind learning environments, on the other hand provide direct, reliable, and immediate feedback on decisions. Daniel Kahneman and Gary Klein also refer to kind learning environments as having high validity. Many argue that backcountry users are operating in a wicked environment

time. I would argue that understanding, application, and synthesis of that knowledge also decline over time without continued education. Brown et. al. in *Make it Stick: The Science of Successful Learning*, demonstrate that low stakes, frequent quizzing can help better cement that information. And taking this to another level, Hoffman et. al. in *Accelerated Expertise* find that feedback at the right time and of the right type can actually propel expertise at a greater rate.

PROJECT GOALS AND DESIGN

The goal of the quiz project was to embed quizzes into the avalanche forecast to help educate users and propel them to the next level of critical thinking (*Figure 1*).

I began brainstorming with folks and exploring using Google forms to implement this project. I learned that Paul Diegel and the UAC were planning a very similar project so Paul and I started collaborating and sharing ideas. My quizzes consisted of seven demographic questions followed by four questions quizzing 1) the avalanche problem 2) snowpack 3) weather and 4) terrain or slope choice. The quizzes were progressively more

maps, etc (*see Figure 2*) to make them interactive, interesting, and applicable to tour planning. Quiz takers obtained immediate feedback after submitting a quiz and the feedback could include a detailed explanation of the question and correct vs incorrect answers, a link to a paper, or a link to a video providing additional educational opportunities when users answered incorrectly.

RESULTS

Sixteen quizzes were issued throughout the season and directly embedded in the 'bottom line' of the avalanche forecast. An average of 48 people took the quiz each week with 759 total quizzes taken throughout the winter. Social media advertising increased the response rate, but high and dry unchanging conditions resulted in lower response rates. Figure 3 Shows the number of times each person took a quiz.

Figures 4, 5, and 6 show the results from the demographic questions from all the quizzes throughout the year. The majority of respondents were Rec Level 1 trained, traveled on touring equipment with 2-5 years of experience, traveled in the backcountry 3x/month or less and were



Figure 1. Quizzes embedded into the Avalanche Forecast.

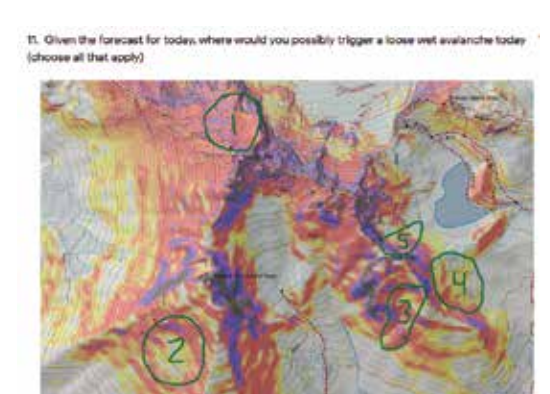


Figure 2. Engaging and interactive quiz questions

What feedback caused you to change your practice?

- A** When a friend offered advice.
- B** When something bad happened.
- C** I read a book and changed how I operate.
- D** Why would I change my practice?

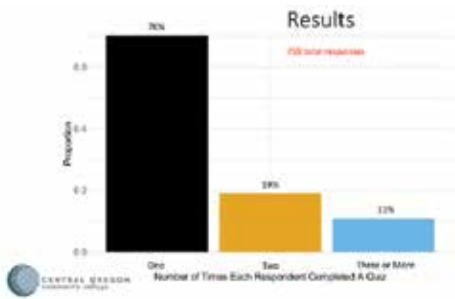


Figure 3. Number of times each person completed a quiz

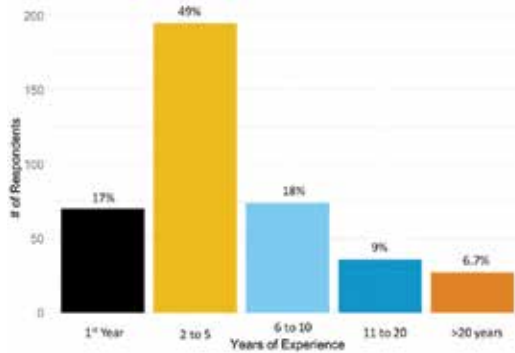


Figure 4. Years of Experience

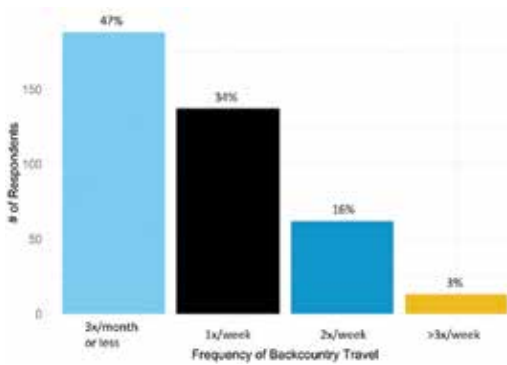


Figure 5. Frequency of travel in the backcountry

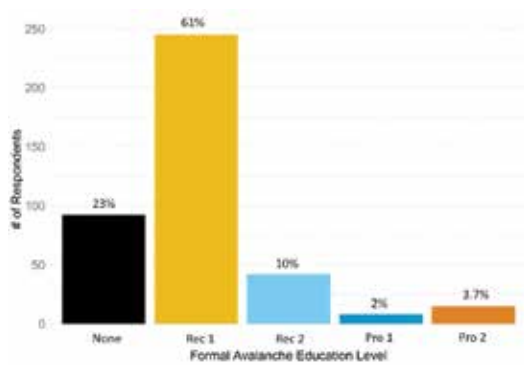


Figure 6. Avalanche Education Level

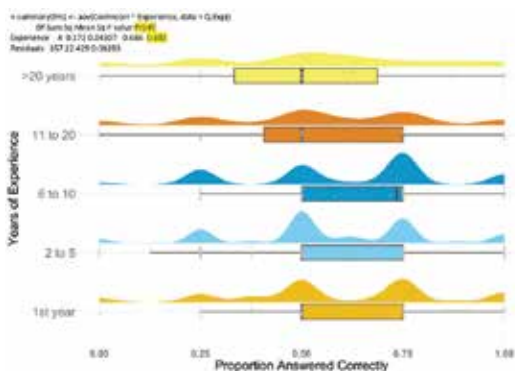


Figure 7. Years of Experience vs correct scores

Level of Education	None	Rec 1	Rec 2		
Median Quiz Scores	50%	50%	63%		
Frequency of Travel	3x/mnth or less	1x/week	2x/week	3x/week	
Median Quiz Scores	50%	50%	60%	75%	
Years of Experience	1	2-5	6-10	11-20	>20
Median Quiz Scores	50%	50%	73%	50%	50%
St. Clair User Typology	A	B	C	D	E
Median Quiz Scores	25%	50%	54%	50%	63%

Figure 8. Median quiz scores for different individual population groups

self-reporting at the D bulletin user classification from St. Clair et. al.

Some of our preliminary statistical analysis is shown in a raincloud plot (Figure 7). The upper portion shows a distribution of the data and the box plot below shows the median (dark bar) and 50% quartile (inside the box is half of the data). We are looking for a statistically significant difference between the different demographic information (i.e. years of experience, education level, etc.) and percentage correct from the quiz scores. So far, we have found no significant statistical correlations but are working on more sophisticated models. The takeaway message for this dataset is that we cannot use any of the demographic information, taken alone, to predict how well a respondent will perform on a quiz.

Figure 8 shows the median values for how well each group responded on the quiz. A few interesting trends do stand out that the median increased as frequency of travel increased. Also, the median scores for folks with 6-10 years of experience was 73% compared to 50% for all other years. There is interesting research from Peitzsch, et. al. showing that between 1950-2018 the median age of fatalities has risen from 27.6 to 34.3 years of age. Also, Birkeland, et.al. reported at WYSAW last week and in TAR 40.1 that last season there was a linear progression comparing ages and numbers of fatalities in the backcountry, suggesting the older, more experienced people are dying more frequently than folks just entering the backcountry. This could perhaps suggest that experience in the backcountry is not necessarily resulting in

expertise. Perhaps we need to consider bolstering the continuing education of recreational users over 30 years old, who may be at the top of their game in their early years and then taper off in terms of knowledge, understanding, and their ability to apply these concepts in the field later in their career. Embedding quizzes and other interacting, engaging, and educational components into forecasts could help educate this population.

CONCLUSION

When teaching engineering mechanics courses at COCC, I need to assess how well my students are learning. This comes in the form of questions in class, homework, quizzes, and exams. Feedback is a huge part of this assessment so I can see how well the content I am delivering is absorbed, understood, and applied by my students. This is, of course, an iterative and circular process that works well. Folks traveling in the backcountry can learn knowledge, develop understanding, and begin to apply these concepts in entry-level avalanche courses. Feedback is an incredibly valuable component and I am grateful for the feedback I received in courses from folks like Don Sharaf, Sarah Carpenter, Margaret Wheeler, and Christian Santelices. We believe that avalanche education should be a lifelong learning pursuit with feedback to help users cement knowledge and develop mental models of avalanche character and then implement those models into how to best use terrain to avoid avalanches given the current hazard. Embedding quizzes into avalanche forecasts can be one way to help provide this continuing education.

I would like to offer a special thanks to Central Oregon Community College for funding this sabbatical project, Erich Peitzsch for helping with the data analysis, Pascal Haegeli for providing much insight and guidance, Paul Diegel for collaborating on the project and the Central Oregon Avalanche Center for helping facilitate this project. ●

REFERENCES

- Brown, et.al. *Make it Stick: The Science of Successful Learning*, The Belknap Press, 2014
- Hoffman, et. al. *Accelerated Expertise: Training for High Proficiency in a Complex World*, Psychology Press, 2014
- St. Clair, A. *Exploring the Effectiveness of Avalanche Risk Communication*, Simon Fraser University, 2019
- Finn, H. *Do Recreationists Have the Skills they need to use Avalanche Bulletins Effectively?* TAR 39.2 December 2020, AAA.
- Robin M. Hogarth, Tomás Lejarraga, and Emre Soyer that appeared in *Current Directions in Psychological Science* 2015, Vol. 24(5) 379-385.
- Peitzsch E. et.al. How Old are People Who Die in Avalanches? *Journal of Outdoor Recreation and Tourism*, Issue 29, 2019.
- Birkland, K et.al. *NAC Season Summary*. TAR 40.1, October 2021, p 34.



KEVIN GROVE is an engineering, physics, and avalanche educator at Central Oregon Community College and has been on the board of the Central Oregon Avalanche Center the past eleven years. He spends most of his time these days chasing powder, corn, and his two daughters.

Examining a New Addition to Our Avalanche Education Quiver

BY PAUL DIEGEL

Why were quizzes given in school?

- A** Punishment
- B** The teacher forgot to prepare a lesson that day.
- C** Being tested on content just learned helps retain information
- D** Being tested sharpens focus.

THE AVALANCHE FORECAST QUIZ PROJECT

Did you ever stop to wonder why you were given quizzes in school? Was it punishment? Did the teacher forget to prepare for class that day? That's what I assumed. If I'd had access to the Google then, I might have done some research and found that study after study confirms that being tested on content we've just been taught helps us retain that information. And knowing that we are going to be tested sharpens our focus and attention on what we're learning.

Pascal Haegeli, Anne St. Clair, and the rest of their team at Simon Fraser University observed that a user may interact with an avalanche educator for just a few days, but the same user may interact with the avalanche forecast on a daily basis. This daily interaction provides an opportunity to educate our users. Inspired by their work to better understand how forecasts are used and interpreted, the Utah Avalanche Center attached quizzes to daily forecasts during the 2021–22 winter to allow users to test and get feedback

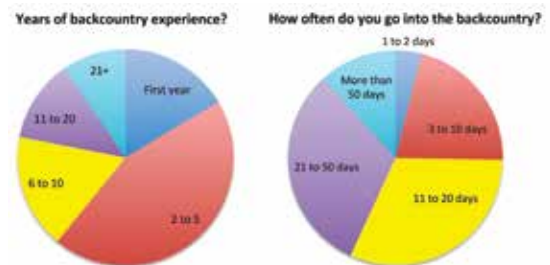


Figure 1: User Experience Level

on what they learned from the forecast. A link to a Google Forms quiz was included in the forecast for the day. The quiz gathered demographic data along with testing the user's interpretation and recall of the forecast and how they use that information to plan their day.

We hoped to:

- Learn how well users understood and retained the information we intended to convey
- Provide micro-avalanche education by giving users a chance to repeat back what they thought they learned, use that learning to make a plan, and get feedback on how well they did.
- Provide our forecasters feedback on the effectiveness of their style, language, graphics, examples, and overall messaging.
- Entice our users to put more thought and focus on the forecast message for the day.
- Develop a tool for testing the effectiveness of forecasting products, e.g., quantify the effectiveness of alternative danger rose configurations.

We attached the following quiz to eight forecasts for different regions around Utah last winter:

- A.** A few questions about you. What's your name? You don't have to answer but we'll need this and your email address to enter you in the drawing for gear.
- B.** What's your email address? You don't have to answer this. If you do, we'll add you to our email distribution list for announcements.
- C.** Overall, how much experience do you have in all your winter backcountry activities combined? (*years*)
- D.** Which backcountry activity or activities do you most associate with?
- E.** How often do you go into or plan to go into the backcountry? (*days*)
- F.** Which Red Flag warning signs would you expect to encounter today? *Choose all that apply.*
- G.** One of your partners tossed out the idea of a route heading to upper elevation northeast facing slopes. The avalanche danger rating there today is: [*multiple choice*]
- H.** Another partner wants to stick to mid-elevation west and northwest facing slopes. What is the highest danger rating level you are likely to encounter there? [*multiple choice*]
- I.** Which avalanche problems were identified in the forecast? (*select all that were listed*)
- J.** Did you look at Observations for the region you are interested in during the last 24 hours? [*yes/no*]



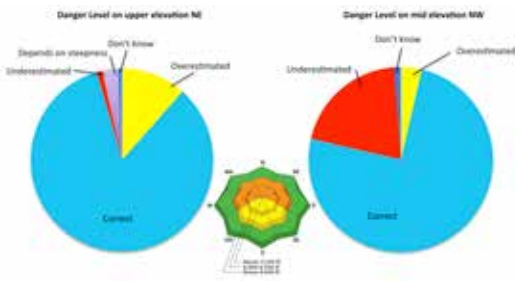


Figure 2: Danger level by elevation and aspect

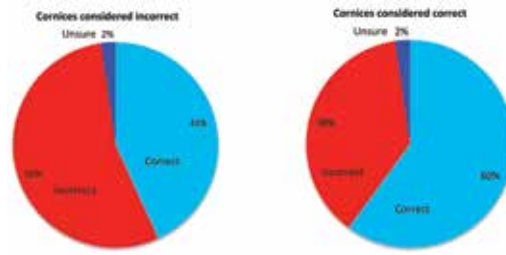


Figure 3: Avalanche problems correctly recalled (cornices mentioned but not listed as a problem)

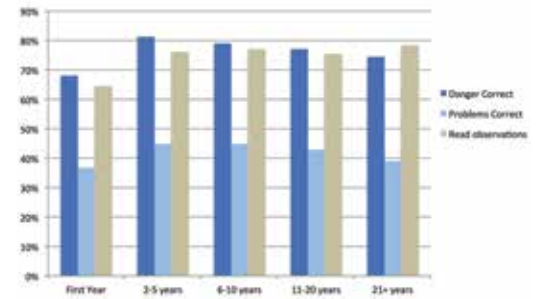


Figure 4: Correct danger and avalanche problem and "read the observations" by experience level

- K.** Did you get all the information you wanted in today's forecast? [yes/no]
- L.** If no, what else would you like to have seen?
- M.** Which of the following statements best describes your use of avalanche forecasts when planning a backcountry trip? [multiple choice]

We issued eight quizzes with 20,969 total forecast page views plus opened and presumably read forecast emails that included quizzes, and we received 1,867 responses (9% response rate). A profile of the respondents is shown in Figure 1.

