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Contact *The Avalanche Journal* editor: editor@avalancheassociation.ca
Return undeliverable Canadian addresses, change of address and subscription orders to: Canadian Avalanche Association PO Box 2759, Revelstoke BC V0E 2S0 Email: info@avalancheassociation.ca
Publications Mail Agreement No. 40830518 Indexed in the Canadian Periodical Index ISSN 1929-1043

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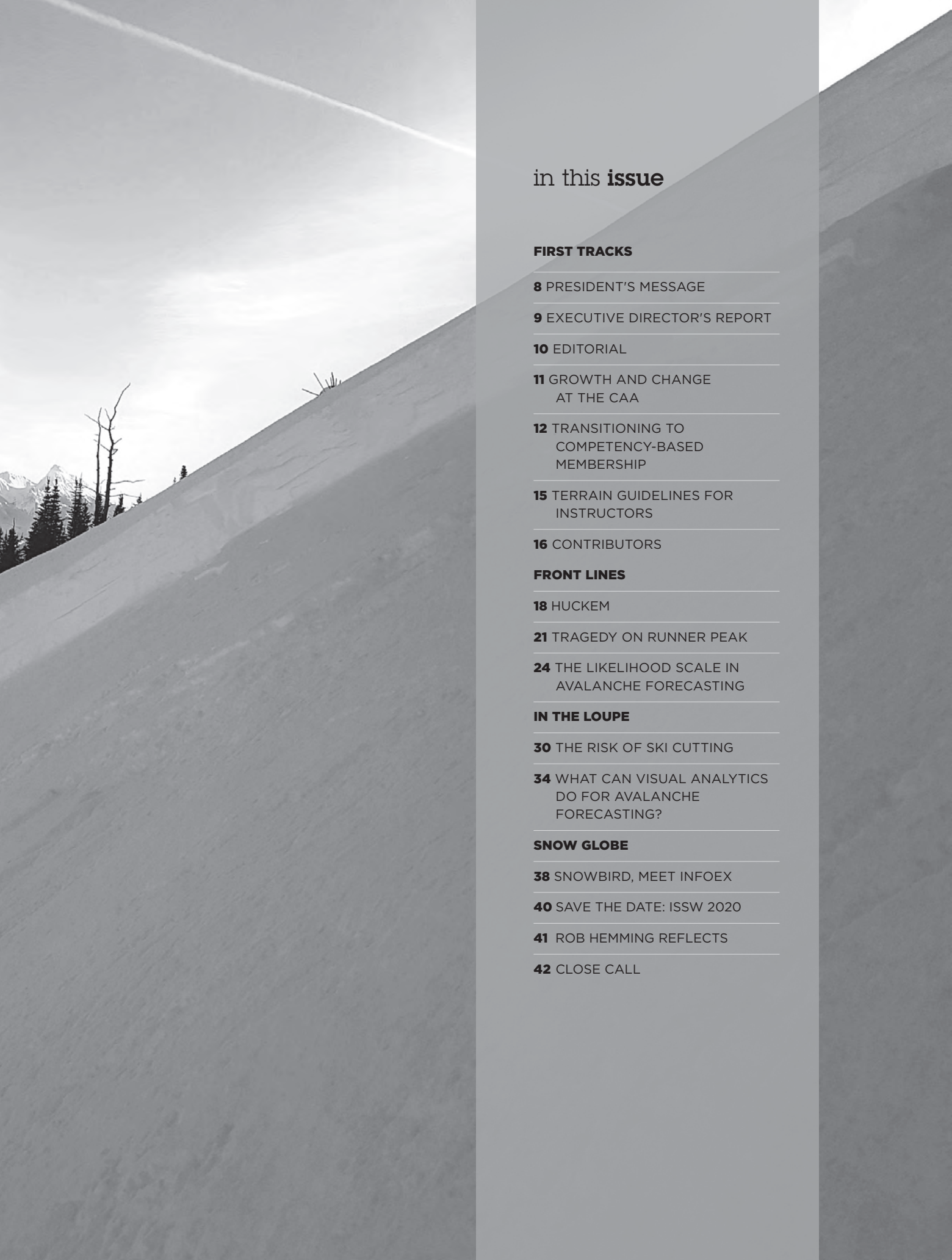
COVER DAVID PETCH // **CONTENTS** JASON KURUC



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President's Message

Walter Bruns
CAA President

ABOUT SIX YEARS AGO, your association embarked on its "professional path." Several ambitious goals and objectives were declared in a strategic plan. They established the requirements for the CAA to function as a fully self-regulating society. An initial objective was the development of competency profiles on which new requirements for membership would be based.

Setting a lofty goal is one thing, getting there is quite another. Just think climate change: it takes more than a declaration of good intention, it requires individual commitment, personal sacrifice, and concrete action.

The competency profiles were presented to the membership at the annual general meeting in 2015. The profiles set clear indicators for the revision of training and membership criteria. ITP manager Emily Grady kicked off the massive effort to incorporate the competencies through the Competency Aligned Avalanche Risk Assessment Training (CAARAT) project. This work has substantially revised Level 1 and Level 2 course curricula.

Changing course content affects course progression and thus everyone working their way through the system. The logistics of sequential implementation are challenging. Emily summarized the project status at our spring conference and in the spring 2019 issue of *The Avalanche Journal*.

More daunting yet is the effort to dovetail these changes with a revised set of membership requirements, assessment tools, and application processes. We have been fortunate to take on Kathy McKay as project manager and Brendan Martland as subject matter expert. Together, they presented the broader project status at the spring conference, and Kathy wrote a summary in the summer issue of the Journal. She provides a further update here on page 12.

You may recall the competency profiles were focussed on two categories of membership, which were given the working titles "practitioner 1" and "practitioner 2" (P1 and P2 for short). P1 corresponded most closely with the existing "active member" category and P2 with "professional member." We have used P1 and P2 as shorthand for a few years now.

The challenge has been to come up with a proper name for each membership category that would be relevant within the CAA and meaningful beyond our association. The ethics and standards committee, after spirited discussion and careful deliberation, recommended limited practice avalanche worker (LPAW) for P1 and avalanche professional (AP) for P2. You will see the new abbreviations in Kathy's update.

Finally, since membership categories are defined in our bylaws, we will propose a bylaw change at the next AGM to effect the transition. We will continue to report on progress via the Journal and monthly member news so that you can cast an informed vote.

Until then, best wishes for a safe and successful winter season.

Walter Bruns, CAA President

Executive Director's Report

DIVING INTO WINTER

Joe Obad
CAA Executive Director

THIS UPDATE IS A LOT LIKE OPERATIONS getting ready for fall: lots to take care of various fronts, and it all needs to be done before show time. Without delay, let's dive in!

INDUSTRY TRAINING PROGRAM

After several years of effort, the National Search and Rescue Secretariat-funded project to align our curriculum with the CAA's competency profiles is coming to fruition. The first cohort to take the revised Avalanche Operations Level 1 will do so this season. Many of the same students will go on to take the first offering of the revised Avalanche Operations Level 2 next year. Hats off to everyone who contributed to this success, from outgoing ITP Manager Emily Grady, who stewarded this project from grant writing conception through to the hand-off to project manager Kathy McKay; to the committed team of subject matter experts and curriculum advisors who turned vision into reality; and many more. Kudos team!

Another small victory includes the development of the Introduction to Avalanche Operations online course. This course offers a convenient way for many early students to take in the fundamentals of risk management, snowpack, and other basics so they hit the ground running when they reach the Level 1 course.

Technically complex IT work in the background allowed us to integrate our registration system with the third-party system that hosts the course. This allows us to smoothly offer other online courses in the future. These courses are no substitute for field work, but if we can help students along their professional journey with efficient and cost-effective options, they will be able to spend more time in the field learning from our excellent instructors. Additionally, online work has huge potential for continuing professional development offerings.

MEMBERSHIP

We hope many members were able to make the CPD sessions we developed with the ACMG in Revelstoke from Nov. 22-24. CPD is always huge challenge and we welcome member input and suggestions for sessions. We were disappointed to cancel the Squamish CPD this year after many challenges securing presenters. Member input and suggestions that lead to new options are a huge help to lock down these sessions. Please be in touch if you feel you have a strong lead or are yourself a great presenter on something valuable for members.

It's worth noting the CAA has no monopoly on CPD offerings. The further members are from the Banff-to-Whistler corridor, the harder it is to come by opportunities, so alternatives for delivery have to be considered.

Many veteran members and subject matter experts lead sessions regularly that members count towards CPD points. If you have a valuable skill and the entrepreneurial spirit to lead your own CPD session, hang out your shingle and invite members to join you to learn. By sharing these skills you'll likely have to answer questions that sharpen your skills as an expert while helping fellow members advance their development.

FUTURE MEMBERSHIP CHANGES

Walter Bruns and Kathy McKay write in this issue about changes to membership criteria that will be voted on at the spring AGM. Please read those pieces! We need an informed membership to consider the changes expected to come this spring.