We mostly kept the questions simple with objectively right or wrong answers to minimize judgment calls. We provided feedback to the respondents when they completed the quiz. On most of the quizzes we included a bonus question that required a little more thought and basic avalanche knowledge, the forecast for the day, and some judgment.

The following are some of the key lessons we learned:

- We received positive feedback on the quiz concept. Our users appeared to like the ability to be tested and get feedback on their answers.
- About 3/4 of the respondents recalled the avalanche danger correctly (Figure 2). Interestingly, of those that selected the wrong danger level, those that did so on upper elevation NE slopes mostly overestimated the danger level, yet those who answered incorrectly on mid-elevation NW slopes mostly underestimated the danger level. Are we teaching people to assume that higher NE slopes are always more dangerous than mid-elevation NW slopes?
- About 40% of the respondents correctly identified the avalanche problems listed for the day (Figure 3). Cornices emerged as source of confusion. In three forecasts, cornices were mentioned as a sub category under wind drifted snow but they were not listed as a formal avalanche problem. If we mentioned the presence of cornices without listing them among the Avalanche Problems but then allowed Cornice Fall as a correct answer, the number of respondents listing the correct combination of Avalanche Problems increased from about 40% to 60%. So users recognized that we used the term "cornices," but didn't recognize the difference between cornices as indicators of recent wind and snow vs stand-alone Avalanche Problems.
- The results indicate that users remember the avalanche danger more than the Avalanche Problems, suggesting that more emphasis on Avalanche Problems, why they are important, and how we deal with them in different ways could be an effective education strategy.
- There was a consistent small percent of users that believed the danger rating is based at least in part on slope steepness.
- About 3/4 of respondents reported looking at the observations for the region they were interested in, confirming our belief that user observations are a valuable part of the forecasts.
- A UAC staff member who wasn't forecasting prepared the quiz answers and feedback that were vetted by the forecaster on duty that day. Typical preparation time was 1-2 hours for the non-forecaster and 10-15 minutes for the forecaster. The quizzes were prepared the evening before the early morning forecast release and we avoided issuing a quiz during periods of rapidly changing or highly complex conditions. The time required to set up and administer the quizzes decreased greatly by the end of the season.
- More experience did not correlate well with better quiz performance as shown in Figure 4.
- Some of the responses to "what else would you like to see in the forecasts" suggested that users were not familiar with all the products we offer. There could be some benefit to periodically mentioning other avalanche products in the forecast. For example, there were

several suggestions that we release the forecast earlier than 7:30 am, presumably from people who were unaware that we offer a recorded phone dawn patrol hotline.

Public avalanche forecasters have a unique opportunity to reach thousands of backcountry users with small doses of avalanche education on a daily basis. We've concluded that including a self directed quiz with feedback in the forecast is an effective educational tool and something our users appreciate and benefit from. It tells us more about our users, what they are looking for, and how we can better serve them. We intend to repeat the program this season and hope to add a follow-up survey to learn more about how our users use what they learned in their planning and decision-making for the day. ●



PAUL DIEGEL is the former Executive Director of the Friends of the Utah Avalanche Center. Since his retirement, he can cherry pick projects that interest him in the avalanche world.



Caption page 6.
BOB RANKIN



PHOTO CONTEST FINALISTS



◀ Dylan Miller performs mitigation to protect a remote gold mine in the Kakuhan Range of Southeast Alaska with Lionshead Mountain in the background, February 2021. Arctic high-pressure weather brought extremely low temperatures and high winds giving us windchill factors down to -60F. This created a layer of concern in our region, causing widespread avalanches throughout the winter.

📍 ALAN GORDON

▼ Idaho. Mid-February 2017 we received 63" snow/7.7" of water and strong winds over a five-day period. The avalanches started out as dry snow slabs entraining wet snow as they descended. The result was 80' piles on the center line. The wet snow hit the highway leaving debris piles a quarter mile down from its runout. Here Bill Nicholson walks up the shoulder.

📍 CHANTEL ASTORGA



▶ Teton Pass Ski Area, Montana is small with a large overhanging avalanche hazard. During a particularly active cycle, slides were triggered by both an avalauncher and hand charges. Every path emptied out, as the mountain came unglued! This photo was taken at first light the following day as we sorted trees out of the debris and recut all the cat roads.

📍 CHARLES HLAVAC

▼ Snowslide Gulch on Thane Road, Juneau, southcentral Alaska, during a post-mitigation snow distribution lidar survey on April 16, 2021.

📍 KATREEN WIKSTROM JONES



THE *Avalanche* REVIEW

1986

TAR transitions from pasted layouts to digital PageMaker layouts.

1993

"I distinctly remember John Montagne's admonishment that I keep the *Review* a serious publication and not include the humor that Sue was known for under her editorship."

—Steve Conger
Editor 1993–2000

2001

"I kept working to grow TAR, though I still saw myself as an interim editor. For most of Volume 21, TAR was at least 20 pages with material left over. That was partly because I'd Tom Sawyered the gregarious and well-connected Lynne Wolfe into my old job as assistant editor. Over the next two years, she and I planned theme issues and hired an advertising coordinator."

—Blase Reardon
Editor 2001–2004

1987

"I can only pick up the history from about 1986 when Sue Ferguson—the brilliant and visionary founder of *The Avalanche Review*—"chose" me to take over as its second editor. For the word "chose" you should substitute: "finally found some damn fool stupid enough to take on the time-abys, creativity-sucking albatross of a young, struggling newspaper—all without pay of course."

—Bruce Tremper
Editor 1987–1993

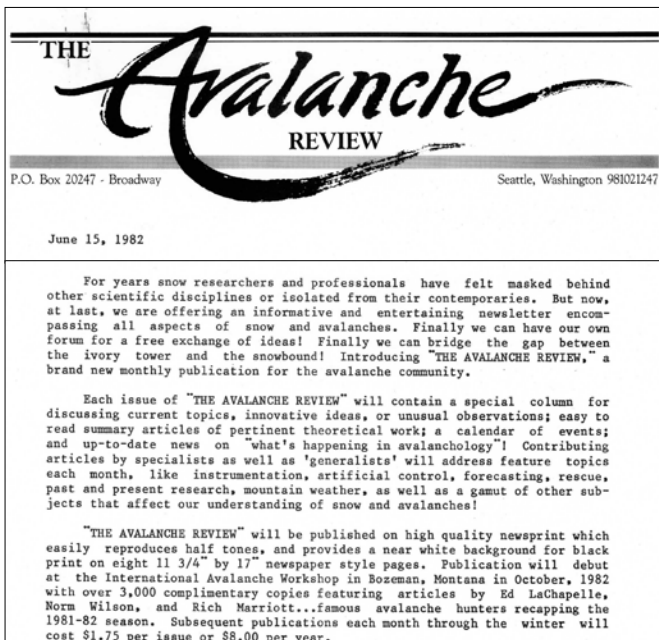
2000

"When the opportunity arose to become the editor of TAR, I figured this was an opportunity to connect to others in the avalanche community who must feel isolated in their mountains too."

—Faerthen Felix
Editor 2000–2001

1982

The first issue of TAR, the brainchild of Sue Ferguson, is published.



■ COURTESY STEVE CONGER

1994



Sue and Bruce at Snowbird.

■ BRUCE TREMPER COLLECTION



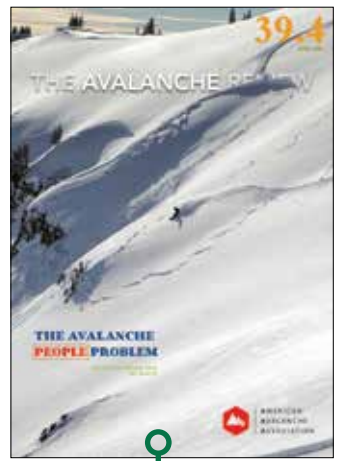
Steve Conger



2002
Our graphic design duties transitioned to Karen Russell of Fall Line Design, who, with her love of skiing, midwestern humor, and responsiveness to input, took us to a new layout level.



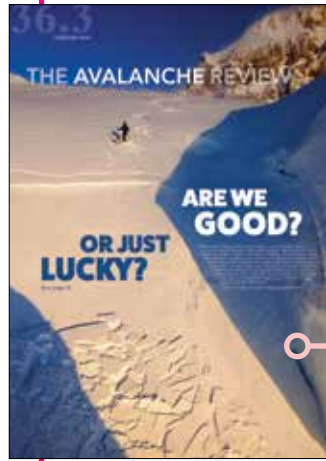
2003



2004

2004

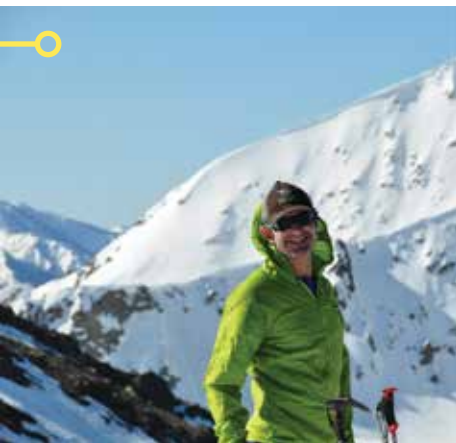
2005
First issues with color.
"TAR has become a forum for timely case studies with honest analysis; a place for subtleties of perspective, sidebars that clarify, expand, or contrast a central point."
—Lynne Wolfe
Editor 2005–Present



2005



2006



Blaise Reardon



2007

2015
TAR transitions to full-color magazine format.



2007



2008

the AVALANCHE REVIEW

THE EDITOR WHO KNOWS EVERYBODY

Lynne Wolfe's 18-Year Tenure and Reflections on TAR at

BY EMMA WALKER



At the A3 member meeting at ISSW 2002 in Penticton, Lynne Wolfe, then a peripatetic avalanche instructor, sat herself next to *The Avalanche Review* editor Blase Reardon. Both were feeling loose, with a couple of beers on board, and as a speaker waxed poetic about some A3 issue or another, Lynne elbowed Blase.

“This guy needs an editor,” she whispered. I can only assume this missive was accompanied by a knowing eye-roll.

“What do you know about editing?” Blase whispered back.

“I’m a good editor,” she said, “Just try me!”

That, as I understand it, is how Lynne became the assistant editor of *The Avalanche Review*. The story may sound too on-the-nose to be anything but apocryphal, but both of them have confirmed its authenticity, or at least the broad strokes. Anyway, it makes a great story.

This—a great story—is a common thread in Lynne’s 18-year tenure as editor of this publication. It’s a responsibility she takes seriously, although, if you know Lynne, you know it’s not too serious. After editing TAR for nearly half its life, Lynne’s name is practically synonymous with the publication you’re holding, and while she’s by no means shy, she tends to nudge the spotlight onto the magazine itself. Hell, it took me two years to talk her into letting me profile her.

I met Lynne for the first time at ISSW in Banff in 2014. I was on the docket to do a presentation of my master’s thesis research, a prospect that had me practically nauseous. Worse, I had to wait until the end of the week to stand on that stage. The night after I presented, I tagged along with some other Alaska folks to a dive bar a few blocks from the main drag. That’s where I met Lynne. After nervously navigating my first ISSW all week, chatting with Lynne over beers in the crowded bar was a breath of fresh air. She asked me to write up a piece about my thesis for TAR, and I’ve been doing my best to absorb as much of her wisdom as possible ever since.

A couple of years ago, Lynne approached me about helping her with a series for TAR on some of the many women who act as mentors and role models in our industry. As we sat curled up on the couch in my living room in Boise, I thought

about who I wanted to hear from—the women of the avalanche world whose footsteps I’d tried to follow. Lynne was at the top of my list.

“We should feature you!” I said.

Lynne demurred, instead listing other influential women whose stories she wanted to print in the pages of the publication she’s been involved with for nearly two decades. That, in my experience, is what Lynne does: she elevates other women, singing their praises, promoting their projects, telling their stories. I wonder how many women credit some portion of their success in the snow and avalanche world to Lynne?

Of course, like any successful endeavor, Lynne didn’t become the editor of an industry-standard publication overnight.

After their fateful encounter in Penticton, Blase offloaded some of his least-favorite aspects of the editing job to his new assistant. Lynne acquired some of the newsier, more time-consuming sections, as well as a handful of regular contributors who didn’t particularly want to be edited.

It turned out she was, as advertised, a good editor. Blase, focused on quality over quantity, had recently cut the number of annual issues from six to four, increasing the page count for more in-depth coverage. With more content to edit, Blase—who began his TAR career as Faerthen Felix’s assistant editor, then became editor upon her departure—soon promoted Lynne to co-editor. This would mean taking on a bigger share of the workload.

“I basically Tom Sawyered her into it,” he admits. (This resonates deeply with me because I, too, have experienced a classic Blase Reardon

Tom Sawyering; it’s how I was promoted from assistant to editor of *The Snowy Torrents*.)

Now, as co-editors, Blase and Lynne had the capacity to put out the themed issue he’d conceptualized when he took over the publication and began envisioning its future. This was part of his vision for TAR: “I thought it could be more than a club newsletter,” he explains. “I think that’s what Sue [Ferguson] wanted, but I think in our rush to fill the damn thing once a month, it became a little newsletter-y. I wanted to take the time to edit it—not just in terms of proofing, but ‘let’s make this better.’”

The first theme came to them as they wandered the poster hall at ISSW 2004 in Jackson.

“We’re seeing all these posters about human factors,” Lynne recalls. “This is not our usual slate of stuff from ISSW—this isn’t about fracture mechanics and metamorphism. This is a different way of looking at things!”

The co-editors tapped the authors of some of the posters they found most interesting, and the result was the first Human Factors issue, TAR 23.3. In their editorial, Blase and Lynne invited commentary, which led to one of the most significant pieces TAR has published in its 40 years.