INFOEX

If there was a hot oven named SAR NIF, InfoEx manager Stuart Smith slaved over it this summer, pulling together our application for funding to rebuild InfoEx. "But wait! Didn't we just rebuild InfoEx in 2013-14?" you ask. Well, yes, and the CAA was blessed to work with TECTERRA on the rebuild. That said, our control over the project came fairly late when several technology choices were made. Combined with the breakneck development of IT in general, InfoEx faces a number of IT "cul-de-sacs" that make it difficult to adapt to the needs of members. Nowhere is this more apparent than mobile applications, where the power of handheld devices in every pocket has the potential to increase efficiency and data sharing. Our application focused on rebuilding InfoEx's front-end, where users interface with the product. The back-end, where all the data is stored, is in great shape due to hard work by the team.

SAR NIF applications are a great resource, but they come with a "hurry up and wait" component. After a mad dash to complete the application, one needs to hold one's breath until the decision. The knock-on effect is operations need to understand development will be modest until we know if our application is successful.

Lastly, I want to thank outgoing InfoEx developer Luke Norman who, along with his wife Kristin, is headed on a personal journey away from Revelstoke. Luke's commitment to excellence led to more InfoEx advances than I can name here. We could not have done it without you Luke!

It is impossible to cover everything in these updates. Please reach out with any concerns you have that were not covered here. Until then, all the best for a safe, productive, and powder-filled season.

Joe Obad, CAA Executive Director

Alex Cooper
Managing Editor

Back to the **Future**

AS I SAT IN MY OFFICE looking for inspiration for this issue's editor's column, I couldn't help but peer upward for inspiration. No, I wasn't looking to God, or the weather (which is its typical October gloom as I write this), but to the archives of past issues of *The Avalanche Journal*, which sit on a shelf high above my desk.

I pulled out the oldest issue – *Avalanche News* #1, published 40 years ago in October 1979. This eight page newsletter was dutifully typed out and its lone graphical flourishes were a concave title and a large "1" on the front page. The introduction said: "People engaged in avalanche work in Canada have expressed the wish to keep informed about new developments and to maintain contact with others working in the same field. In response to this need the Canadian Avalanche Committee is planning to mail a newsletter about three times per year."

Peter Schaerer was the editor and Geoff Freer, through the BC Ministry of Transportation, was responsible for printing and distribution. On page two was a note saying the newsletter will only be successful if people in the industry contribute. "If you have developed new techniques, discovered better equipment, observed interesting snow and avalanche features, experienced a close-call or an accident that might be educational, wish to announce training opportunities or open positions, then write to Peter Schaerer in a form that can be copied and printed."

The newsletter has come a long way in the 40 years. It's transformed from eight pages type-written and stapled together to a glossy print magazine. However, the type of stories being sought hasn't changed all that much. This issue contains a mix of CAA news, new research, front-line reports, and tales from the backcountry. In it, Bruce Jamieson contribute an abbreviated version of his paper on the risk of ski cuttings. AJ Maheu reflects on a challenging rescue & recovery, and challenging snowpack in his article about the Runner Peak avalanche fatality. Scott Thumlert proposes some new ideas for the Likelihood of Avalanches Scale, and Stan Nowak provides a peek at the future of forecasting. We take a look at how InfoEx is being adopted abroad, and Felix Camire shares the story of a close call.

A few of the section names have changed. "First Tracks" remains and contains news from the CAA. "Front Lines" articles relating to field work. "In the Loupe" presents research-based articles, while "Snow Globe" contains stories from the avalanche community.

While I'm happy with this issue of the *Journal*, I'm still looking for feedback on how to improve it. As CAA members will have seen, we are conducting a membership services survey with the goal of gathering feedback on our existing member services and soliciting thoughts on new ones. We're seeking more information on our members so we have more data when we approach potential supporters.

And I'm using it to get feedback on the *Journal*. So far we've received about 100 responses and most readers have positive feedback, which is heartening. There's also some valuable suggestions for new styles of articles, particularly gear and equipment reviews, so I'll be reaching out to people about those. If you have something you'd like to write or read about, please let me know.

Alex Cooper

Failure Plane

I did not do a diligent enough job of checking photo credits in the last issue.

The photo of the Rogers Pass summit ponding area on page 21 of the Summer 2019 issue of *The Avalanche Journal* was taken by Jim Philips of Parks Canada, not Dynamic Avalanche Consulting as indicated.

In the article on Rick Schroeder on page 36, the headshot photo was taken by Melissa Saarinen, and the ski photo was by Mark Gallup.

I regret both of these mistakes and apologize to the photographers for not providing the proper credit despite them letting me use their work.

Growth and Change at the CAA

Krisitn Anthony-Malone, Operations Manager

THERE'S BIG STAFFING NEWS at CAA head office in Revelstoke. I want to welcome Andrea Lustenberger as the new Industry Training Program manager, Jess Landing in the membership services role, Emily Grady as our new ITP curriculum specialist, Meg Irving as ITP logistics and support, and Dru Petrosan as software developer. Many of these names may be familiar, but there have been some significant shifts in their roles.

The Industry Training Program has seen tremendous growth in the past decade and, in particular, the past two years. Given this growth and the continued demand for professional training, the CAA has restructured staff to ensure the best service to students, instructors, members and stakeholders.

As part of this restructuring, a new position has been created—the ITP curriculum specialist. Emily Grady, the current ITP manager, has taken on this role. Her decision to leave the manager role was not easy. She has been in the position for nearly 10 years and has poured her heart into maintaining and growing this world-class program. She has enjoyed the dynamic and challenging role but is ready to focus her energy on curriculum, guiding, and teaching for the program, as well as having a bit more time to spend with her two kids.

With Emily's departure from the manager role, we had big shoes to fill. After an extremely competitive hiring process we were fortunate to secure Andrea Lustenberger for the role. Andrea has been working with the CAA in membership services, and with HeliCat Canada for over four years. Before that she was a lodge manager for CMH. She is no stranger to our industry and we are extremely lucky to have her leading the ITP team.

With Andrea's departure from membership services, we had another vacancy. After another healthy competition, Jess Landing was chosen for the position. She has been with the CAA for about a year. She will soon be sinking her teeth into the member survey in hopes of understanding the membership and what she can do to help support you.

We then hired a replacement for Jess in the Industry Training Program logistics & support position and are happy to have Meg Irving join the team. Meg's work history centres on administrative support and community building. She most recently worked for Selkirk Tangiers Heli Skiing, understands our community, and will be an asset to the CAA.

In other staffing news, ITP Coordinator, Katherine (Kat) Dalman, will be on maternity leave by the end of November.

Transitions are also taking place in the CAA's IT department. Many CAA members and InfoEx users will have worked with IT manager Luke Norman, who left in early November. Luke and his wife (and dog) are taking a year to explore some of North America in their camper, starting with chasing powder this winter. Huge thanks are owed to Luke for many years of diligent work, mostly focussed on InfoEx.

Dru Petrosan has been hired as a software developer starting in November. He will work alongside current developer Ben Clark and InfoEx manager Stuart Smith as the CAA moves forward with the next development plans for InfoEx.

We are now fully staffed and operating in the new roles. With these shifts in staff roles, some new but many who have been with the CAA for years, I can't help but reflect on how proud I am to work for an organization that can retain employees by offering growth within the organization.

FROM LEFT: JESS LANDING, MEG IRVING, EMILY GRADY, ANDREA LUSTENBERGER, AND DRU PETROSAN ARE ALL ENTERING NEW ROLES WITH THE CAA // ALEX COOPER

Transitioning to a **Competency-Based Membership**

Kathy McKay, Professional Path Project Manager

YOU HAVE HEARD a lot about the CAA's work towards competency-based membership. Below, I describe the plan to roll out expected changes based on many meetings with the CAA board, staff, committees, and subject matter experts.

WORKING TOWARDS THE AGM - REVISING MEMBER NAMES AND GRANDFATHERING

As CAA President Walter Bruns notes in his report on page 8, new membership category names have been brought forward to better address what members do and signify the shift to the new requirements for new members. Officially, these categories cannot take effect until voted on by the membership in 2020, but for now it warrants clearly describing the direction the board endorsed for the project team and staff.

At the Spring 2020 AGM, the board will look for members to pass motions for bylaw changes that:

1. Grandfather all existing active members under the new title limited practice avalanche worker (LPAW).[1]
2. Grandfather all existing professional members under the new title avalanche professional (AP).[1]
3. Set forth new requirements to join these categories, and the dates when these changes come into effect .

TRANSITIONING TO FUTURE MEMBERSHIP REQUIREMENTS

The transition from the existing system of courses and application for membership will be a series of changes over time. The progression is designed to lessen the impact on those who need time to prepare for the changes, while also providing opportunities for members to embrace the new process early.

The first changes visible to members have already begun. The Avalanche Search & Rescue Advanced Skills course was developed to align with the competency profiles, and the online course Introduction to Avalanche Operations was launched in August. The online Introduction to Professionalism course for members and applicants is nearing completion, and the next cohort of students to take Avalanche Operations Level 1 will be the first to go through the version designed to align with the competency profiles.

The CAA will be offering an optional competency-based membership application process to applicants who wish to embrace the process early:

- Starting in December 2019, applicants for active membership may use the competency-based process;
- Starting in January 2020, professional applicants may use the competency-based process.

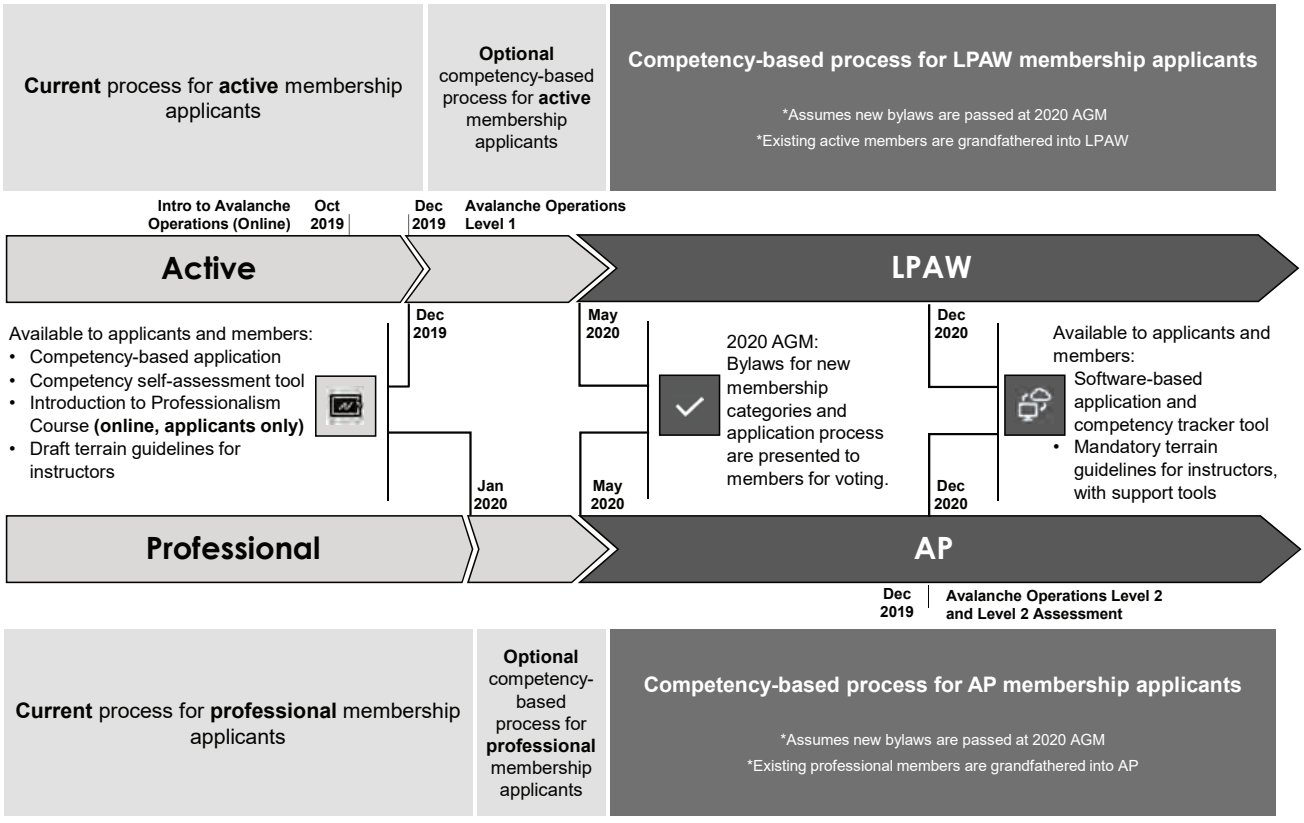
These options do not replace the existing membership requirements. The membership committee and staff reviewed the requirements and found the new ones are consistent with the minimum requirements of the current process, which applicants can still use until the AGM. The changes are explored in depth below.

This voluntary optional-use period will allow the CAA to fine tune the staffing, committee procedures, and workload before the new categories become standard following the AGM. It will also allow the volunteer applicants to get a jump start on assessing and developing their competency profiles. Details regarding incentives for volunteering will be provided shortly on the CAA's website.

Once the bylaw changes are passed, the new categories and requirements will become mandatory. At that time, all existing active and professional members will be grandfathered as LPAW and AP members respectively. Once the transition is complete, the CAA will work on completing the updated continuing professional development program to connect the CPD requirements and offerings to the competencies and establish ongoing competency requirements.

Please keep an eye on the CAA website for details about the new competency-based membership requirements, application process, and transition plan.

[1] Names for the new LPAW and AP Membership categories, previously referred to as Practitioner1 (P1) and Practitioner2 (P2), were voted on by the Board of Directors and are subject to change until approved by Members. The competency profiles for these categories are available via the members only portion of the CAA site.



THIS CHART OUTLINES THE PROCESS FOR EXISTING CAA MEMBERS TO TRANSITION INTO THE NEW COMPETENCY-BASED PROFILES.

NEW INDUSTRY TRAINING PROGRAM COURSES

The CAA Competency Aligned Avalanche Risk Assessment Training Project (CAARAT) is in its final year. The following courses are a result of the project and are available for enrolment as indicated:

- **Introduction to Avalanche Operations:** This online course is available to anyone and is a prerequisite for the new Avalanche Operations Level 1 course. It frees up time during the Level 1 course so more time can be spent applying the basic concepts in the field. It launched on August 6.
- **Avalanche Operations Level 1:** The revised course provides students with more quality learning in the field. It opened for registration September 4 and the first course starts December 7 at Keefer Lake Lodge.
- **Avalanche Operations Level 2 and Level 2 assessment:** The course is changing to two modules from three, and will include new student resource materials, including case studies, exercises, and reference material. Registration opens in October 2020 and the first course is in November 2020.
- **Introduction to Professionalism:** This online course allows individuals to fulfill the professionalism competency requirements needed to be a member of the CAA. It is designed to be taken by prospective members who have successfully completed the Avalanche Operations Level 1 course and is likely to become a CPD requirement for all members. It becomes available to applicants volunteering to use the competency-based process in December. It will be available to all members once the new bylaws have passed at the 2020 AGM.

It is understood some applicants will have taken the old Avalanche Operations Level 1 and Level 2 courses. Since the new courses are designed to ensure coverage of specific competencies, applicants who took one of the previous courses may be asked to provide supplemental information to demonstrate all competency requirements are met.

OPTIONAL APPLICATION PROCESS (PRE-AGM)

Starting in December, active and professional member applicants will be able to voluntarily use the new competency-based application process. Alternatively, they can continue using the existing process. Members who opt to use the competency-based process at this time will be granted active or professional member status if they are successful.

The following components will be required when using the voluntary process, and further details will be available online to help guide applicants:

Active member competency-based application requirements:

- Avalanche Operations Level 1 (both the new and old courses will be accepted);
- Introduction to Professionalism;
- A workplace portfolio that includes a description of the applicant's current avalanche-related roles and responsibilities, as well as descriptions of experiences that prove they are proficient in the required competencies. Evidence for each experience and related competency is required. When evidence cannot be obtained, testimonial by an authority on the subject will be accepted. Templates will be available for completing each portfolio component.
- Reference from one professional member.

Professional member competency-based application requirements:

- Avalanche Operations Level 2 modules 1, 2 and 3 (the new level 2 courses will not be offered until December 2020);
- Introduction to Professionalism;
- A workplace portfolio that includes a description of the applicant's current avalanche-related roles and responsibilities, as well as descriptions of experiences that prove they are proficient at the required competencies. Evidence for each experience and related competency is also required. When evidence cannot be obtained, testimonial by an authority on the subject will be accepted. Templates will be available for completing each portfolio component.
- References from two professional members.

COMPETENCY SELF-ASSESSMENT AND TRACKING TOOLS

In December 2019, the CAA will provide existing members with a spreadsheet tool to rate their individual competencies and describe how/why this rating applies. Completing this exercise is not mandatory, but it is highly recommended for an individual's own professional development. Using the tool will help members get a feel for their current proficiency levels compared to the new membership application requirements. Tentatively, in December 2020, this tool will be offered online and existing entries can be transferred over. By tracking their competencies over time, members can more easily identify their strengths and weaknesses, and determine where they need to focus their CPD or work experience. As the new CPD program emerges, members who have proactively worked with the self-assessment tool will be a step ahead when it comes to adapting to future CPD requirements.