The following March, the co-editors received an email from Ed LaChapelle. “*Finally caught up with your February issue*,” it read in part, “*got inspired to join the decisions discussion and finally got an article ready after hand-to-hand combat with my computer for eating some files*.” He modestly surmised that it might be too late in the season to do anything with his essay, but asked them to fit it in where they could.



"I'm like, 'Oh my god! Ed LaChapelle is in my inbox!'" Lynne remembers. The piece that would become his seminal essay, "The Ascending Spiral," was attached. She and Blase both count it as the best piece they ever published.

The human factors issue, followed by LaChapelle's essay, marked a turning point for TAR: now, it was a conversation. This, I think, is one of the coolest things about our industry: it's very plausible to meet, even work with, your heroes.

"We're not so socially stratified as a community," as Lynne puts it. "I've been deeply gratified, over my 20 years of involvement with TAR, that people talk to me! Maybe it's my incredible, terrible persistence—I just will not take no."

Shortly after the publication of "The Ascending Spiral," Blase started graduate school, and, in a move that would make Tom Sawyer himself very proud, was persuaded to stay on as A3 Publications Chair. In that role, he edited a volume of *The Snowy Torrents*; later, he co-authored a subsequent (forthcoming) volume. Editors emeriti of this publication tend to stick around.

Lynne, now TAR's sole editor, was ready to make more changes.

"If anyone's the perfect fit to edit TAR, it's Lynne," Steve Conger, who edited TAR for nearly a decade, told me with a chuckle. "Since she's taken over, my contributions are far better than they were when I was editor. She provides this incredible feedback and clarity in her editing."

In addition to the thoughtful content and regular **invitations to have conversations**,

Lynne made some cosmetic updates to the publication. The most significant, beginning with Volume 34, was the switch to the glossy, large-format magazine you're holding, courtesy of present-day TAR designer McKenzie Long.

"I wanted it to fit on the back of the toilet," she says. "I want it in the bathroom at the top shack so patrollers are like, 'Oh, the new TAR is here!'" Cheekiness aside, it's what she strives for: an approachable publication that people in our community actually read.

"It's a place where people can work out ideas," Blase says. "This is one of the fields where research to application can happen in a matter of a winter." TAR, he says, is a big part of that, thanks to its accessibility.

When I reminded Lynne of our meeting at my first ISSW, she remembered her own first ISSW, in 1996, also in Banff. "I could go up and ask people questions. I mean, I was too intimidated to really do that, but people were open, and I appreciated it so much." That experience, she says, is one of the root causes of her longtime focus on paying it forward: You've been mentored; now it's your turn to mentor. And while she's mentored plenty of other women, that also applies to everyone in the avalanche community.

"I'm trying to honor not just the women, but also the quieter stars out there who deserve recognition," she says. "That's where I'm really useful at this, because I know just about everybody."

This is hardly an exaggeration—as far as I can tell, she really does know everybody—and

Conger says it's one of her greatest contributions to the publication. "The network she's created, the way she interacts," he says, "Lynne's kept it relevant. One of the things she's done really well is draw out these conversations—pulling a little piece from a lot of different people around a topic."

Keeping a print publication relevant over the last 18 years is no small feat; consumers bought 60% fewer magazines in 2020 than they did in 2005. But for a community like ours, there are some things you just can't find online. As Conger puts it, anyone in North America who wants to know what's going on in the avalanche community should be a subscriber.

"Lynne's mark on TAR," Conger ponders for a second, "is that she's made it a world-class publication." ●



EMMA WALKER holds an MS in outdoor and environmental education from Alaska Pacific University. She works as the curriculum manager for AIARE and is the author of *Dead*

Reckoning: Learning from Accidents in the Outdoors (Falcon 2021), as well as the editor of two volumes of *The Snowy Torrents*.

From Sue Ferguson's Brother Bob

Hi Lynne,

Well life comes full circle because you have now become our family's hero. Thank you so much for keeping this part of Sue alive and thriving. Thank you for your work. I remember the beginning of this *Avalanche Review* adventure. Sue had to sign her house over to my Dad in order to secure a loan from him to start *The Avalanche Review*. I remember many evenings helping her prepare for the dreaded mailing. This was a big deal back then. As a college student she worked for a T-shirt maker, she had this brilliant idea (all her ideas tended to be brilliant) to make T-shirts to raise money and to promote the *Review*. I wore mine until it was a faded rag. While we were cleaning out her house I found a brand new one. It has become my favorite thing of hers, along with her two black cats named Toby and Frieta. I think these two cats have some kind of spiritual connection with Sue this past year. We did not spread Sue's ashes on the Black Glacier this summer (on St. Swithins Day... July 15) But while we were up there on the very minute we were not spreading Sue's ashes in a National Park, these two cats were found spooning on one of her old sweaters...they have not done that before or since. Sue always had two cats and they were always a brother and a sister. Thinking of Sue brings tears to my eyes. Thank you for allowing me to get a little emotional over the phone yesterday...it still hurts.

Our family wants to send along our gratitude for Ed's life as a teacher and a mentor to our sister and daughter. He was a very special person in Sue's life and in the lives of so many other people. I first met Ed at Sue's Phd. dissertation. I was the lone family member. I remember Ed asking Sue a tough question in a tone I did not appreciate. I remember vividly wanting to pounce on him, but instead I cleared my throat as loudly as I could...Sue nearly killed me. I met him again at Sue's graduation party, and finally when he spoke with so much eloquence and joy about his beloved student and colleague at Sue's memorial.

They will both be missed.

With Love,
Bob



JOIN THE CONVERSATION



AMERICAN
AVALANCHE
ASSOCIATION

Join or renew your A3 Membership and receive these benefits:

- Subscription to *The Avalanche Review*
- Pro-deals on gear
- Professional development opportunities
- Pro employment job alerts
- Access to continuing education



Inspire / Educate / Network
americanavalancheassociation.org

Will Mook

SEARCH & RESCUE

in the San Juans, winter of 2020–2021

BY TRAVIS LAVERTY

At the end of every winter season, we can process what we just went through. There are often moments of challenge, reward, stress, and accomplishment; **it is not uncommon that there is also tragedy.** The mountains call to us: to be there, to work there, and to do our best up there. There are times when people do not come home. There are friends, coworkers, and family that we remember for their love of the mountains.

These are the stories of Jeff and Bert, and of Seth, Adam, and Andy. This is the story of a rescue team and a community in SW Colorado. This is the story of things that went wrong, and some things that went right. I am not here to lay blame. By evaluating this incident, we can support those impacted by these events and support future people engaging in the mountains.

The 2020–2021 season was one of uncertainty. There was increased use in the backcountry. Tragedy was what SAR teams feared the most. By the end of the season, no place was spared. This season was one of the most deadly in our recorded history. This is uncharted territory for many, as most of us have not endured a season like this one. When considering the deep burials of the Ophir incident, it was an opportunity to apply new techniques to that uncharted territory.

*Hole # 2:
Probing for
Subject 2. Burial
depth was 3.5
meters.*

■ JEFF DAVIS
COURTESY OF SJCSAR



Our winter started with a stormy early season; however, by December we had a thin snowpack in the San Juans. Snowfall had been intermittent, punctuated with prolonged periods of high pressure. Near-surface faceting created weak layers during the periods of high pressure. Major storms entered the area in December and in January, setting off deadly avalanche cycles. These storms built dangerous slabs over persistent weak layers. In the week before the Battleship incident, the area received 28.5" of snow and 1.95" of water. In the ten days before the Ophir incident, the area received 35.5" of snow and 2.7" of water. Also on February 1, there was a significant warmup, with hours of above-freezing temperatures.

In San Juan County, we had two significant avalanche accidents. The first of these occurred on December 19, 2020, on the north face of a peak locally known as the Battleship, NW of Silverton. On this day, two subjects (Jeff and Bert) entered the area intending on skiing in the north face zone. They made one run, skiing adjacent to avalanche debris. They triggered the avalanche while touring up for another lap.

SAR efforts were initiated as soon as the overdue report came in. During the initial search of the area, Flight for Life (LifeGuard5 or LG5) spotted fresh avalanche debris on the north face. Soon after, the search was suspended for the night, as it was considered too dangerous for rescue work to continue in the dark. At this time, three friends of the subjects entered the area in order to continue the search. This was a risk that this group was willing to take. The group communicated with SAR before leaving the trailhead. They located (via beacon signal) and exhumed the subjects during the night. SAR returned the next day and recovered the subjects with assistance from LG5.

Avalanche conditions were dangerous during this time. Four out of five red flags were present (all except rapid temperature rise). Six out of seven indicators against ALPTRUTH were present. The avalanche danger was rated Considerable in the NTL and ATL (moderate BTL). The north face of the Battleship is a known avalanche path with terrain traps present and had experienced recent loading with storm snow. Signs of unstable snow and recent avalanche activity were widespread in the terrain. The SAR team recognized the dangerous conditions, and the safety of the team was considered to be the top priority. The CAIC assisted with an assessment of the conditions. After the hangfire was determined to be an acceptable hazard, the team moved through the terrain using tried-and-true safe travel techniques.

Early on we implemented the Incident Command System, which set the tone for the entire mission. Our predetermined organizational scheme could be scaled up or down as necessary. The right pace was set and there was appropriate oversight and leadership. The mental toll on the team and the community was heavy. These were two well-known and loved locals. The community rallied behind the families and the SAR team. Little did we know this support was to be needed again later in the winter.

The second accident occurred on February 1, 2021, in the same drainage as the incident related above. A group of seven was skiing in an area known as the Nose, which is a steep NE facing alpine slope. The slope hangs directly above a significant terrain trap gully. The group ended up below the Nose area due to what seems to be miscommunication. They had not intended on skiing the Nose itself and had not communicated about how to travel further after reaching the gully wall. Before they could regroup, four skiers dropped into the gully, triggering the avalanche which buried all four.

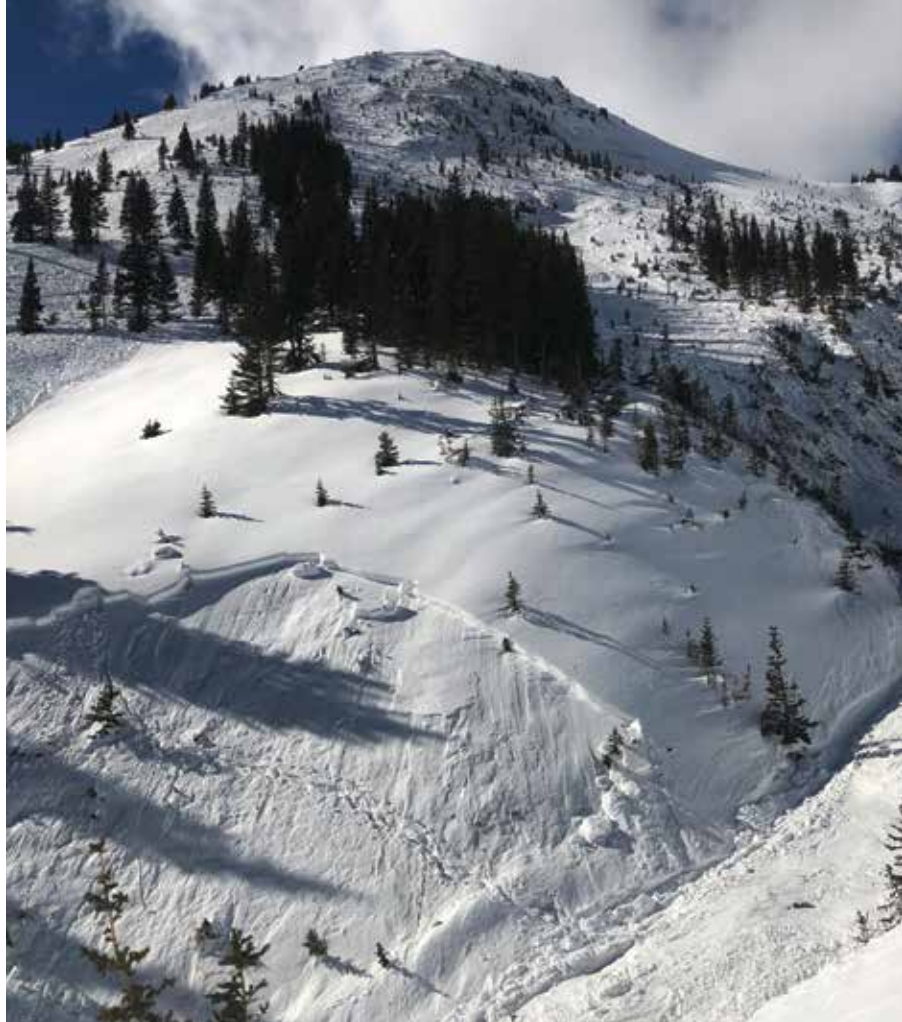
The remaining group of three did a remarkable job of companion rescue on Subject 4—furthest up the gully. His airbag was visible on the surface. He survived. There were still three missing and the group was able to locate what they thought were three beacon signals; it turned out to be only two. They began digging and were able to get a probe strike on subject 1—furthest down the gully. After two hours and digging through 2m of snow, they called for help. SAR responded, and assisted the group back to the trailhead.

The recovery continued the next day. The CAIC again assisted with an assessment of the avalanche conditions. Scene safety mitigation by Telluride Helitrax produced many large avalanches. SAR entered the scene using a risk treatment centered on team safety. We collected input from all team members to make a go or no-go decision. This was prudent, as the avalanche hazard was still elevated. SAR recovered Subject 1 and continued recovery efforts on Subject 2. Late in the day on February 2, a large natural avalanche came down out of Ophir road path #1 and buried the Ophir road in up to 10 feet of debris, halting the recovery operation. At this time, the incident command team and rapid response team at the trailhead had to completely refocus on the safety of the field personnel and their extraction from the field. All personnel had safe passage back to the trailhead; however, many snowmobiles were stranded behind the debris. It took a dedicated small team of diggers and a lot of hard work to make the road passable again.

The recovery continued on February 3. Subject 2 was recovered and it was discovered that what was thought to be a close proximity burial of Subject 3 in relation to Subject 2 was not the case. Subject 2 was using an outdated beacon, which was erroneously indicating a close proximity situation. After Subject 2's beacon was turned off, the signal of Subject 3 was discovered 100 yards upslope at a burial depth of 6m. It was only at this time that the entire debris field was cleared. Through the confusion of a complex scene and by relying on information which did not prove true, the location of Subject 3 was not discovered until well into the operation. The field should have been cleared sooner.