TERRAIN GUIDELINES FOR INSTRUCTORS

The competency profiles reference new CAA Guidelines for "delivering avalanche instruction to recreationalists and workers." The CAA plans to release the initial draft version of these guidelines in December. Then, in the 2020-21 season, a finalized version of the guidelines will be made available and following the guidelines will become mandatory when instructing in avalanche terrain. At that time, the CAA will also begin to make tools available to help members adhere to the guidelines. For more, see the article on the next page.

NEW MEMBERSHIP CATEGORIES AND APPLICATION PROCESSES (POST-AGM)

Contingent on approval by members at the 2020 AGM, the revised bylaws detailing the new membership categories (LPAW and AP) and the associated requirements and application processes will become standard. As explained above, basic templates and tools will be used until December 2020, when they will begin to be replaced by online software tools. These initial tools will allow the CAA to respond to member needs before committing to full-fledged software programs. The ultimate goal is to provide a system that allows applicants and existing members to track their work and competencies over time, allowing these individuals to demonstrate their abilities and achievements to both the CAA and potentially external audiences, such as employers, at the member's discretion.

Update on Terrain Guidelines for Instructors

Brendan Martland, Subject Matter Expert

TEACHING IS AN IMPORTANT ROLE of many CAA members. Whether it's co-instructing an AST 1 course, educating workers in avalanche safety, or teaching in the ITP program, a large number of our members are instructors.

Course instruction in the field requires diligent planning and a predetermined safety net to provide a safe and successful outing. As the CAA has developed its competency profiles, it has recognized there's a need to incorporate field education into these competencies. As we have developed our terrain competencies, we have also created terrain guidelines for instructors.

These guidelines apply to all levels of field education that CAA members might offer, from introductory recreation field education such as AST 1 to advanced professional training such as Avalanche Operations Level 2. This article offers a brief background and update on these guidelines, which are nearing completion of the first draft.

In the interests of promoting public safety and defining industry best practices, the CAA undertook to create terrain guidelines to ensure instructors are working within their competencies and staying within terrain appropriate to their individual education and experience levels. The guidelines are being created to enable avalanche instructors to meet a crucial need – helping students acquire skills in avalanche terrain while ensuring CAA members do so as safely as possible.

The CAA board envisions these guidelines becoming a requirement for the 2020-21 season for members of the CAA who wish to instruct in avalanche terrain. There will be some changes and adjustments for current instructors, but the goal is to enable them to continue instructing without onerous requirements to their teaching programs. The best practices set forth in the guidelines will be practicable for both individuals and organizations providing field-based avalanche education. Planners, directors, boards, managers, operators, and others who support practitioners delivering avalanche education should find the guidelines accessible, allowing larger programs to readily adapt to the best practices described within them.

For active members, there will be clear restrictions for terrain use (such as traveling in simple ATES-rated terrain only) and work condition requirements (such as operating under a risk management plan, such as an ASP). For professional members, there will be a requirement to provide evidence of key competencies, such as leading groups safely through avalanche terrain. This might include uploading photos of field book entries, route plans, and sign-off by a mentor who was overseeing the outings. Restrictions will include undertaking field trips in areas where there is a firm working knowledge of terrain features, snow climate, slope history, and current avalanche conditions. Glacier travel will likely not be permitted unless members are certified by an external regulating body that provides specific training in these areas such as the ACMG.

NEW REQUIREMENTS MEAN NEW TOOLS

As members face new requirements, the CAA also recognizes these changes come with a certain amount of anxiety. To address this, we are developing a clear road map to help members understand the changes, and new tools to help members adapt to the guidelines. We believe these tools will allow instructors or organizations to address the guidelines with modest effort.

Addressing these guidelines evokes a number of touchy subjects that concern CAA members and our stakeholders: distinguishing between guiding and instruction; ensuring that guidelines are meaningful, but do not disrupt successful instructional programs that have taught thousands of students without incident. We intend to offer a phased process that allows members to review the guidelines:

- The first draft will be shared with members in early winter 2019-20.
- A trial period will begin where feedback and further input is collected from all affected parties.
- Implementation is scheduled for 2020-21 to allow members and stakeholders ample time to adjust their current practices to meet the guidelines.

Meetings and conversations will continue with key stakeholders as the first draft nears completion. Stakeholders include Avalanche Canada, the ACMG, CAA ITP managers, Parks Canada, and others. Many other groups, such as the Ethics & Standards Committee, will be providing input to ensure the guidelines are reasonable, attainable, clear, and in the best interests of both CAA members and the public.

By having clear parameters for following best practices for instruction in avalanche terrain, the CAA will continue its commitment to enabling a community of avalanche practitioners that the Canadian public and workforce have come to respect and trust. We look forward to providing you more updates in the monthly member newsletter and *The Avalanche Journal*.

Contributors

AJ MAHEU
André-Jean divides his time between ski areas, search and rescue and industrial avalanche work. He has been the avalanche forecaster for Grouse Mountain since 2010. He also works as an avalanche technician for Alpine Solutions Avalanche Services and as a part-time ski patroller on Whistler mountain. He is one of four volunteer avalanche forecasters for North Shore Rescue.
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STEVE CONGER
Steve has been a contributor to the avalanche community beginning with the creation of the first snow crystal card and companion waterproof field book specifically for recording snow profile observations. A graduate of the UBC Avalanche Research Group, he continues to facilitate the innovation, integration, and use of technology such as automated weather systems and the blade hardness gauge. Steve serves on the CAA ethics & standards and education committees.
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BRUCE JAMIESON
Bruce started hauling toboggans and working on the avalanche forecasting and control team at the Fernie ski area in 1980. After six winters with two ski areas, he started graduate studies at the University of Calgary, focusing on field studies of avalanches including snowpack tests. As a professor from 1997 to 2015 and research chair, Bruce managed field studies of snow and avalanches. Now, when not sliding on snow or riding a two-wheeler on dirt trails, he works as an avalanche consultant and educator.
30 THE RISK OF SKI CUTTING

CHRIS BREMER AND SEAN ZIMMERMAN-WALL
Chris is a Colorado School of Mines graduate (BS Engineering, '03). Now, he is Snowbird's snow safety supervisor and enjoys product testing pre-public. Sean is consistently striving to improve his operational awareness by working for various entities such as Snowbird ski patrol, Snowbird Backcountry Guides, and Patagonia Ski Tours. He also serves as a pro program manager for AIARE and is a board trustee of the American Avalanche Association.
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STAN NOWAK
Stan is a PhD student at Simon Fraser University studying visual analytics. Having an academic background in cognitive psychology, a professional background in visual analytics, and a passion for backcountry skiing, Stan naturally took to developing visualization tools for the avalanche community. His research is focused on the development of visual analytics systems that address uncertainty and ambiguity in avalanche forecasting and other complex analysis domains.
34 WHAT CAN VISUAL ANALYTICS DO FOR AVALANCHE FORECASTING?

SCOTT THUMLERT
Scott is an engineer and ski guide currently working with Alpine Solutions and for Canadian Mountain Holidays. Previously, he dug a lot of square holes for the Applied Snow and Avalanche Research University of Calgary (ASARC) and was thoroughly confused during a post-doc program learning 'for loops' at the Simon Fraser Avalanche Research Program (SARP).
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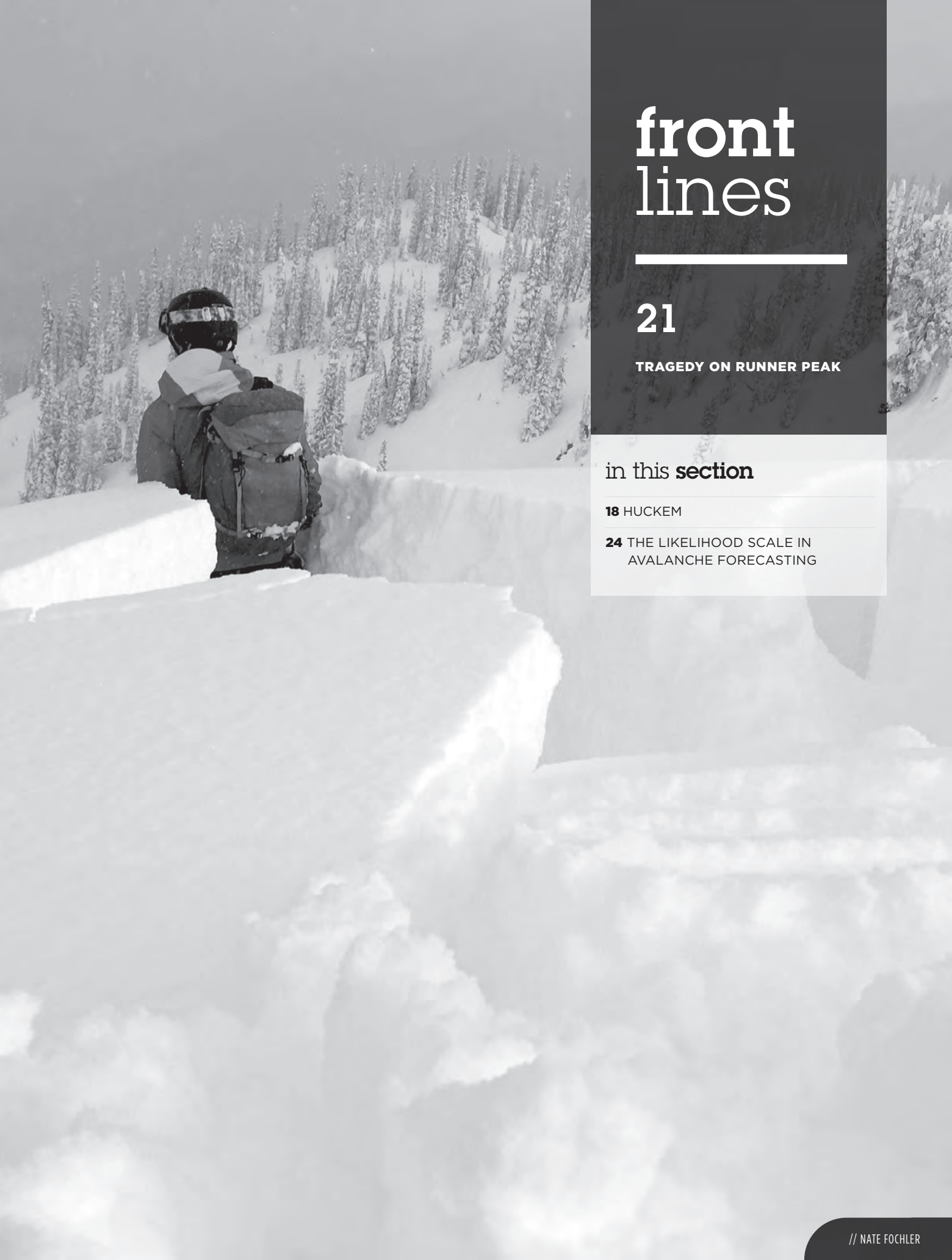