This was a complex multi-day mission with a lot of moving parts and agencies involved. Some things went well; others did not. Many lessons came out of this mission:

- There were actually two incidents. The natural avalanche that buried the road was an incident within an incident—a SAR responder's worst nightmare. (WS-N-R3D3-O, Ophir road path 1). This was a natural slide that came down a southerly aspect while rescuers were in the field. It blocked the only ingress-egress by snow machines. This was definitely a near-miss. This incident was a sobering reminder to maintain situational awareness. We needed to be more mindful of the temperatures.
- Having a dedicated lookout in the field can be very useful in maintaining situational awareness while the rest of the crew has their heads down, digging 6 meters down in a hole. The ideal lookout is a person with a snow science oriented mindset. Updates on the snow, weather, and avalanche conditions should be made hourly over a common radio channel. Common threshold values should be considered.
- These deep burial depths created an incredibly challenging recovery; we learned a lot, and we used a lot of what we had trained on. We had a 36v chainsaw and 18v sawzall. The chainsaw cut blocks out of the extremely hard debris. The sawzall was used to cut through ski equipment. We used an ice axe to pry the blocks out, as well as for fine detailing work in chipping ice away from the subjects. Steel probes froze in place, so we mostly used aluminum probes. We also used



The Nose.

■ COURTESY OF SJCSAR

techniques specific to deep burials such as creating space for the frequent adjustments to our digging strategy, and working in rotations in order to conserve the energy of the crew.

These incidents are a somber reminder that the basics are paramount. The beginner works on taking basic skills to an advanced level, while the advanced practitioner returns to the basics.

On our team, we are continually training and re-evaluating protocols in an effort of self-improvement. We also have good relationships with our mutual aid partners. This dedication to professionalism is what has allowed us to prepare for whatever comes next.

The collective support of our community has enabled us to process these tragedies, to learn what we can, and to build a stronger team. As we head into another winter, we are correcting our mistakes and learning how to prevent making new ones. We are sending folks to ProAvSar classes. We are engaging in mentorship with new members. We make sure that every member has the resources they need to be competent at their job and to stay healthy during stressful times. Some team members have sought therapy, while others have looked to the Responder Alliance. We are reflecting on the trauma in our past in order to better our future. ●



Hole #3: Burial location of Subject 3. Burial depth was almost six meters.

■ TRAVIS LAVERTY



TRAVIS LAVERTY grew up in Colorado and roams deserts in summer and mountains in winter. He is an active member of both La Plata County and San Juan County mountain rescue teams. He was most recently the Director of Snow Safety at Wolf Creek Ski Area.

DEEP SPACE

STORY AND PHOTOS BY GABRIELLE ANTONIOLI

Growing up in a small town in Montana, I was immersed in snow, yet I saw it as many do—an unmoving cold white mass. Only later did I learn what a changing and integral role snow plays in daily life. Snow drives the winter economies of Western states, acts as water reservoirs for those same regions and far beyond, and is a fundamental part of life. Globally, 20% of humanity depends on snowmelt water to live (Bormann et al., 2018). This is a complex statistic to wrap one's head around and seems misunderstood and undervalued. Humans are funny that way, we seek to tie broader ideas to something more tangible that affects us. I can read that statistic and feel little, yet if you told me that 20% of the skiing I will partake in this winter will be zipper crust, I'd feel concerned.

Geophysics and Remote Sensing group (CryoGARS) at Boise State University.

The focus of the SnowEx airborne and field effort in Idaho was part of a time series experiment at sites in the Boise and Sawtooth mountains, in addition to sites in Utah, Colorado, and Montana. Radar sensors were flown at 40,000ft each week across all sites from January–March, producing a time series with a sensor that has shown promise for mapping changes in snow water equivalent (SWE). This same sensor will be launched into space in 2023 by a joint U.S. and Indian satellite mission called NISAR, which will produce similar data every 12 days globally.

Remote detection of SWE has long been a coveted goal of the hydrologic sciences. This overlap in the fundamental importance of SWE to the

signal returns to the sensor and is recorded. As snow properties change, this causes amplitude and phase changes in the recorded signal.

I find it helpful to envision this system functioning similarly to a submarine using sonar to detect things in the ocean around it. Differences in total SWE, snow density, and liquid water content affect the timing of the return wave, thereby creating a snow “signal.” Ground-based radar can be used to measure crusts and density contrasts, while the airborne and spaceborne radars will only detect changes in bulk snow properties. The ability to utilize these different technologies en masse in set locations, at set times, with set people, allows for better data collection and validation. The weekly interval of InSAR flight measurements will be used to provide information about the spatial pattern of changes in total SWE, which will help tune snowpack models.

Remote sensing instruments require validation with actual snow data collected in the field. Coordinating with the weekly InSAR flyovers, we dug snow pits, identified crystal structures, measured density and liquid water content, tracked different layers, and checked for new snow on interval boards placed along an elevation gradient. The interval board layout was used to study new snow amounts along the avalanche-prone Highway 21 between Boise and Stanley. These weekly observations are helping interpretation of the InSAR phase changes for mapping SWE change spatially.

The snow is shifting beneath our skis, whether we sense it or not. Disparities in weather patterns, rising rain lines in the mountains, and an ever-changing climate are at our doorstep. Research like the NASA SnowEx campaign is key in developing new tools to observe these environmental changes. To keep pace with this change, we practitioners must adapt how we approach the changes we see in the snow. Our efforts to synthesize and utilize new and non-traditional tools can help us better understand the past and the changing future. If not continually refining how we find and utilize data, educate and forecast for a usership fueled on mountain culture with lightweight gear, or even generalize a season's snowpack structure as some reflection of a previous trend—rather than a whole new beast—we're already falling behind. ●

REFERENCE

Bormann, K.J., Brown, R.D., Derksen, C. et al. Estimating snow-cover trends from space. *Nature Clim Change* 8, 924–928 (2018). <https://doi.org/10.1038/s41558-018-0318-3>



A: Remote sensing advances could help forecasters better identify precipitation amounts and types, particularly where they lack observations. This could prove important if wet slab events, like this one outside Lowman, Idaho, become commonplace. B: Density sampling of a snowpack. C: A late season snowpack stacking up outside Stanley, Idaho (January 2021).

Years ago, I shifted focus from threading needles into veins in an ER and on the cusp of interviewing for medical school to threading lines in the backcountry. A fundamental switch flipped as I worked in mountain environments, found mentors, and realized that snow could be as changing and complex as any living organism—a sentiment many reading this likely share. This story is relevant because I identify primarily as a practitioner. I lack an extensive data science background and I like that what I do requires being on skis in the mountains and can't be replicated by a device—perhaps another sentiment readers may share. A friend and I joke about being “the strong backs of snow science,” due to our overarching preference for fieldwork. My deficits lie in adapting to the rapidly changing world around snow, new tools, and my role in that change, something I think resonates with practitioners at a variety of levels, but we will stick to the technological aspect for now. I found a path to the Earth sciences by a convergence of luck and passion, and thus to HP Marshall's metaphorical doorstep, inquiring about research technician positions for the 2021 NASA SnowEx Mission based in Boise, Idaho. HP is a co-project scientist for the SnowEx 2020–21 winter campaign and heads the Cryosphere

avalanche world is likely not lost on the reader. Thus, large hydrology-focused projects like SnowEx can directly benefit the snow and avalanche community. Spatially mapping SWE in real-time would shift the entire landscape of forecasting, which is currently based on using index sites such as SNOTELs, combined with historical knowledge and experience, to help extrapolate that information. Even with current technology, precipitation estimates are relatively coarse spatially and can be highly uncertain in both amount and type. With remote sensing technologies like those being tested with SnowEx, we can fill that gap in observations.

SnowEx campaigns utilize traditional snowpit observation techniques alongside Unmanned Aerial Vehicles (UAVs, light detection and ranging (LiDAR), SnowMicroPenetrometry (SMP), liquid water content sensors, ground-penetrating radar, and airborne interferometric synthetic aperture radar (InSAR). The primary instrument being tested during the 2021 SnowEx campaign was L-band InSAR, which uses changes in the time of flight of radar signals, to estimate changes in SWE. Radar works by sending out an electromagnetic wave that travels from the sensor, interacts with the snowpack, and some portion of the



GABRIELLE ANTONIOLI is completing a Master's in Snow Science from Montana State University. She performs snow research with the CryoGARS group and teaches avalanche education for AAI.

COMMUNITY SNOW OBSERVATIONS

From Concept to Operations

BY DAVID HILL

Lost among all the talk of finding water on Mars is the fact that NASA is obsessed with water on Earth. The Tropical Rainfall Measuring Mission was tasked with mapping global precipitation patterns from orbit. The planned Surface Water and Ocean Topography mission will carry out the first global survey of Earth's surface water. And ICE-Sat-2, short for Ice, Cloud, and land Elevation Satellite, measures glaciers and just about everything else. With lasers. From space! Snow enthusiasts, NASA has your back as well. The Moderate Resolution Imaging Spectrometer (MODIS) provides daily information on snow cover and longer-range plans of NASA include a satellite mission that can measure global distribution of snow water equivalent, or SWE.

NASA's not afraid of a little cold weather, and they put plenty of effort into directly measuring snow distribution on the ground as well. In most cases, these efforts are to provide validation or 'ground truthing' for their satellite missions. In a 2019 issue of *The Avalanche Review*, you were introduced to the Community Snow Observations (communitysnowobs.org; @communitysnowobs) project, funded by NASA. CSO is an organic, grass-roots effort to collect unique snow depth information from snow recreationists and snow professionals. Sure, there are other sources of snow depth information out there, notably the Snow Telemetry (SNOTEL) network operated by the Natural Resources Conservation Service, but CSO data tend to be from areas that are higher in elevation and have more complex terrain than those covered by SNOTEL.

Our initial article introduced you to the concept of CSO and its basic operation, which, by design, couldn't be simpler. If you're a snow professional and submit data to SnowPilot, you're actually already a participant. Thank you. If you are a snow recreationist and head out on a tour with your avalanche probe (and beacon and shovel) and your phone, it's simple for you to participate (Figure 1). Grab the Mtn Hub app (iOS and Android are both available), watch a quick tutorial or two (see the CSO website) and you're good to go. Back in 2020, CSO acquired Mtn Hub from Mammut and we continue to improve the app to make it easier to use and more effective for community science.

So, a few years into this project, where are we? The results are in, and they're remarkable. We have an assimilative approach where we

Figure 1: David Hill measures snow in the Craigieburn Range, New Zealand.

■ Kendra Sharp

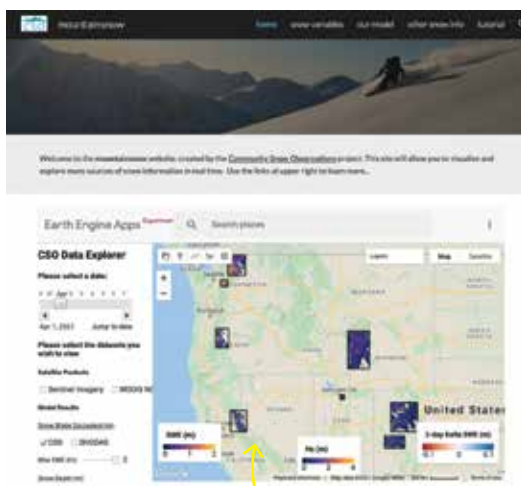


Figure 3: The basic interface, with user controls at left, of the mountainsnow.org website.

incorporate CSO observations as frequent 'corrections' to the physically-based snowpack models we use. Our results (Figure 2) show dramatic model improvement thanks to community scientists who send us data. Additional testing has shown that CSO data are as valuable or more valuable than SNOTEL data, in terms of an assimilation source. What this means is that, when we get CSO participation, even in locations lacking dense SNOTEL coverage, we are able to provide high-resolution, high-quality snow distribution information.

Based on these successes, and the desire to return high-quality snow information immediately to our participants (and the general public), CSO has now taken its modeling effort operational, which means you can see snow depth and SWE in near-real-time.

At mountainsnow.org (Figure 3), you can find daily grids of SWE and snow depth at many domains across the USA. The website is interactive, allowing you to overlay the snow information on a map or terrain layer, and to adjust transparency and other visual elements. You also have the ability to select the date, from 1 October 2020 through the current date. At mountainsnow.org we also display a number of other sources of snow information, including satellite imagery, MODIS data, and modeled snow information from the Snow Data Assimilation System (SNODAS). Our models are typically run at a spatial resolution of 25-100 m, while SNODAS provides information at 1 km. These products, combined, give you the best possible way to explore the snow and how it is changing, in your location of choice. One feature of particular interest is the ability to show three-day changes in the snowpack, so you can see just how much it dumped during that last storm. As the 2021-2022 season progresses, we will continue to add new domains, and to make improvements to the modeling approach and the website interface. New domains are added in areas where we see demand, in terms of clusters of CSO observations. So, to get your local mountain on the map (literally), get yourself and your friends involved with CSO. Tell us the snow depth, and we'll take it from there. ■

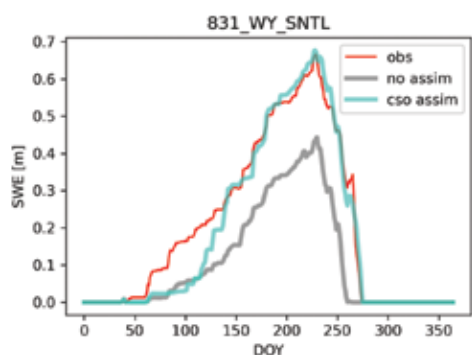


Figure 2: Time series of SWE from a SNOTEL site. When CSO data are assimilated (teal line), the model agreement with observations improves considerably.



DAVID HILL is a professor at Oregon State University and a National Geographic Explorer. For over 25 years, he has studied how water behaves. He currently co-leads the Community Snow Observations project, funded by NASA to improve understanding of our physical environment.

A CONFLUENCE OF FACTORS

FAC

The most challenging forecasting problems for the Flathead Avalanche Center often involve basal crust-facet structures created early season. However, the nemesis for the winter of 2020–2021 developed mid-season, near the snow surface. Late January saw a 10-day dry spell, the longest of the winter, and at the end of the month, the upper snowpack consisted of surface hoar and/or a few inches of faceted snow above a knife-hard melt-freeze crust or ice. This structure existed to at least 7200 feet—the crest of the Swan Range, and near the summits of many peaks in the Whitefish and Flathead Ranges.

Snowfall returned the last few days of January. The first few inches of snow accumulation were enough to produce reports of shooting cracks, whumping collapses, and propagating snowpack tests. As snowfall continued, the slabs quickly thickened to several feet. Many broke across the full width of start zones, often with remote triggers. Riders in the sidecountry of Whitefish Mountain Resort reported a near-miss on January 31. The next day, a skier in the Flathead Range was caught and carried several hundred feet in a D2.5 soft slab.

That was the start of a grueling month. February 2021 ended with 13 near-misses or accidents, nearly twice the tally the region sees over a full winter. Two riders were injured in those incidents, and one rider was killed. The toll might have been higher if bitterly cold temperatures hadn't dampened backcountry enthusiasm for a week. All the incidents involved the same weak structure—the facets or surface hoar buried in late January. That structure proved reactive to human and explosive triggers for over a month, with avalanches up to D3.5 in that period, yet it produced relatively little natural avalanche activity, even when loaded with new and drifted snow. Forecasters and riders were relieved when we were finally able to drop the problem from our products in early March.

In comparison, the rest of the season was mostly uneventful, with good riding conditions. One exception was an accident on April 13,

two days after our daily forecasts ended. A rider triggered a shallow pocket of drifted snow on a very steep face in the Flathead Range; it carried him nearly 1800 feet over a rockband and downslope but left him uninjured. Whew.

For the 2020–2021 season, the FAC recorded 18 near-misses or accidents, two to three times the total reported in recent seasons. The events were concentrated in the Whitefish zone, coinciding with increased use in what is already the busiest zone in the forecast region. Five (28%) of the parties involved in the region's incidents were traveling by snowmachine or snow bike, a ratio very similar to the percentage (30%) of motorized riders killed in avalanches nationally. Another four incidents (22%) involved hybrid riders who used snowmobiles to access ski or snowboard terrain. As noted above, most of the near-misses and accidents occurred in February, echoing the historic national spike in fatalities that month.

The FAC issued 184 conditions summaries or daily forecasts on 143 days. The total number of products was down from the season prior, primarily because conditions in the three zones didn't diverge as distinctly and we often issued one forecast covering all three zones. The avalanche danger was Considerable or High on 37% of the products, the highest in the past three seasons. The FAC adopted the National Avalanche Center's common avalanche forecasting platform midway through the season; the staff found working with it straightforward, and we received numerous compliments about the new look to our products. A new weather station in the Flathead Range aided forecasting operations immensely, as did a snowmobile loaned to the center by Ski-Doo and a local shop, Dream Marine. The staff put over 950 miles on the state-of-the-art machine. An upgrade to an existing weather station at Whitefish Mountain Resort should dramatically reduce riming issues on the wind sensors and provide more reliable data next season.

The FAC logged 517 observations for the season, a 5% rise over the previous winter. An increase in observations submitted by the public accounted for that growth and continues a trend from the past five seasons.

2020–2021 Avalanche Center Season Summaries Part II



The last hurrah for the January 30 weak layer. The slides released during a February 24 mitigation mission above the BNSF Railway were the last—and among the largest—of the slides that ran on the Jan. 30 persistent weak layer.

This very large avalanche (AE-HS-D3-R4-0) ran nearly full track in the Shed 7 East path, with the powder cloud depositing several inches of snow on U.S. Highway 2 in the runout. ■ MIKE REAVIS/ DAVE HAMRE ASSOCIATES

The FAC website saw a 43% increase in unique visitors from 2019–20, and the number of subscribers or followers on our social media channels rose between 9 and 39%.

The FAC and its key partner, the Friends of the Flathead Avalanche Center, shifted much of our education program from in-person classes to virtual sessions. Over 1100 people participated in a virtual version of the annual Northern Rockies Snow and Avalanche Workshop and our virtual Topics classes. Those events allowed live presentations and question/answer sessions that covered gear, risk, avalanche safety while ice climbing, rescue dogs, and spring touring, with both local and national speakers. FAC and FOFAC did offer some in-person, on-snow avalanche safety training by reducing the instructor to student ratio. Among those courses were three Level 1 courses and one Intro to Avalanche Safety course for motorized users, with 54 total participants.

More details about the winter's totals and trends are available in our 2020–2021 Annual Report.

The FAC and FOFAC staff for the winter consisted of familiar faces. Veteran forecaster Mark Dundas returned, along with Clancy Nelson and Cam Johnson. Guy Zoellner reprised his usual role of do-everything observer. Blase Reardon stepped in as Director after Zach Guy returned to Crested Butte, hoping for less bushwhacking. Meg Killen and Kira Frye shone in their second seasons as educators for FOFAC. And FOFAC Director of Operations Emily Struss somehow kept track of the innumerable details involved with virtual and live class, fundraising, and maintaining the website.

We expect that the increased use we saw during the 2020–2021 season will continue, and will continue manifesting in unexpected ways. In the off season, the FAC is preparing with a full suite of virtual and in-person classes, upgrades to the website, and modifications to our existing snowmachines. We look forward to another winter fine-tuning our operation.

—Blase Reardon

MSAC

The Mount Shasta Avalanche Center successfully finished its 23rd season of operation. The 2020–2021 winter was characterized by well below-average precipitation and a lot of wind. As of December 1st, precipitation was 23% of normal for the wet season. A winter storm on Christmas Day got us back in the game with 14 inches of snow and began an active wet weather pattern that lasted through the first week of January. Then on January 22nd, a series of major storms began impacting the area bringing around 45 inches of snow over a 12-day period, much of which fell at low elevations. Though we received regular precipitation events through the end of March, the series of January 22nd storms brought us most of the snow for the season. Extended gale force wind events after these storms left the above treeline regions of Mount Shasta devoid of snow. Lack of snowfall in late March and April did not improve the situation. Climbing routes on all aspects of the mountain became more dangerous than normal due to rockfall and icy conditions. At season end (April 11th), we received 47% of normal precipitation in the city of Mount

Shasta with 64 inches of snow near treeline.

Unlike other avalanche centers that experienced exceptionally poor snowpack stability, there was no significant avalanche activity in the Mt Shasta forecast area this season. While there were a few small avalanches throughout the season, only one occurred that was notable. The fatal avalanche happened near Etna Summit, which is outside our forecast area, but is close enough to be relevant. On February 3rd, an experienced snowboarder and skier triggered a D2 wind slab avalanche as they were transitioning to ride down. The crown was 70 feet wide and two feet thick and the slab ran 200 feet. Both riders were caught, one was completely buried and pinned against a tree, the other only partially buried as he was swept past the small group of trees. The rescuer immediately attempted to search with his beacon, but the beacon malfunctioned (corrosion in the battery compartment). The rescuer began to dig in the most likely burial location (tree well), located a ski pole which eventually led to the victim. The rescuer was able to unbury the victim within 30 minutes. CPR was performed but the buried individual, 35-year-old Brook Golling of Ashland, Oregon, did not survive.



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

The MSAC was involved with the recovery and incident reporting in cooperation with Siskiyou County Sheriff's Search and Rescue. Like any avalanche fatality, it struck hard within the small communities of Northern California and Southern Oregon. This was the first avalanche fatality in Siskiyou County since the late 80s, which was on Mt. Shasta.

For the 5th season in a row, the MSAC had three full time employees. Nick Meyers, the only permanent employee, returned for his 12th season as director and forecaster and 20th season as a climbing ranger. Aaron Beverly worked his fifth season as a professional observer and forecaster, and Ryan Sorenson worked his third season as an avalanche forecaster and ranger. The USFS funds Nick and Ryan's salaries, while the Friends of the Mount Shasta Avalanche Center (FMSAC) funds Aaron's.

The Friends group is a nonprofit that was created in 2002 and is an essential component of the Avalanche Center. FMSAC funds Aaron Beverly's position as a Forecaster and Professional Observer, the MSAC website and all of our remote weather stations. They also organize all fundraising events and help with the education and outreach components of the avalanche center. FMSAC is a volunteer group with one paid position, the Executive Director, Casey Glaubman. FMSAC board members include Hanne Meyers, Sean Malee, Dave Brown, Jason Koster, Nick Joslin, and Clayton Coles. The group represents the soul of adventure and passion for backcountry mountain recreation in the greater Mount Shasta area. We extend a huge thank

you for all of their effort and support this season.

Last fall, through an OHV grant from the State of California and funding from FMSAC, the six weather stations maintained and used by MSAC forecasters had their components upgraded, pre-programmed, and installed. These new components have allowed more control over the operation of the stations, are more supportable and reliable. And as a side benefit, the technical expertise needed to maintain the stations is now in-house.

The primary goal of the MSAC staff is to communicate current avalanche, snowpack, and mountain weather information through our avalanche forecasts. The 2020–2021 season was the fifth year in a row we were able to issue daily forecasts. A total of 135 forecasts were published between December 1, 2020 and April 11, 2021 on our website www.shastaavalanche.org

To convey the most accurate message to the public, it is critical to get out into the backcountry regularly to gather current information on conditions. Days begin early for us to be able to publish the advisory by 7 a.m. and are followed by field outings on skis and snowmobiles in our 800-square-mile forecast area. Forecasters are also responsible for local trailhead maintenance, cleaning, and snow removal as well as snow ranger/law enforcement/patrol duties. Like most areas across the United States, Mt. Shasta experienced increased use over the winter. This created crowded parking lots, user conflicts, a rise in localism, motorized/wilderness boundary encroachment and tracked out ski

AIARE
Avalanche Research + Education

Training for Backcountry Riders & Mountain Professionals

AIARE 1 * AIARE 2 * Avalanche Rescue
PRO 1 * PRO 2 * Instructor Training

Scholarships available for PRO, Instructor, and Recreational courses!

Learn more about scholarship criteria & apply today!

AVTRAINING.ORG/SCHOLARSHIPS

and snowmobile slopes. Overall, the MSAC is doing better than ever and we are confident our services and information will be provided for many winters to come.

MSAC: By the Numbers:

December 1, 2020–April 11th 2021

- The Old Ski Bowl on Mount Shasta (near treeline) received 159 inches of snow.
- The maximum snowfall in 24 hours was 22 inches.
- The total snow water equivalent (SWE) measured was 16.8 inches.
- The maximum average wind recorded was 65 mi/hr and the maximum wind gust was 98.
- Temperatures averaged 30 °F.
- The minimum and maximum recorded temperatures were 7 °F and 56.5 °F, respectively.
- We are currently at 47% of normal precipitation for Mt. Shasta City and 72% of historic average for snow survey courses 6-8,000 feet (mid-April).

—Nick Meyers

MWAC

Last winter was the third season of range scale forecasts for our unique program that grew out of the need to forecast a small area that sees intensive use. The [Mount Washington Avalanche Center](#) is currently the only official American avalanche program in eastern North America with Avalanche Canada now supporting the forecast program in the Chic-Choc range on the Gaspé Peninsula of Quebec. Though Mount Washington likely has the heaviest concentration of use and perhaps largest avalanche terrain in the northeastern US, other spots like Smuggler's Notch, the Adirondacks, and Mt. Katahdin are seeing rapidly increasing winter use along with increasing exposure of the public to avalanche terrain. The rapidly developing man-made glade zones in Vermont, New Hampshire, and western Maine remain without forecasting efforts but fortunately, widespread avalanche problems in sheltered terrain are the exception rather than the rule.

Speaking of avalanche problems, last season did produce some unusual avalanche activity around the region. The season's storm track generally favored southern areas with a few good nor'easter dumps hitting New York and Massachusetts during an otherwise cool and dry season. After some early storms,

(and snowmaking), rapidly warming weather and 6.5" of rain triggered a wet avalanche that flowed into the mid-mountain lodge of Bellayre Mountain ski resort in New York on Christmas morning. The Mount Washington area did not escape the holidays without receiving copious amounts of the "R" word either, recording 1.4" of the stuff. A few more rain events marred the snowpack through the season. The November to May portion of the calendar was notably warmer than average but was lacking in tremendous temperature extremes in either direction. November through January was around 5F above normal and February, March, and April trended just a degree or so above normal. The season was also marked by drought conditions which have continued up to this writing in July. December, April, and May were the only months that were near average for snowfall. Every other month, including our snowiest ones, were 25-50% below average. Past years have often had protracted warm spells or cold snaps though this year did not. You can count the number of below zero cold snaps in 2020–21 on one hand, with the coldest reading of -26F occurring in mid-March. Overall a generally dry and warm winter, for sure.

The lack of snowfall led to fewer natural avalanche cycles than usual, and far fewer than the past two seasons. Despite the meager snowfall totals, several micro-climate driven snowfalls led to some challenging forecasting due to the wide variations in snow totals across our tiny 400 square mile forecast range. The dry and clear conditions also led to some faceting adjacent to buried water ice or rain layers. These layers were typically found outside of major avalanche paths and in sheltered areas not frequently swept out by natural wind slab avalanche activity. It is possible that this faceting created the conditions that led to the only avalanche fatality of the season. Unfortunately, a heavy snowfall event following the incident wiped out any definitive evidence. On February 1st, an experienced skier summited Washington and skied out through technical terrain marked by small cliff bands and ice floes, triggering a small avalanche which unfortunately swept him into a depression in a drainage. Heavy snow the following day led to a natural avalanche cycle that buried him further and a challenging rescue effort. This is the second burial of a solo skier in the range in the past three years; fortunately for rescuers and family, both subjects were wearing beacons. Another close call occurred about a week earlier in Tuckerman Ravine when a



After a RECCO and beacon search found a signal four meters beneath the snow, rescuers needed to lower the height of snow to get a positive probe strike. Due to the depth of burial and limited resources, a digging strategy developed to [tunnel down](#), try for a probe strike, then make platforms to transfer snow up and out. FRANK CARUS



skier was buried to the neck. In this case, the two poorly equipped skiers were new to the sport, with the less experienced of them left to manage the rescue. Fortunately, more prepared skiers were nearby and aided the pair in the face of actively loading slopes. (Interestingly, the buried skier's wristwatch recorded his slide at 53mph.)

A strong effort from Friend's group and MWAC staff led to a tremendous uptick in educational messaging with 15 virtual pro or awareness level talks with 2100 participants, including 500 people for ESAW. We wrote 121 forecasts with 703,000 pageviews of the site from 118,000 different users. Two rock-star interns helped us this year, one of whom took our social media to a new level with IG up to 25k followers now and other outlets growing strongly. It seems like a lot of engagement, but it is remarkable how many of the 11 million people within a day's drive arrive here, surprised to hear that avalanches exist and are dangerous. Good old-fashioned, face-to-face messaging at various pinch points, particularly Tuckerman Ravine on the weekend, continues to be a critical way to steer decision-making and reduce injuries and fatalities. Our 20-member ski patrol is crucial to that success. Despite a season

with heavy but well-distributed use throughout the season, our rescue responsibilities were called upon at around normal levels, with 25 calls for assistance and 16 of those serious enough to warrant rescue, intervention, or transport. The shift in use from climbing to skiing, especially mid-winter skiing, has the potential to drive avalanche involvements up, but strong efforts from local avalanche educators, the community and this forecast center appear to be helping. Next year, with luck, we will add more staff and interns to continue this trend.

—Frank Carus

NWAC

It's easy to look at the 2020–2021 season and immediately focus on the impacts of Covid, persistent weak layers, or widespread very large avalanche cycles. However, for the **Northwest Avalanche Center**, those bullet points would largely miss the culmination of years worth of efforts to grow our forecasting, education, and community outreach programs. Instead, the theme of big changes seemed to underlie our winter. This included shifts in tools, staffing, and



Diversity, equity, and inclusion initiatives formed a large focus for NWAC's organization during the 2020–21 season, including partnering with local BIPOC organizations. ■ TRUC ALLEN

events for our entire operation that brought a notable increase in community engagement and coincided with a memorable and active avalanche season.