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HUCK EM

Steve Conger

PICTURE YOURSELF sitting in a row of winter enthusiasts listening intently in an avalanche awareness class or a continuing professional development course. Look left and right in your row. It would be pretty easy to go ski touring with someone sitting next to you. You know them. Take a look and think about their qualifications. You know how good you're going to feel getting out there and how easy it will be to communicate.

Now look at your whole row. You're out there skiing in that big group, with a really big set of qualifications and experience, along with what you know about each person. Are you going to have a morning meeting before you go out? How is the tour going to unfold?

This exact situation occurred in January 2019 when a group of eight planned a ski tour where they were very familiar with both the terrain and each other. The planning consisted of, "We're doing the Z circuit, who's going?"

Nearly every letter in the acronym FACETS (Familiarity, Acceptance, Consistency, Expert halo, Tracks/scarcity, Social facilitation[1]) came in play on that day. The group splintered in the field with everyone still going the same way, just spread out a bit and not traveling cohesively. The group converged at the base of the crux. There was some conversation before going up the slope, such as sharing of pit results and some other info. However, the decision-making was tacit versus explicit. More importantly, not all group members expressed doubts or concerns. The decision to go was more or less finalized by one person taking the lead, with no discussion of the best route up. The decision to go one at a time (a good one) was essentially from experience rather than discussion.

The feature was visually homogenous; however, as the trailbreaker shuffled from the steeper slope at the convexity, a slab released at the tail of their skis at a thin spot where the wind slab had been scoured (arrow top center of photo). The ensuing avalanche was two metres deep on climber's left (the side where the group was waiting below) and a metre deep on the right. It was a healthy size 2.5 that could have been a size three with a real track rather than a profile like a hockey stick, and it covered part of the up-track.

This commentary expands on "acceptable uncertainty," which I described in an article for *The Avalanche Journal* in 2016[2]. In summary, during avalanche risk management, first we acknowledge uncertainty's presence, then we reduce it by changing the hazard with explosives, changing our exposure in space and/or time, or changing the objective to one unaffected by the uncertainties. The final steps include

// SAUL GREENBERG

communicating the irreducible uncertainty and embedding it in decisions.

This is where the personally applied risk assessment question of "Is the uncertainty acceptable?" comes into play. It is the final filter before acting. Asking the question as part of on-site decisions will help limit treacherous biases associated with the affect heuristic. It goes a long way towards removing the ego and emotion from the decision process.

So, how do you start the conversation with the people in your row when you are out ski touring? Can this all too common group dynamic be alleviated in a manner that leads to better backcountry decisions?

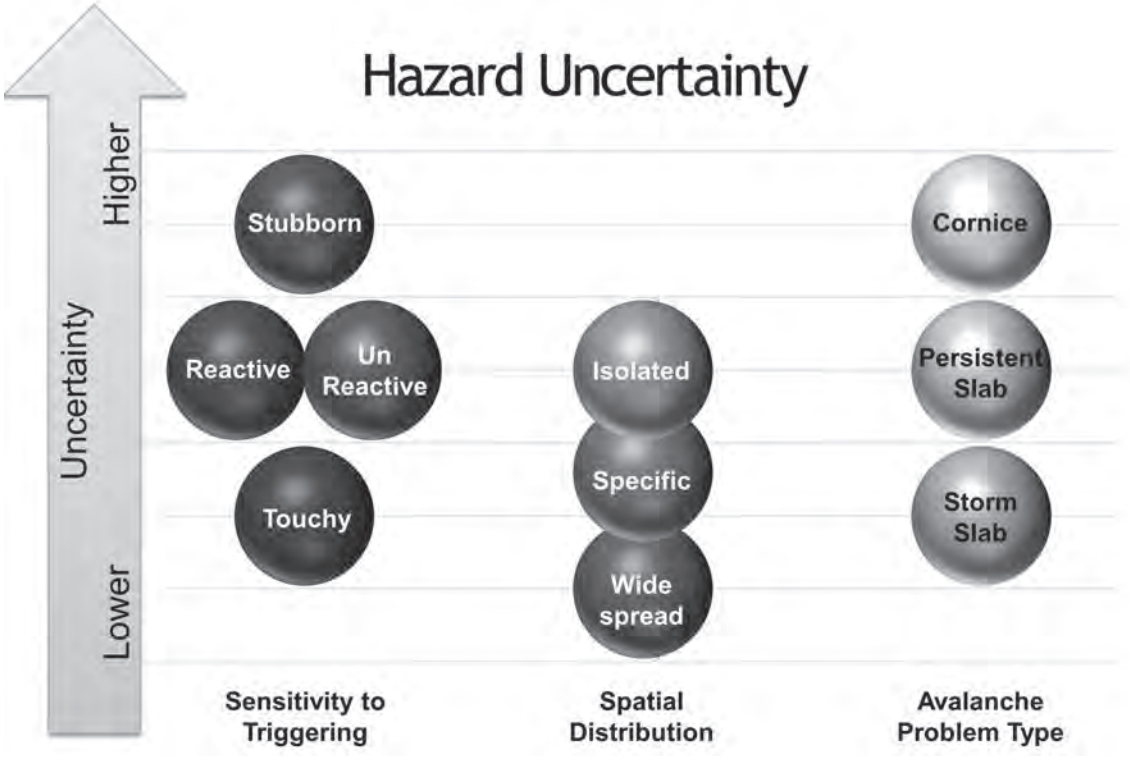
A survey of recent literature revealed a suggestion by Swiss researcher Benjamin Zweifel. He outlined the parameters for a group process and decision-check tool at ISSW 2014 stating: "…such a tool has to be simple enough to be practicable in real life situations with limited time and limited capacity of individuals…"[3] He utilized an acronym to provide a mnemonic for a six-element guidance matrix. Though not ideal for facilitating field discussion, it is an excellent instructional tool for recreationists learning a framework to assemble and operate as a group.

For the all too common situation described in the opening paragraph, a group check tool must be **friendly**, **effective**, and **memorable**.

HUCKEM is a prompt, a stimulus for a structured discussion in an informal moment. It can be employed by novice and expert alike. It is a holistic way to address what Roger Atkins suggested when he wrote about how it is important to create motivational bias towards actions that fit the situation. It captures the axiom that increased uncertainty increases risk. Though each letter represents a word that we could spend a lot of time talking about individually, they combine into three two-letter concepts: **H**azard **U**ncertainty, **C**ollaborative **K**nowledge, and **E**xchanged **M**indset.

HAZARD UNCERTAINTY elicits thought to what component of hazard has the most uncertainty associated with it. We have an extremely useful framework in the Conceptual Model of Avalanche Hazard[4] that segregates key contributory components: avalanche problem type, location, sensitivity to triggering, spatial distribution, and destructive size. There are inherent uncertainties associated with many of the different value descriptors for each of these components:

- Sensitivity to triggering is informed by test results. Sensitivity values that are *reactive* or *unreactive* are on a similar level of uncertainty theoretically (illustrated in the hazard uncertainty image below). When conditions or results are *touchy*, uncertainty is typically much lower. Stubborn (and planar) test results leave the observer with the highest uncertainty.