At first glance the changes in NWAC's forecasting operation can appear small. However, most of these moves took years of planning and ushered in a shift to our daily workflow, product creation, and forecast distribution. After years of steadily increasing field forecasting capacity, NWAC created a new Deputy Director position to provide direct support to field operations, forecasting services, and educational content creation. Dallas Glass has worked with the avalanche center since 2013 as an avalanche awareness instructor, professional observer, avalanche forecaster, and now as the Deputy Director. NWAC also hired an additional field based forecaster, Irene Henninger, to expand field operations and forecasting capacity in the West Central and North Washington Cascades. This brings NWAC's forecasting staff to nine individuals covering 10 zones in addition to our mountain weather forecasting program. The greatest changes on the forecasting side of our operation likely came in the form of tech projects. NWAC received a fresh website and some under the hood changes thanks to collaboration with the NAC, Sawtooth Avalanche Center and with special thanks to Chris Lundy. As part of the Avalanche Center Web Platform collective we were thrilled to get our hands on the new forecast editor. This platform excels at forecast creation and media management. We used these new platforms to drastically increase the number of photos

and videos embedded in our daily products.

The staff worked tirelessly this winter to maintain community engagement, education, and outreach amidst a global pandemic. This season was the second for the Women's Mentorship Program. Six women participated in the program by assisting with an AIARE Level 1, teaching avalanche awareness courses, and shadowing professionals in the field. This program strives to connect women with individuals and resources as they explore careers in the avalanche industry. Following a similar theme, this spring NWAC ran the first ever Women's Professional Workshop. This brought together 140 women from all over North America, connecting budding professionals and seasoned veterans in order to build connections and knowledge among women in the avalanche industry. (See article about this workshop by Charlotte Guard in TAR 40.1.)

We continued to build on our DEI initiatives, including hiring a consultant to evaluate our program and to also support initiatives around hiring, programming, and recruiting. This past season we expanded our networks to increase imagery that better captures the diversity of users in the backcountry and partnered with the local organization Climbers of Color to increase representation and outreach in our avalanche awareness courses. In addition to these community outreach initiatives, NWAC's substantial educational programs pivoted to an entirely virtual format. This included hosting Awareness, Laying Tracks, and Members Webinars entirely online. Despite or perhaps due to this

IPA COLLECTIVE **PRO DEAL ACCESS**
to the best brands in the industry.

REGISTER TODAY
WWW.IPACOLLECTIVE.COM/AAA or

Black Diamond **THE NORTH FACE** **DAKINE**
dps **MAMMUT** **Marmot** **FISCHER**

... + over 50 more great brands.

shift, over 5,000 individuals participated in at least one education event this season. These moves continue to expand the reach and effectiveness of NWAC's message and forecasts across the community.

Like many centers around the country, NWAC saw an increase in backcountry use this winter coupled with an increase in website traffic. Avalanche forecast page views increased dramatically this season with more than a million visits. However, the truly impressive big change in community engagement came in public observations and membership. Our users submitted ~1400 observations, nearly tripling previous seasons! Given the size of our forecast zones, this information combined with reliable observations from our professional partners creates an invaluable data stream from which to create our avalanche forecasts. We can truly say NWAC's forecasts are a community effort. Similarly, even in the year of Covid we saw our membership grow by 20%. We feel constantly humbled and appreciative of our regional community that continues to step-up and support NWAC through observations, memberships, donations, and time.

Beyond the program developments and increased community engagement we experienced a long winter season in the Pacific Northwest. We saw above average snowfall, along with some of the largest and prolonged avalanche cycles in recent memory. Our winter began in earnest in late October. Many ski areas opened prior to Thanksgiving with respectable bases and backcountry recreationists took full advantage of the early season snow. Despite the strong start, like much of the mountain west, Washington would see its share of nasty persistent weak layers. An atmospheric river in mid-January brought high-elevation rain to nearly the entire forecast region and formed a robust crust. As the deluge ended, temperatures cooled, and several inches of snow fell. In the dry weeks following this event, the surface snow quickly faceted. When the storm track once again focused on the PNW, a crust/facet sandwich was primed and waiting. Numerous very large avalanche cycles occurred during the prolonged and stormy February period. At Stevens Pass more than 180 inches of snow fell during the 28-day stretch. The center issued 10 avalanche warnings during February and forecasted Extreme danger for the first time in 4 years. This persistent slab cycle resulted in one fatality, several involvements, and numerous near misses. This served as a stark reminder that the difference between one fatality and a dozen fatalities is often razor

thin. These avalanche cycles culminated the last weekend of February with several days of continued D3-4 avalanches from Highway 20 in the north to Crystal Mt in the south.

When we reflect on the 2020–2021 season, the effects of Covid, increased backcountry use, and numerous huge avalanches will remain at the forefront of our minds. We're also cognizant that long term initiatives from across our program continue to bear fruit in terms of community engagement, staffing, professional relationships, forecast products and education.

—NWAC Staff

PAC

Short and Spooky

Fall of 2020, the West Central Mountains got their first significant snowfall on November 8. As was the case across the region the early season brought a mixed bag of heavy precipitation, rain crusts, cold temps, and two significant high-pressure regimes that set the stage for a challenging winter for forecasters and recreationists in the **Payette Avalanche Center** advisory area.

Mid-December marked the beginning of the PAC forecast season with several high SWE storms that quickly increased the snowpack depth. The early season snowpack and its layer-cake stratigraphy made for some interesting early season conditions. One layer (lovingly referred to as the MPBS (mid-pack bulls#t) persisted through the first half of the winter. The MPBS, an extremely weak but thick layer of faceted snow below an early-season rain crust, caused a lot of tip-toeing around on low-angle slopes as it let loose in impressive collapses for several weeks. December 21 marked the first of several notable events with a high elevation rain event and our first major natural avalanche cycle followed by a rapid cool down. This created a slick crust with a combination of near-surface facets and large surface hoar resting above it. Looking back through our precipitation records, the majority of the December storms came in relatively low density and temperatures stayed cold. These storms never reached a critical mass but continued to build a slab through incremental loading until January 7th. The persistence of the buried weak layer from December 21 kept the majority of folks off steep terrain. The term “spooky moderate” pretty accurately described the lack of avalanches in what was a horrible snowpack structure. Pit test results did not reflect



Early season double stack of surface hoar. COURTESY PAC

our concern over the poor structure and the growing thickness of the slab as it transitioned from a soft slab to a hard slab in many areas. Variability across the advisory area provided even less confidence and required a constant re-evaluation of the overall hazard level as we gained more information from different areas.

On January 7th a group of snowmobilers remote triggered an avalanche from a flat ridge just outside the boundaries of Tamarack Resort where one of the machines had gotten stuck. This avalanche was on a relatively small slope (400 vertical) but went wall-to-wall, confirming all of our concerns about the low probability/high consequence scenario that was developing. Storms that started around the 11th provided consistent snowpack growth punctuated by a quick warmup and short windows of cold clear weather that added another crust and two new layers of surface hoar and near-surface facets to the snowpack. By mid-January, our problem list included wind slab, persistent slab, and deep persistent slab with natural and human-triggered avalanches occurring in all of these layers. The last week in January brought a powder skiers paradise with cold temps and 26 inches of blower pow. It also brought on the next round of

Equipment designed for

- Avalanche Professionals
- Research Scientists
- Students and Educators

snowmetrics.com • 970.482.4279 Since 1985

skier-triggered avalanches. Between January 29 and February 5, one popular drainage saw at least four skier-triggered avalanches. Three of these incidents occurred within a few hundred feet of each other. PAC forecasters investigating one of these incidents remotely triggered a very complex R4, D3 avalanche from the top of a flat ridge while skinning into the area. The common thread was widespread surface hoar sitting on a slick sun crust. Low-density snow and moderate wind loading did not overload the layer but provided a perfect scenario for widespread human-caused avalanches.


February provided consistent snow, great skiing, and riding with similar themes to the previous two months. A quick spring-like warmup created a crust on February 12 and was followed by light accumulations and periods of cold, clear nights. Storms slowly added depth and kept the avalanche hazard on the spicy side through the end of the month. Several additional skier and machine-triggered avalanches occurred with some close calls and one burial. Luckily, all these incidents had good outcomes. Early March marked the end of the storm train with just a few exceptions and provided a solid base, low hazard, and some great spring conditions.

During March, what had originally looked like a strong La Nina winter fizzled and we watched our basin-wide water totals drop from above to below average with the early May report showing a meager 35% of average SWE left in the West Central and surrounding mountains.

This winter provided all local avalanche professionals and recreationists a chance to re-evaluate our views of our typical snowpack as human-triggered avalanches were posted not only on the PAC website but also across the many social media platforms. Overall, we saw lots of moderate and high wind events, then several quick warmups that produced rain or sun crusts and were followed by cold temperature regimens that were perfect for forming SH and NSF above the crusts. Colder temps overall that allowed weak layers to develop and persist combined with light density storms that kept the snowpack verging on failure for longer periods of time were major themes. More users and a touchy snowpack combined to increase human triggered avalanches significantly over previous years.

Increased traffic clearly led to the increase in incidents as motorized and non-motorized users competed for fresh snow. Increases in



In the Sawtooths, looking north from Bald Mountain towards the Baker Creek drainage on January 5th, 2021. A quick-hitting storm brought around 1" of SWE to this area, the first rapid load it had seen following the development of a widespread layer of early season facets. This storm prompted the first Avalanche Warning for the season for this zone.  COURTESY SAC

snowmobile and snowbike technology also allowed more folks to get into more committing terrain. The Canadian border closure also brought more out-of-area skiers and riders to the PAC area. Traffic at local ski resorts, backcountry areas near resorts, and at local snowmobile parking lots was much higher than in past years which can probably be attributed to both Covid-19 effects and a lack of snow in other nearby states. The increase in use taxed the recreational infrastructure, kept our local SAR and Law Enforcement busy, created major parking challenges at both improved and unimproved locations, increased traffic on groomed snowmobile routes, and increased competition for fresh snow unlike anything we have ever seen in this area. Course providers set records for student enrollment in local avalanche classes and PAC saw an increase in website and social media traffic on all platforms. We also saw a noticeable increase in observations despite some submission glitches with the new standardized web platform.

From an operational standpoint, the PAC remained status quo from previous years with two seasonal part-time forecaster positions and a permanent director from the District Recreation Staff. Throughout the season we were able to post five advisories per week. PAC staff put out 73 Avalanche Advisories

and 20 Condition Updates with 1 High Hazard, 19 Considerable, 38 Moderate, and 15 Low Hazard Advisories. We continue to rely heavily on volunteer travel companions, public observations, and the fundraising efforts of our Friends group to help us keep the lights on, snowmobiles running, and the advisories fresh.

—Dave Bingaman

SAC (Sawtooth)

In many ways, the 2020–2021 winter began where last season left off—adjusting the **Sawtooth Avalanche Center's** operations to the “new normal” that came with Covid. As Zoom and “virtual events” now seem so commonplace, it’s hard to believe they were a new phenomenon back in October. Once the winter got rolling in November, it was a relief to think about something we have a better handle on—snow!

Like many ACs, we spent a good chunk of our fall re-tooling our educational programs to be online. We learned Zoom, did practice webinars, and got used to talking to a screen and not hearing anyone laugh at our bad jokes. As we’re sure other ACs discovered, the new platform had valuable benefits but



Backcountry Mapping Evolved



Best-in-class mapping tools that seamlessly transition from computer to phone

Plan | Collaborate
Adventure | Share

Get started: caltopo.com/app



Mountain goats in the Sawtooth Mountains. These creatures had wisely chosen to travel in an area free from avalanche hazard. ■ SAC

also major drawbacks. With an expanded reach, our online programs kicked off with an enthusiastic viewership. Over the course of the winter, however, we saw a steady decline in our audience numbers as “Zoom fatigue” set in. We look forward to returning to more engaging in-person presentations, but we’ll continue to record our talks for remote viewers.

The early season was also spent wrapping up web projects. We built new avalanche occurrence and weak layer databases and added geospatial capabilities to our existing observation platform. We also added a new Trip Planner tool that leverages this location data. By clicking (or searching for a location) on a map on our homepage, the user gets a one-stop-shop of information to plan their day: the relevant avalanche forecast, nearby geo-tagged field reports, avalanche occurrences, media, weather stations, and an NWS point weather forecast. This new tool helped the Covid-driven “newbies” figure out which forecast zone they were playing in and simplified their website navigation. Our observation system is critical to sharing information within the local backcountry community. This season saw nearly 1000 observations—a 25% increase over last season.

The winter seemed to get off to a strong start in the mid-November when a series of warm storms dropped several feet of dense snow in the mountains. Unfortunately, this early snowfall was followed by three weeks of dry conditions, clear skies, and relatively cold temperatures. This drought produced a once-in-a-decade persistent facet layer that plagued us until March. This unusually weak and widespread layer was first put to the test during small storms towards the end of December—and it failed.

Beginning the day after Christmas, 11 large human-triggered avalanches occurred in just 12 days with many remote triggered slides.

Like most places, we saw a significant uptick in backcountry traffic. Combined with the makings of an abnormally unstable year, the importance of effective and wide-reaching public safety messaging was foremost on our minds. With many new backcountry users, it was perfect timing to launch our Trip Planner tool. To reach more folks, we also did significantly more field videos—over twice what we did last season—and we experienced a 600% increase in views. Finally, each Friday afternoon, we put out a “Weekend Update” product that gave a summary of the past week and an outlook for the coming weekend.

The New Year rang in with several storms that produced HIGH danger and multiple Avalanche Warnings. On January 26th, the largest storm of the winter smashed into our area. From Jan 26-29, the Sun Valley Ski Resort recorded 52” of snowfall, and 4” of SWE fell in the town of Ketchum. This storm broke the camel’s back on the December weak layer. The avalanche danger was HIGH for five straight days, and we issued a three-day Avalanche Warning. Skiers were caught in two separate avalanches in the “out of bounds” area adjacent to the resort. A third “out of bounds” skier-triggered slide partially buried a vehicle near the Warm Springs base area and narrowly missed catching a maintenance worker.

The snowy pattern continued through February, with measurable precipitation occurring daily for two weeks. The constant trickle of snow heavily favored our northern and western mountains where more

than four feet of snow accumulated. On February 19th, a snowmobiler was killed in the Smiley Creek drainage by an avalanche that broke on a midpack weak layer.

There’s little doubt that the first two-thirds of the winter was exceptionally unstable. From December 20th through March 1st, the Sawtooths & Western Smoky zone was rated CONSIDERABLE or HIGH for 63 of 72 days. We were fortunate that many natural slides and an eerie number of remotely-triggered avalanches made it (mostly) obvious to the public that conditions were especially dangerous. But as the December weak layer became more deeply buried, signs of instability became less pronounced. Message fatigue set in from over two months of dangerous conditions, and it was a challenge convincing backcountry users to remain conservative. Local guiding operations entered an “entrenchment” mindset to help them manage the prolonged instability.

The season went out with a whimper. March was exceptionally dry with less than 24 inches of snowfall recorded during the month. Our first major warm-up in early March produced many wet loose avalanches and one very large wet slab in the Sawtooths. When the temperatures cooled on March 7th,

the danger across the forecast area dropped to LOW for the first time since mid-December. The first half of April proved drier yet, with only a few inches of snow recorded by the time we issued our last avalanche forecast on April 11. Compared to the first part of the winter, the last third was relatively stable due to the lack of loading. Despite an above-average snowpack in November, the snowpack was at 55-80% of normal when we closed for the year.

Just as we never seem to have a “normal” winter, the lingering, long-term effects of Covid-19 may prevent our lives from returning to what we used to consider “normal”. This season taught us that we can learn, grow, and benefit from challenges and uncertainty—whether dished out by the snowpack or a pandemic—and become better at our jobs because of it. Which is good, since the future is likely to be anything but “normal.”

—Chris Lundy and SAC Staff

SAC (Sierra)

Every winter is different. Big storms, small storms, snow, rain, wind, warm, cold, sunny, or wet, the



BUILT FOR THE BACKCOUNTRY

At Black Diamond, backcountry safety continues to drive our innovations in equipment. This winter, our snow safety tools feature the latest advancements in technology, from our fast and accurate Recon BT avalanche beacon to our industry standard Quickdraw Carbon Probe 300 and Evac 7 shovel.

SHOP SNOW SAFETY AT BLACKDIAMONDEQUIPMENT.COM

 **Black Diamond**

Sierra Avalanche Center forecast area sees it all. The average winter has never happened. The numbers representing the average winter come from averaging extremes. The 2020–21 winter was characterized by moderate storms followed by extreme NE wind events and long cold dry periods. Persistent weak layers led to persistent slab problems that lasted months and produced several large avalanches. While the persistent slab problems captured quite a bit of attention, wind slabs and storm slabs made up the bulk of our avalanche issues.

In contrast to the high variability in weather from winter to winter, some trends remain consistent. Backcountry use in the SAC forecast area continues to increase dramatically each year. Full parking lots, waiting lists for avalanche classes, and tracks everywhere within days of any storm were the norm this year. More and more people want to explore the backcountry with human-powered and motorized recreation. Along with this increased use comes more incidents in the backcountry. During the 2020–21 season, there were 15 reported avalanche incidents in which a person was caught and carried. Two of these resulted in full burials with live recoveries. One of these full burials required a helicopter evacuation due to the

serious injuries the victim sustained. There was one avalanche fatality due to a cornice collapse that took a person over a ~900-foot cliff.

On the bright side, demand for avalanche education hit an all-time high this year to accompany the increased use. The Sierra Avalanche Center expanded its free motorized avalanche class offerings and provided four Rescue classes, five Level 1 classes, and two Level 2 classes to a total of 97 students. They all filled up within minutes of opening sign-ups. SAC also continued to offer avalanche education scholarships. SAC awarded \$9700 to 24 people (10 women and 14 men ages 24 to 49) to take avalanche classes that included Rec 1, Rec 2, Rescue, and Pro 1. Other education offerings had to scale back due to Covid-19. SAC pivoted to more online presentations and still managed to reach a wide audience with an online California Avalanche Workshop in the fall and other virtual presentations throughout the winter.

The non-profit side of SAC made few changes this year. The Board of Directors remains strong with 13 invested, engaged, and driven directors. David Reichel, one of our long-time professional observers, moved into the Executive Director role at the Sierra Avalanche



Andy Anderson investigating a deep persistent slab avalanche on Carpenter Ridge in late December. We triggered this avalanche while digging a pit in low-angle terrain 150m away. ■ BRANDON SCHWARTZ

Center non-profit. Going into the season he was nervous about switching from tracking weak layers in the snowpack to tracking products provided valuable tools to the backcountry users in the area. Overall the 2020–21 season defied expectation. SAC's symbiotic partnership between non-profit and Forest Service thrived. Their joint efforts brought community avalanche awareness to an all-time high despite challenging snow conditions and a global pandemic.

—Andy Anderson

Duncan Lee at the crown of a large wind slab avalanche near Bear Valley at Little Truckee Summit in late December. This was accidentally triggered by a snowmobiler earlier that day. The rider was buried up to his chest and his sled was fully buried. ■ SAC



On the Forest Service side of SAC, Brandon Schwartz continues to lead the crew as the Director of the Sierra Avalanche Center. Andy Anderson and Steve Reynaud make up the rest of the forecasting team. This year SAC switched over to a new forecasting platform developed in partnership with the National Avalanche Center and several other centers around the country. It provides more consistency from region to region. The collaborative effort also allows SAC and the other centers to leverage better tools on small tech budgets. The combination of forecasts, observations, and other

AMERICAN AVALANCHE INSTITUTE

Professional Avalanche Rescue Course

January 4-7, 2022

Little Cottonwood Canyon, Utah



Photo: Kelly Elder



Professional Level 1 Courses

Jackson, Wyoming

Salt Lake City, Utah

Bozeman, Montana

Other courses offered:

Professional Level 2

Recreational Level 1 & Level 2

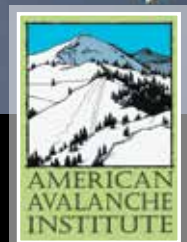
Rescue Fundamentals • K9 Course

Custom Courses Available

COURSE DETAILS & QUESTIONS

307-733-3315

avalanche.institute@gmail.com



www.americanavalancheinstitute.com

The winter of 2020–2021 was a complex and challenging season for all backcountry users. Compared to the previous winter, there were 40% more recorded avalanches, 22% fewer human triggered avalanches, and 64% more people were caught in avalanches. Sadly, there were six avalanche fatalities in Utah and one just across the border in southeast Idaho. For the **Utah Avalanche Center**, there were many unknowns in how we would do business with the global pandemic raging. Would we be able to have on-snow classes? How would we do fundraising events? How would we deliver the KBYG program? The team worked hard all summer preparing for the season and reinventing almost everything we do. When the fall came, demand for our products and services was at an all-time high. Classes had large waiting lists and we had to increase the capacity of our website to handle the surge in user traffic. There were 43% more pageviews than last season.

The first significant snowfall arrived in early November followed by minimal snowfall across most of the state the rest of the month. December was generally dry and cold with a shallow snowpack that became faceted. This weak layer existed on shady, north, east, and some west-facing slopes. In many places a brief period of warm weather created an ice crust adjacent to this weak layer. Unfortunately, this layer persisted throughout the majority of the winter and caused avalanches with every major loading event.

The Logan and Uinta area mountains closely mirrored the Central Wasatch with a widespread persistent weak layer covering their north, east, and west facing slopes. The Skyline region of central Utah had an even more dramatic persistent weak layer which continued to weaken and facet as the snowpack remained shallow well into January. Snowfall totals in the Skyline region for November, December, and January were below 50% of average.

The mountains near Moab suffered a similar fate with minimal, early season snow. Most skiing and riding was confined to groomed trails and roads until early February when the storm track finally made a welcome drop into the Four Corners region and brought more snow. With a persistent weak layer near the ground, each storm led to hair-trigger avalanche conditions and pockety, natural avalanche activity.

The season's first avalanche fatality occurred on January 8th in the backcountry in Dutch Draw near



Avalanche crown in Wilson Glades, Utah from a fatal avalanche that killed four people on February 6th. **■ TRENT MEISENHEIMER**

Park City after 8-10" of new snow, accompanied by strong winds, had fallen in the area. Following this fatality, January continued to have more storms with more avalanche cycles, all failing on those facets. The increase in snowfall continued to create a thicker slab, and avalanches grew larger with each storm.

January 30th brought the second tragic avalanche fatality on Square Top Peak, also near Park City. This avalanche directly followed 20" of new snow and increased winds. That weekend over 30 human-triggered avalanches were reported. The following week, winds increased to speeds up to 100 mph and another 10-15" fell across the Central Cottonwoods.

On February 6th, a significant and heartbreaking avalanche occurred in the Wilson Glades area in Millcreek Canyon involving two parties with six people caught, carried, and fully buried. After a heroic rescue, two of the six were recovered alive. Sadly, four of the six did not survive.

The following week, February 12th through February 18th, a series of significant storms led to a historic avalanche cycle, especially in Little Cottonwood Canyon with 60-80" of snow where three slide paths hit the road for the first time in recorded history. Avalanche danger remained elevated throughout the week, peaking with Tuesday and Wednesday at Extreme Danger at all elevations and aspects, the first such danger rating on record for the Salt Lake City region.

On February 20, just north of the Logan forecast zone on Sherman Peak, a snowmobiler was killed by an avalanche that was remotely triggered by his party. The last reported

remotely triggered avalanche in the Logan Zone occurred on February 28 on a mid-elevation slope in the Elk Valley Area. Around the same time, the Skyline region was experiencing a large avalanche cycle.

After many stressful months, the troublesome layer near the ground gradually became dormant by the

end of February. For the first time in 33 days, the overall avalanche danger dropped below Considerable and finally, backcountry riders enjoyed some good turns and generally stable conditions for a few weeks.

A large storm arrived in the Moab area on March 14, when 30" of snow (3.5" SWE) fell over three days producing the most widespread avalanche cycle of the season. Relative stability followed until an extreme heatwave between April 3-5 produced some large, wet slab avalanches.

April brought a statewide warmup, and a significant warm up bringing multiple nights without a solid refreeze. Despite this entire warmup, no significant avalanche activity was reported across the state except for some wet slabs near Moab, and a challenging and eventful backcountry season in Utah came to a rather quiet close. The full annual report is available at: <https://bit.ly/2021UACAnnualReport>.

A few numbers:

- 797 reported avalanches
- 246 human triggered avalanches
- 1,134 forecasts
- 114 classes or presentations
- 13,100 people attending some class or presentation

- 18 employees
- 422 field days
- 2x number of on-snow classes over last winter
- 0 known Covid cases
- 1 minor shoulder injury

—UAC Staff,
compiled by Mark Staples

WAC

Winter began a bit earlier than usual this past November in the mountains of Northeast Oregon. By mid-November we had 2-3' of snow on the ground and backcountry riders were already poking around looking for lines to ski and ride. As in most areas across the west, this early snowfall was followed by a couple of weeks of high pressure. I can attest that I had some of my finest early season snowmobiling in that time period, but the writing was on the wall for the decline in snowpack structure.

The **Wallowa Avalanche Center's** formal avalanche forecasting began on December 17th across our four forecast zones. New to us this year was the ability to associate a danger rating with our bi-weekly forecasts. In the past we would produce

two snowpack summaries a week, without the use of the danger scale. Working with Simon Trautman and the National Avalanche Center, we instigated a new format that was developed for Type 2 avalanche centers, allowing us to provide danger ratings. On Thursdays and Saturdays the forecasters would write a forecast, followed on Fridays and Saturdays with a General Avalanche Information summary. This format was well received by our users, especially those who are used to seeing a danger rating every day of the week.

After an early December lull in snowfall, conditions started to improve in mid-December. On December 20, our first avalanche warning went into effect due to a warm Pineapple Express that produced rain on snow at lower elevations. During this period the infamous Solstice Rain Crust (SRC) was introduced to our snowpack. With a wildly fluctuating snow level we were left with a sandwich of crusts and snow, which later turned into a troublesome persistent problem. Persistent slab was our primary avalanche problem for much of January and into mid February. **The SRC crust woke up around the end of January as a couple of human and natural avalanches in the D2.5 range were reported in the Northern Wallowas.** Fortunately we



received copious amounts of snowfall throughout the second half of February, to the point we could finally remove the deep persistent slab from the problem list.

Generally speaking we had an average year for snowfall and SWE. The Western Wallowas and Blues were generally favored with the NW flow. In total we produced 37 avalanche forecasts, 37 general avalanche information posts, and five avalanche warnings over the course of the winter.

Besides implementing the danger scale in our forecasting, we also increased our forecasting team to four with the addition of Caleb Merrill, the host of the popular "Avalanche Hour" podcast. Caleb brought many years of experience looking at very poor snowpack structures in the Ruby Mountains as a heli ski guide. Tom Guthrie, Michael Hatch and myself rounded out the forecasting team. Having an additional forecaster certainly helped our entire team get more eyes on the ground, as like most avalanche centers we cover a lot of terrain.

The local trailheads and sno-parks saw a sharp increase in use this winter. Due to Covid-19 all of our free avalanche awareness presentations were held via Zoom this winter. As part of our annual Eastern Oregon Backcountry Festival we held four virtual training sessions where we covered avalanche awareness sessions, backcountry 101, and navigation and route planning. One huge benefit of the online platform was our ability to capture a greater and more regionally diverse audience. We had over 300 viewers attend our free virtual presentations this winter. Beyond our free education opportunities the WAC offered six AIARE Level 1 Courses, a Level 2 and two companion rescue courses. One of the Level 1 courses was specific to the motorized user, with 17 participants. The WAC also worked specifically with two local snowmobile

clubs this winter on one-day companion rescue field sessions.

In summary we at the WAC feel fortunate to have made it through this winter without any fatal avalanche accidents. The "perfect storm" of increased backcountry use and a poor snowpack structure added stress to the forecasting team. Personally I believe joining the Avalanche Forecasting Platform, which was developed in conjunction with the National Avalanche Center helped us immensely. As a small non-profit avalanche center, we were able to utilize some great technology at a very fair cost. Thanks to the NWAC, Sierra Avalanche Center, Sawtooth Avalanche Center and the NAC for footing most of the bill. This combined effort has allowed the type 2 centers to forecast more effectively and affordably. Having greater consistency and messaging across a larger number of avalanche centers seems to be a huge benefit to the end user.

Thanks to all who helped our organization this past winter.

—Victor McNeil

WCMAC

The winter of 2020–2021 was a long and difficult one. A proliferation of faceted layers and spatial variability made forecasting and recreating safely a challenge. The **West Central Montana Avalanche Center** (WCMAC) issued early season snowpack updates on October 23 and November 24, 2020. In response to higher than average backcountry use and ample snowpack, the WCMAC issued the first avalanche advisory on December 1, 2020. In total, 63 forecasts were issued this winter.

Underlining the challenging conditions, only six forecasts were low hazard days; five in early December and one in March. Conversely, we issued five avalanche warnings. We had 12 days of High hazard and 18 with Considerable hazard. The WCMAC issued its final forecast on April 6, 2021.

Faceted problem layers appeared in almost all forecasts. Contributing to this was the January 13 rain crust that reached 8000' in elevation. Compounding this was drastic spatial variability. Stability varied widely over short distances from drainage to drainage and aspect to aspect, making both forecasting and risk management a challenge.

The weather contributed to the challenging conditions this season. Despite La Niña, abundant early season snow and heavier than average snowfall predictions, it felt more like



GET YOUR PRINT AND DIGITAL SUBSCRIPTION TO

SKI
SKIMAG.COM

an El Niño year. Warm temperatures and below-average snowfall persisted through December and January. In early November, the west-central Montana snowpack was 201% of average. However, drought conditions reduced the snowpack considerably by early December to 89% of average, and depth hoar had begun to form. By late January, regional snowpack dropped as low as 80% of average. February brought up to 12" of SWE, and the snowpack rose above 110% of average. A warm March followed with lower than average precipitation. The regional snowpack decreased to 105% and 93% of average.