- The spatial distribution of an avalanche problem often contributes to hazard uncertainty. Increased uncertainty may be present when evidence is spotty and found in only a few features, i.e. *isolated*. Evidence that is rare, hard to find, and not limited to specific features should be regarded as higher uncertainty.
- Some avalanche problems types are associated with higher hazard uncertainty than others. The hazard uncertainty often increases as expected destructive size increases (*e.g.* 30cm versus 50cm persistent slab or "what may lead to release in that 75cm storm slab?").

Identifying which component of the hazard has higher uncertainty helps keep the perspective focused on where there needs to be the largest margin for error. HU is a prompt for quick focus and prioritization whether sensitivity, distribution, problem type, size, or location has higher uncertainty. There's nothing new here – when one is unsure about hazard, one chooses to dramatically reduce or nullify exposure within or to terrain that potentially harbors the hazardous conditions in a manner that avoids consequence if it's more sensitive, widespread, or larger than expected.

COLLABORATIVE KNOWLEDGE ties the HU to the EM. Collaborative knowledge means everyone in the group is expected to contribute in the hazard discussion and mindset exchange. This does not have to be elaborate, just a quick expression using a CLEAR (Concise, Logical, Explicit, Ambiguity-free, and Resonating[5]) style of communication. Collaborative decisions are a core of the Canadian avalanche risk management framework. One finds them in our operational meeting format, our terrain coding guidelines, and our workplace expectations. Collaborative decisions are consistently better than individual ones. No individual is given the expert halo; no one individual sets the objective.

EXCHANGED MINDSET completes the picture, a necessary conclusion to the process. The concept of an avalanche strategic mindset[6] has permeated our culture thanks to its practicality and relevance as a shorthand method to communicate. Exchanged mindset means each individual states their current strategic mindset using either the operational or the recreational model[7] (e.g. open season versus freeride). Exchanging mindsets is a great way to understand how each individual is viewing the situation. It ensures an acknowledgement and/or clarification of each other's ideas on moving forward. Simply put, we cannot HUCKEM as a group unless everyone is on the same page. Embedded in the standardized list of mindsets is an anticipated risk management strategy.

There are just the three points (HU-CK-EM) to drive a quick, explicit, and systematic discussion amongst peers. To keep it effective, we do not want to stand around for any noticeable amount of time. Try it. Just look down your row, side up to your partner, pause at key decision points, and kindly ask, "Dude, can we HUCKEM?"

Returning to the January 2019 ski touring situation, any one of the group could have asked it over breakfast and anyone could have asked it to refocus the group at the crux.

Thank you to Lynne Wolfe, Tannis Dakin, Saul Greenberg, and Markus Ebner for their proofing and suggestions.

[1] McCammon, I. 2004, Heuristic Traps in Recreational Avalanche Accidents: Evidence & Implications, Avalanche News, v68.

[2] Conger, S., 2016, Acceptable Uncertainty, The Avalanche Journal, v114, Winter 2016-17

[3] Zweifel, B. 2014, SOCIAL – A Group Check Tool, Proceedings ISSW2014 Banff.

[4] Statham, G., Haegeli, P., Greene, E. et al., 2018, A Conceptual Model of Avalanche Hazard, Natural Hazards, v90-2.

[5] Bischoff, N. and Eppler, M. 2010, Caring for Clarity in Knowledge Communication, Journal of Computer Science, v17-10.

[6] Atkins, R. 2014, Ying, Yang, and You, Proceedings ISSW2014 Banff.

[7] Atkins, R. 2015. Strategic Mindsets, The Avalanche Journal, v109, Spring 2015.

Tragedy on **Runner Peak**

ON FEB 18, 2019, A SNOWSHOER DIED IN AN AVALANCHE ON RUNNER PEAK IN THE NORTH SHORE MOUNTAINS. FORECASTER AND RESCUER ANDRE-JEAN MAHEU REFLECTS ON THE INCIDENT AND THE UNUSUAL SNOW CONDITIONS LEADING UP TO IT.

Andre-Jean Maheu

EVEN OVER THE PHONE, there was something unmistakably urgent in Doug Reid's voice.

"There's been an avalanche!" he said. "Can you come to Seymour right now?"

"Sure thing," I replied. "What do we know?"

"Not much at this point," he answered. "The call came in to the RCMP at 09:57 from one of the subjects. They are on Runner Peak. Two snowshoers. One is out of sight and the one who called is clinging to a tree on steep hard ice in the middle of the slope. I don't think they have transceivers on"

"OK. I'm leaving Squamish right now. I'll be there in an hour."

The drive provided me with time to analyze the situation. It was Monday, Feb. 18, and only two hours earlier I had issued a forecast for North Shore Rescue (NSR) calling the hazard low at all elevations.

THE SNOWPACK

The North Shore Mountains are a small patch of steep mountains framed by Indian Arm to the east, Burrard Inlet to the south and Howe Sound to the west. They are part of what is referred to as the inlet zone of the Coast Range. They present a textbook maritime snowpack characterized by heavy precipitation and mild temperatures. Avalanche cycles are frequent but are generally short-lived, direct-action storm slabs that settle rapidly, or wet loose activity. Crusts are frequent but rarely cause too much trouble. Persistent weak layers are almost unheard of. Almost…

Despite my low rating, I wasn't entirely surprised by the report. In fact, I felt I knew exactly what had happened as soon as I heard the words "steep hard ice." It all started with some unusual weather two weeks before.

On February 1 and 2 we received 37 mm of rain. This was followed by sudden cooling and 7 cm of low-density snow on Feb. 3. From Feb. 5-9 it got unusually cold with lows down to -15 C and winds from the southeast. This caused faceting and redistribution of the snow sitting on the crust. From Feb. 10-14, this facet layer was progressively buried with daily snowfalls of 9, 12, 5, 14 and 1 centimetre, all low density with only dry loose activity, and excellent skiing throughout the period.

On Friday, Feb. 15, a big coastal storm dumped 39 cm of wet snow. While conducting avalanche control on nearby Grouse Mountain, ski cutting produced touchy but small soft slab results in the top 20 cm. It was a typical North Shore cycle until one result got my attention.

Standing on a cat track, I eyed a 30-degree planar open glade. I knew it was an infrequent performer, but I'd seen it go on especially touchy days. Out of curiosity, I gave it a gentle kick. It immediately broke 70 cm down and the fracture propagated 100 metres! The facet layer on the Feb. 3 crust was lighting up. This was so unusual for the North Shore that, in addition to my InfoEx entry, I uploaded a report to the Mountain Information Network to provide an immediate heads up to the community. As the storm continued, we lapped our terrain, only kicking off the new snow.

And then, nothing.

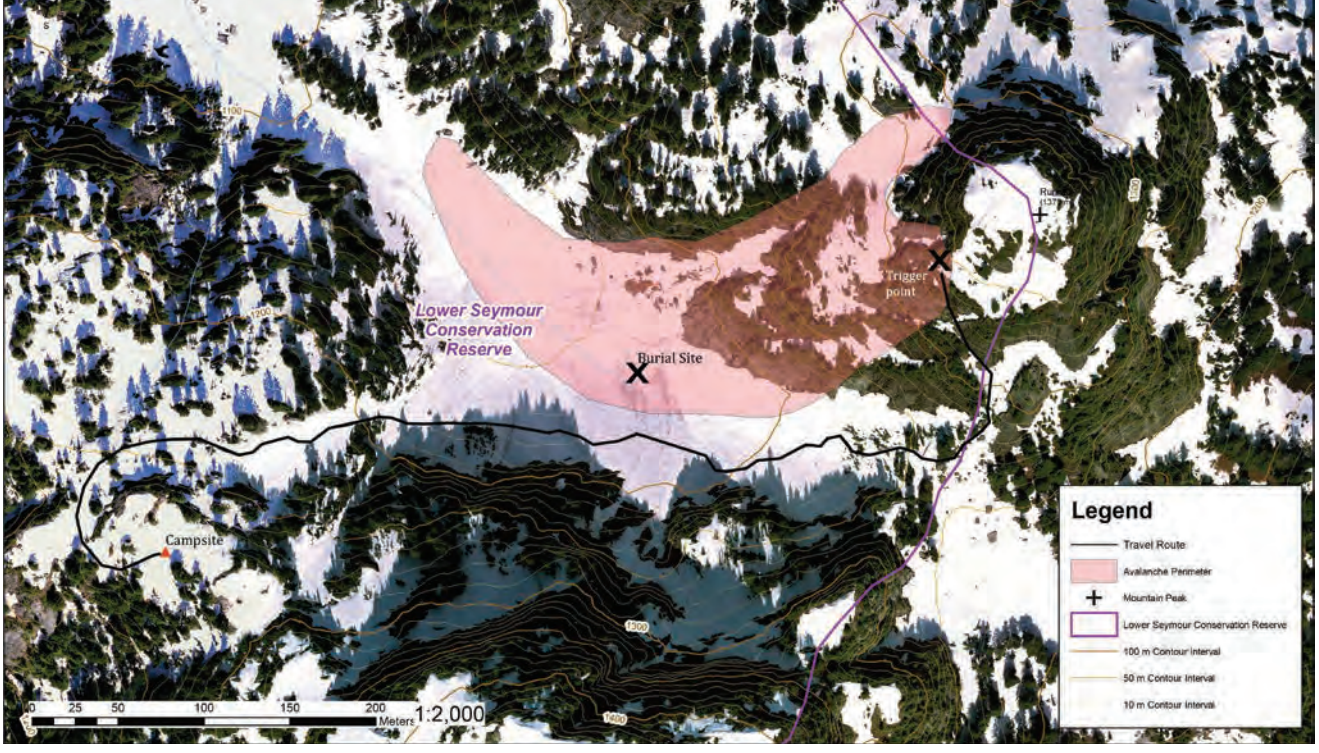
The weekend was sunny with heavy skier traffic and plenty of solar radiation melting the surface snow. Entries on the MIN reported whumpfing, shooting cracks, easy hand shears and numerous small natural and human-triggered avalanches, but no activity on the Feb. 3 crust despite aggressive terrain use and warm, sunny weather.