Our first avalanche warning and high danger rating on December 20 responded dramatically to rapid loading on top of facets and crusts. This pattern was repeated four more times throughout the winter. During February, despite conditions that we usually associate with bonding and rounding in the snowpack, such as warm temperatures and snowpack depth, facets and persistent layers continued to develop and propagate. We speculate the January 13 rain crust contributed to the persistence and development of facets. This layer was likely the culprit behind the late February 21, 2021 avalanche cycle that generated numerous slides that ran full path in the central Bitterroot and included the R5/D4 Lost Horse slide.

A mid-February cold snap created some unusual layers in the snowpack. Thirty-six hours of -25°C and strong north winds created near-surface facets in the Rattlesnake Mountains that were large, cupped, and striated, resembling depth hoar. The last week of the season brought 72 hrs of above-freezing temperatures to the mountains. We did not see a significant avalanche cycle even with the rapid warming, a snowpack saturated to the ground, lingering facets, and a widespread crust near the base.

Despite the hazard and increased backcountry recreation, we were lucky to have only one reported avalanche accident within the west-central Montana forecasting area. This event occurred on January 3 on St. Joseph Peak in the Bitterroots, a class 1-2 skier-triggered wind slab with no burial or injuries.

On January 17, a group of snowmobilers reported another close call just outside of the forecast area in the Flint Creek Mountains. The group remotely triggered an avalanche in depth hoar. One rider was buried to the shoulders. There were no injuries.

During the winter operating season, the forecast team consisted of two forecasters, Travis Craft and Jeff Carty. The WCMAC generates



This slide (HS-NS-R5-D4) on February 21, 2021 in the Lost Horse drainage of the Bitterroots ran 3000' vertical feet and was the largest of several slides that failed on the January 13, 2021 rain crust/facet combo, our most persistent layer of the season, following heavy snowfall. ■ TRAVIS CRAFT

forecasts for a 1420 square mile area that stretches 150 miles north to south. This is a large area for two forecasters. Consequently, the WCMAC hired five professional observers before the operating season began in order to expand coverage. Increasing capacity in the field helped ensure the most up-to-date and pertinent information was incorporated into each forecast. This was particularly helpful when focusing on specific areas such as the southern Bitterroot and on trying to reduce extended drives for Missoula-based forecasters.

Public observations are a critical and essential resource when assessing avalanche conditions in west-central Montana. The WCMAC received 129 public observations this year, two more than last year. The vast majority of submissions were submitted by non-motorized recreationists, despite heavy snowmobile use throughout the region. To engage the growing backcountry community, we implemented a public observation campaign to solicit submissions. Efforts included social media posts and posters at trailheads and businesses. We added a web-based text number to simplify the submission process. We did not see an appreciable increase in submissions this season but remain hopeful regarding continued outreach efforts and user engagement.

Covid presented a host of unique challenges, but it did not negatively impact WCMAC forecast program operations. Forecasters strategically utilized volunteers as field partners to limit the possibility of cross-contamination and multiple staff being ill. This strategy allowed for more efficient and effective use of resources

and contributed to broader coverage of the forecast area.

This season, George D'Angelo joined the West Central Montana Avalanche Foundation (WCMAF) team as Education Coordinator. He worked hard to ensure the best outcome for all staff and participants and helped

deliver an effective and efficient education program. The WCMAF instructor team consisted of nine instructors, five male and four female.

Covid created challenges to a safe working and learning environment. Retooling in-person sessions via virtual learning environments helped deliver content. Instructors maintained engagement and interactivity by utilizing small group breakout rooms, quizzes, and polls within our Zoom sessions. Google classroom enabled information sharing and facilitated communication between students and instructors. The instructor team safely delivered field components with no incidence of Covid transmission during the season. Covid field strategies included smaller student-teacher ratios (4:1), the use of small student pods, social distancing, and masks.

The WCMAF delivered a total of 34 programs to 900+ participants:

- 14 Awareness Lectures | 500+ participants
- 11 Level 1 courses | 120 students
- 2 Avalanche Rescue | 12 students
- Awareness Motorized | 22 students
- AIARE L1 Motorized | 6 students
- Level 2 | 8 students
- KBYG Program | 253 students

—WCMAC staff,
compiled by Jeff Carty



- **SNOWOBS**
SnowObs software simplifies & optimizes weather observations, avalanche data, team communication & data sharing.
- **AVALANCHE MONITORING**
Proven infrasound technology to detect & track avalanche movement with real time SnowObs integration.
- **MOUNTAIN WEATHER API**
Connect to mountain weather data, either public sources or custom solutions.
- **CONSULTING & CUSTOM SOFTWARE SOLUTIONS**
Web, data and application development for avalanche professionals.



CONTACT US TODAY TO LEARN MORE!



- ☎ 208-352-3034
- ✉ info@snowboundsolutions.com
- 🌐 snowboundsolutions.com



EXPLOSIVES

THE LARGEST AVALANCHE DISTRIBUTION NETWORK IN NORTH AMERICA

**WHEN IT COMES TO AVALANCHE CONTROL, YOU NEED A
SUPPLIER WHO WILL DELIVER - WHEN YOU NEED IT, WHERE YOU NEED IT**

- **HAND CHARGES : CAST BOOSTERS (1 LB, 2 LB, 5 LB) SNOWPRO 1 KG EMULSION**
- **ANFO IN 25LB AND 50LB BAGS AND SUREFOOT HELICOPTER ANTI-SKID SACS**
- **SNOWLAUNCHER AVALANCHER ROUDS : 1 KG CLASSIC, 2 KG SLUGGER**
- **MILDET - USA MADE MILITARY SPEC SAFETY FUSE 90s, 1M, 2M, 3M LENGTHS**
- **INDUSTRY STANDARD M&S PUL-WIRE LIGHTERS**
- **HOWITZER DUD - EXO DISPOSAL SUPPLY'S**
- **CIL IMPERIAL AVALAUNCHER GUN SYSTEM**
- **AVALANCHE GUARD RACS SYSTEMS AND ROUNDS**
- **CUSTOM TRAINING**

**ALL PRODUCTS ARE MADE IN NORTH AMERICA AND SUPPORTED BY THE ONLY
EXPLOSIVES COMPANY THAT SPECIALIZES IN AVALANCHE CONTROL.
WE ARE HERE TO HELP MAKE YOUR JOBS SAFER AND MORE EFFICIENT
EVERY DAY.**



**WHEN YOU REQUEST CIL EXPLOSIVES YOU ARE SUPPORTING YOUR INDUSTRY, A PERCENTAGE
OF PROFITS GOES BACK TO THE AMERICAN AVALANCHE ASSOCIATION FOR TRAINING PURPOSES.**

CONTACT : BRADEN SCHMIDT 250 423 3302 BRADEN.SCHMIDT@CILEXPLOSIVES.COM

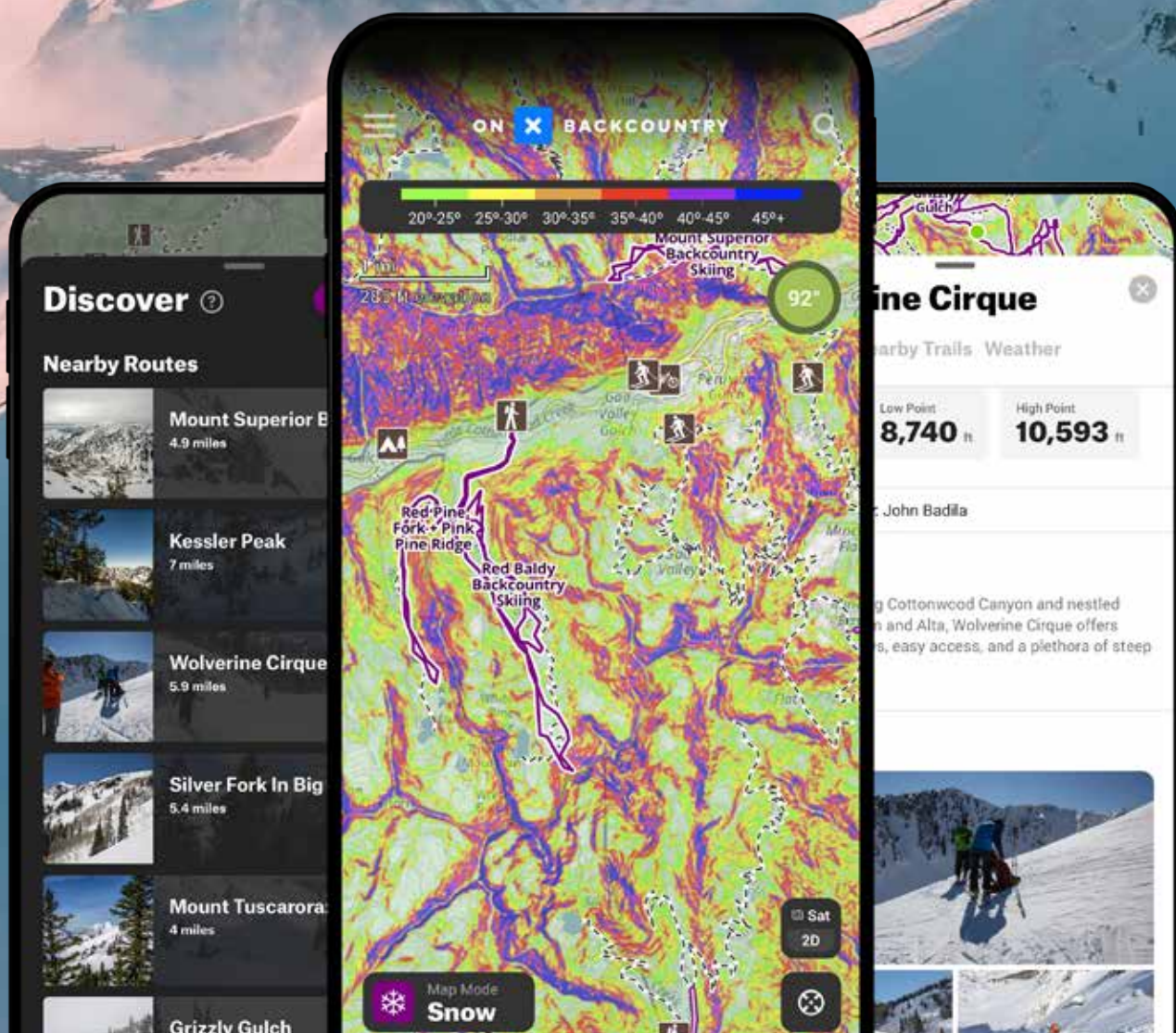
CILEXPLOSIVES.COM/AVALANCHE

ON **X** BACKCOUNTRY

SLOPE ANGLE + AVALANCHE FORECASTS IN YOUR HAND. UNDERSTAND THE TERRAIN WITH **ONX BACKCOUNTRY**.



7-Day Free Trial



FILM REVIEW

Buried: The 1982 Alpine Meadows Avalanche

BY ANDREW HENNIGH, IMAGES BY LANNY JOHNSON



Buried: The 1982 Alpine Meadows Avalanche opens with then Alpine Meadows Avalanche Forecaster Jim Plehn struggling to introduce himself while holding back emotion that still wells up nearly 40 years after such a life-altering event.

The 1982 avalanche cycle at Alpine Meadows was to cause the destruction of resort infrastructure, bury eight people, and leave seven of them dead. As a documentary, *Buried* does a wonderful job of developing the characters, not only those who were involved in the rescue- Larry Heywood the Assistant Ski Patrol Director; Meredith Watson, the sole female patroller at the time; Jim Plehn and others who are still obviously grappling with what happened, but also some of those who were killed, including Mountain Operations Assistant Jake Smith and Mountain Manager and Avalanche Expert Bernie Kingery. The film also does a perfect job of showing the lifestyle of working at a ski area like Alpine Meadows in the early 80s which, with its fun-loving atmosphere, was a stark contrast to the events that would unfold in March of '82.

I watched this film in Park City, Utah at a drive-in style public event that was put on by the Utah Avalanche Center. As a long time ski patroller and ski area avalanche forecaster I thought that this film did a really great job of exposing the general public to not only the lifestyle of working at a ski area, especially as a ski patroller, but also to what it takes to manage a ski area that is threatened by such an immense amount of hazard as Alpine Meadows. I really appreciated that the filmmakers give a nod to the work that Jim Plehn and Bernie Kingery did to create a record-keeping, forecasting, and mitigation program that is still to this day the industry standard. The film then

The one audience we think about more than any is the patrol audience. Highlighting what they do, how they sacrifice, and how they persevere is our primary goal of this film.

—Jared Drake
Director of *Buried*



introduces the late March storm that ultimately produced over 100 inches of snow and along with 100 plus mile per hour winds would, despite the monumental efforts of the Alpine Meadows Ski Patrol's mitigation work, cause an avalanche that no one at the time thought the mountain was capable of. *Buried* showed a lot of what goes into avalanche mitigation work and, despite the film being set in 1982, it was interesting to see how much of what we do today is still the same.

The bulk of the film was dedicated to the heroic efforts of the rescuers to find the eight victims which culminated in the (spoiler alert) unbelievable live recovery of Anna Conrad who was buried with an air pocket and survived for five days, and the tragic recovery of Kingery who was the last victim found. The filmmakers did such an excellent job of building up to and then revealing the astonishing recovery of Conrad that I got to watch a younger patroller's jaw hit the floor. I was pleased and surprised by the film's coverage of the resulting lawsuit, including interviews with Defense Attorney John Fagan and Prosecuting Attorney Wes Walker.

Buried shows the intersection of the lives of fun-loving ski area workers and the often-overshadowed consequences of life in the mountains. The emotions that result from the March 1982 Alpine Meadows avalanche can only be completely experienced by those who were there nearly 40 years ago, but the filmmakers do a beautiful job of making us feel a little bit of that. As an avalanche professional I would highly recommend *Buried: The 1982 Alpine Meadows Avalanche*.

Directed and produced by Jared Drake and Steven Siig. Buried won the audience award at Mountainfilm in Telluride and recently won "Best Documentary" at both the Bend Film Festival and the Austin Film Festival. ●



THE AVALANCHE REVIEW
PO Box 11443
Denver, CO 80211

WHEN LIFE IS AN UPHILL CLIMB TRAVEL SAFELY WITH BACKCOUNTRY ACCESS



Presort Standard
US Postage Paid
Permit #592
Pontiac, IL

A Publication of the
American Avalanche Association



AMERICAN
AVALANCHE
ASSOCIATION

BC AIR HELMETS | BC LINK 2.0 RADIOS | BCA SCEPTER POLES | BCA CLIMBING SKINS

Renew or sign up for a 21-22 BCA Pro Account for discounted gear here:

www.backcountryaccess.com/pro