RESCUE & RECOVERY

As I arrived at the Seymour SAR station, a helicopter was already in the air, but terrible visibility and marginal flying conditions prevented them from getting a visual on the subjects. The team reported numerous crowns between 20-30 cm on all aspects; I knew most were about 48 hours old. Unable to fly in, three of us decided to ski across the three peaks of Mount Seymour in zero visibility to try to reach Runner Peak. I briefed my teammates on what I knew about the snowpack.

As we set off towards the subjects around 12:30 p.m., I knew we had to be cautious. This facet layer was very unusual for our region and outside my usual frame of reference. Was my forecast accurate or did I allow familiarity to cloud my judgement? Seeing the same fairly predictable pattern repeat itself storm after storm for 12 years weighs heavy.

"39cm of wet shmoo followed by a sunny and warm weekend with hundreds of people going after it ought to have squished down any flimsy, low-density facet layer. This is the North Shore – give it 24 hours and you're good to go."



AN AERIAL OVERVIEW OF THE AVALANCHE SITE. THE VICTIMS' CAMPSITE IS MARKED IN THE LOWER LEFT. THE BLACK LINE SHOWS THEIR TRACK TO WHERE THE AVALANCHE WAS TRIGGERED. THE EXTENT OF THE AVALANCHE IS IN RED AND THE BURIAL SITE OF THE DECEASED IS MARKED BY AN X NEAR THE CENTRE OF THE IMAGE.

Needless to say, I was second guessing my low rating. If my suspicion was right and the subject standing on steep hard ice was on the Feb. 3 crust, then clearly the facets were still lurking. As we reached treeline, the uncertainty became more and more difficult to bear. Three kilometres of complex terrain in whiteout conditions separated us from two guys who desperately needed us to navigate it safely.

As we tiptoed through thick fog, we could hear the helicopter still trying to reach the site. After an hour we ended up on Tim Jones Peak with a sizeable west-facing slope to cross. My scary ski cut three days prior was on a west aspect and, due to the southeast winds a week ago, I considered this orientation to be especially suspicious. In the flat light, it was difficult to tell how big and steep the slope was or if it had already slid. Pole probing told us everything we needed to know. Any resistance suddenly vanished 70 cm down and our poles dropped 10 cm before hitting the unmistakable crust.

I made the crushing decision to stand down. The only reason I wanted to cross that slope was to reach the subjects, but the snow doesn't care. All we could hope was the clearing skies forecasted would materialize soon. Meanwhile, two CARDA teams from Whistler arrived and I contacted Grouse Mountain patrol to deliver explosives, thinking they might prove useful.

The weather models didn't disappoint. By 2:30 p.m. there were breaks in the clouds – enough to get a visual of the scene and a better understanding of what had happened.

The two subjects had camped on Mount Seymour. That morning, they set off to climb Runner Peak. From the Seymour/Runner col the route normally ascends the south ridge of Runner Peak, but they strayed onto the steep west face, likely due to the poor visibility. They were probably 50-75 metres apart when the leader triggered a size 2.5 avalanche on the Feb. 3 crust. The first subject was caught and fully buried in the runout zone while the second, who was at the edge of the slab, managed to grab a tree.

From the air, it was obvious there was significant hang fire and no safe way to access either subject. Conditions, while improving, were still not favorable for a long-line extraction. With the weather expected to deteriorate in the evening, a decision was reluctantly made to insert two HEC-trained members on the summit with the risk of triggering the hang fire. A second helicopter hovered over the face to provide support. Large settlements were felt as the pair tried, unsuccessfully, to reach the subject with a rope.

Fortunately, by 3:30 p.m., the clouds had lifted enough to retrieve the HEC members and proceed with a long-line extraction. With precious little daylight remaining, we switched focus to the buried victim. A helicopter with a RECCO detector scanned the debris without results. Explosives were deployed by helicopter to manage the hang fire but didn't produce the results we wished for, triggering only one size 1 on a total of six shots. Nevertheless, the CARDA teams were comfortable to move in and performed a quick, unsuccessful scan of the debris before darkness.

Tuesday came with the very difficult task of trying to support the family of the missing person during the excruciating hours of waiting while low clouds made it impossible to access the scene.

Wednesday dawned crystal clear and a plan quickly emerged. We needed to act fast to avoid being exposed to the overhead hazard as the temperature rose. A support team was flown to the subjects' campsite, where the entire slide path was visible. Two CARDA teams assisted by four others were flown onto the debris. With no indications from the dogs, the subject was finally located under 1.2 metres of snow after 1.5 hours of spot probing. The cause of death was estimated to be trauma.

REFLECTIONS

As we debriefed days later, an NSR member asked me, "How could we have gotten the hazard rating so wrong?" I appreciated his politeness for using "we" while he probably meant "you." I mumbled something about familiarity bias, unusual weather, and facets. In hindsight, I'm not sure we were that far off the mark. While my low rating was certainly tainted by familiarity and overly aggressive, Avalanche Canada's moderate rating might have been spot on.

Of course, it's difficult not to attribute a lot of weight to a salient event such as a fatal accident, but it's always good to go back to the definitions. Moderate is defined as: *"Heightened avalanche conditions on specific terrain features. Evaluate snow and terrain carefully; identify features of concern. Natural avalanches unlikely; human-triggered avalanches possible. Small avalanches in specific areas; or large avalanches in isolated areas."*

Hindsight allows us to see how the snowpack actually behaved under stress. We know, past the initial activity on the Friday and Saturday before the accident, heavy user traffic and solar radiation on the Sunday produced minimal avalanche activity. While Avalanche Canada increased the rating to considerable following the accident, aggressive terrain use and intense sun did not lead to an increase in reported avalanche activity. Under these conditions, it seemed appropriate to set the likelihood at possible and estimate the Feb. 3 layer could only be triggered in isolated areas. What made this moderate special was the unusualness of the problem for the region. It's a good reminder; moderate is still pretty serious.

ACKNOWLEDGEMENT

This difficult operation came together thanks to a large group of exceptionally skilled, dedicated, and experienced individuals too numerous to name here. I wish to recognize their roles through their respective agencies: North Shore Rescue, Grouse Mountain, Mount Seymour and Whistler-Blackcomb ski patrols, CARDA, RCMP Police Dogs Services, Talon Helicopters, Blackcomb Helicopters, BC Parks, Victims Services of BC, and BC Coroner Services.

FORECASTER'S PERSPECTIVE

Following this tragedy, Avalanche Canada raised the avalanche danger to considerable from moderate for the South Coast region. We asked James Floyer, Avalanche Canada's forecasting program supervisor, to provide his perspective on the forecasting challenges presented by this incident.

TRAGEDIES LIKE THIS always come as a surprise – to the victims, their friends, their families, and to the wider mountain community. Given the avalanche danger was rated moderate and it had been three days since the last major snowfall in a region where the snow generally heals fast, this was an even more surprising incident than usual.

Building mental models of snowpack structure is an integral step in assessing avalanche conditions. Professionals – indeed recreationists also – have to make assumptions about how stable or unstable the snow is across a range of terrain since it is impossible to make observations everywhere. We extrapolate from known data points and estimate based on our experience from weather inputs when observations are limited.

Sometimes when new evidence comes to light it adjusts our thinking and changes our perceptions of the nature of the avalanche hazard. The fatal incident on Runner Peak and subsequent snowpack testing by search and rescue members was a case where this happened. Prior to the incident, Avalanche Canada's forecasters had assumed danger was on a decreasing trend. We had been through an active avalanche cycle, and the available data indicated avalanches were becoming harder to trigger. As a result, we had lowered the avalanche danger to moderate.

Immediately after the incident, we brought the avalanche danger back up to considerable, a level which indicates human-triggered avalanches are likely. Was this reactionary, or a case of responding to new evidence that had come to light?

These calls can be hard to make and the truth is there isn't always a right answer. In the area close to the incident, there is no doubt the snowpack was in a state where human triggering was likely. However, in the northern part of the region, significantly less snow had fallen and avalanches were not being triggered by people. Regional variability often brings up dilemmas about how to best describe danger over a wide area with a single set of ratings. But I accept in this case we were also dealing with a data availability bias.

Around the time of the incident, our primary data came from two main sources: recreational users from the north of the region, where I already noted there was less snow, and from local ski resorts, where the snowpack is frequently modified by compaction. Until we were alerted to this tragic incident, observations from the North Shore backcountry in the area near where the pair were caught were limited. We knew there could be elevated danger based on our knowledge of the physical snowpack processes but we favoured the evidence from areas with the most information, which in this case, may not have been the most relevant to the problem at hand.

Avalanche Canada is working on initiatives to improve our assessment and communication of regional variability. While you probably won't see big changes this winter, our new AvID software will be capable of serving sub-regional information in the future. We are actively working with researchers to help address important communications questions. And we are working to include advanced snowpack modelling in our forecasting process, which we hope will allow a more objective assessment of snowpack stability and help reduce some of the data availability biases we struggle with daily.

The Likelihood Scale in Avalanche Forecasting

Scott Thumlert[1], Grant Statham[2], Bruce Jamieson[3]
[1] Alpine Solutions and Canadian Mountain Holidays - corresponding author , [2] Parks Canada and Alpine Specialists, [3] Snowline Associates Ltd.

"EVEN IF AVALANCHE FORECASTING IS PROBABILISTIC AND INCLUDES UNCERTAINTY, IT SHOULD BE GROUNDED IN CLEAR DEFINITIONS, AND UNCERTAINTY SHOULD NOT STEM FROM NEBULOUS TERMS BUT THE NATURE OF THE PROBLEM." – JÜRG SCHWEIZER (SCHWEIZER ET AL., 2019).

TWO YEARS AGO, nine of us gathered before breakfast to plan for the day of helicopter skiing ahead. We aimed to talk about the weather, flying conditions, avalanche hazard, and the run list, except there was an argument about the avalanche hazard forecast. Specifically, what likelihood term should be used to assess the persistent slab problem for the day: "possible" or "unlikely."

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

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

AVALANCHE PRACTITIONER SURVEY

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

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

DISCUSSION OF SURVEY

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

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

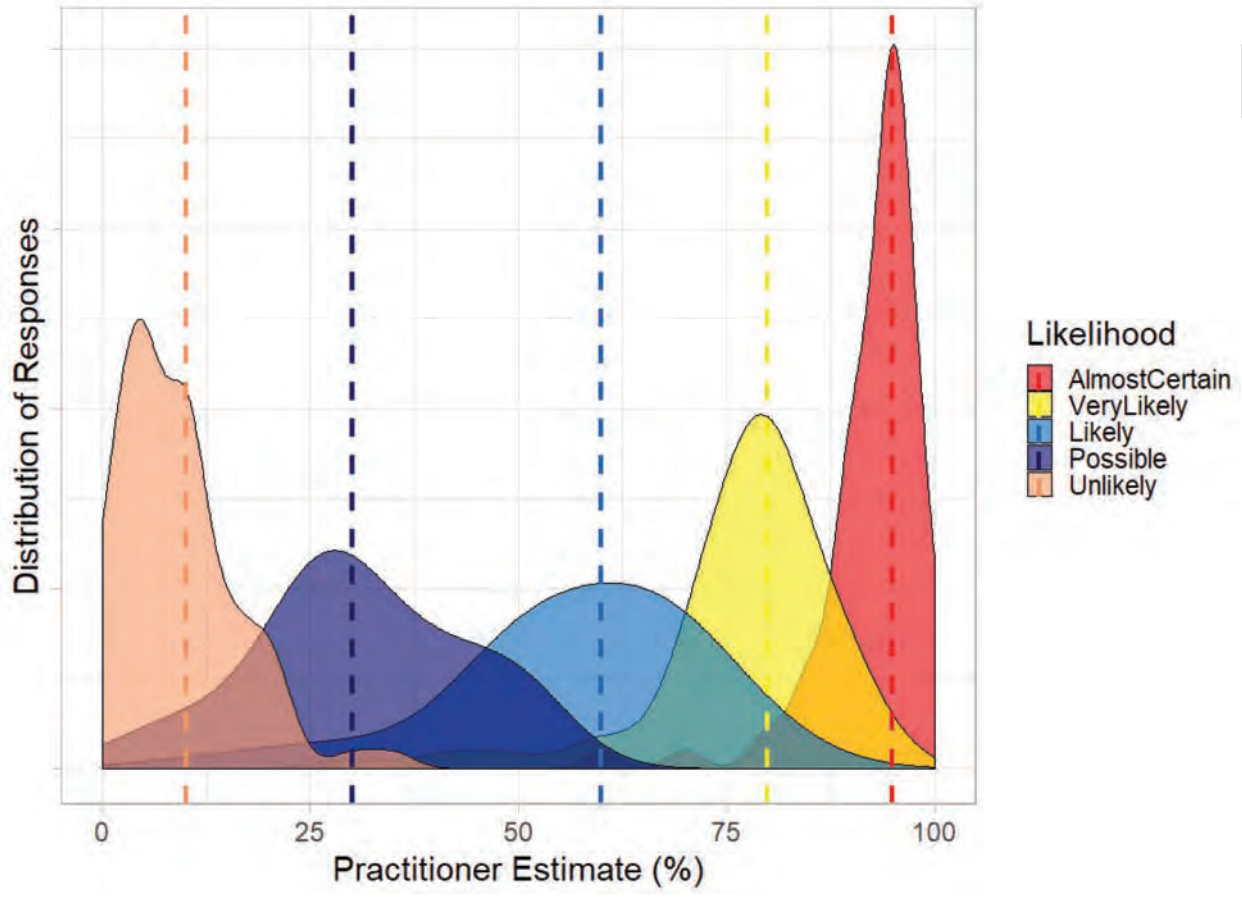


FIG. 1: PROBABILITY INTERPRETATIONS FROM PROFESSIONAL AVALANCHE WORKERS ASSOCIATED WITH WORDS USED TO FORECAST THE *LIKELIHOOD OF AVALANCHE(S)* (CMAH), WITH MEDIAN VALUES SHOWN AS DASHED LINES.

Discrepancy between interpretations of likelihood expressions has been shown to create communication problems (Fischer and Jungermann, 1996). It can reduce forecasting accuracy (e.g. Rapoport et al., 1990) and ultimately compromise decision making (Friedman et al., 2018). In a classic example, in 1961 during the Cold War, John F. Kennedy asked his Joint Chiefs of Staff to evaluate the planned Bay of Pigs invasion. They assessed the probability of success to be about 30% and communicated that as, "The plan has a fair chance of success." Kennedy interpreted "fair chance" as favourable odds and approved the operation, which ended in stunning defeat. The Joint Chiefs later reported, *"We thought that other people would think 'fair chance' would mean 'not too good.'"* The varying interpretations of "fair chance" was the key misunderstanding of the entire project (Wyden, 1979).

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

STRATEGIES

Can we incorporate strategies developed by other industries to help with risk communication and forecasting for avalanches?

First, we have to make some underlying assumptions:

1. Natural or human-triggered avalanches are relatively rare. Jamieson et al. (2009) estimated the odds of a human triggering a potentially fatal avalanche at considerable danger, skiing one start zone, and *"without skilled route selection"* between 1:100 and 1:1,000. These odds change by orders of magnitude with varying levels of avalanche hazard. Further, accident data show the risk from natural avalanches is about 10% of the risk from human triggering (Tremper, 2008). Translating these rough odds of encountering a dangerous avalanche into probabilities equates to 0.1-1% for human triggering and 0.01-0.1% for natural releases at considerable danger. For comparison, let's compare the results from this survey to the North American Public Avalanche Danger Scale (Statham et al., 2010a): "Natural avalanches possible *(practitioner estimate = 30%)*; human-triggered avalanches likely *(practitioner estimate = 60%)*."
2. Associating probability numbers with likelihood terms improves risk communication (e.g. Budescu et al., 2009; Budescu et al., 2012). Further, explicitly combining the term with the intended numerical range is more effective than having a separate descriptive table (Wintle et al., 2019). Writing *"good chance (10-30%) of avalanche release"* is more effective than having a separate table describing the 10-30% range for "good chance."
3. Using frequency statements greatly improves understanding of probabilities and ensures the reference scales are defined (Gigerenzer and Edwards, 2003). For

example, a frequency statement for a "20% chance of avalanches" could be translated to "20 out of every 100 avalanche paths."

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

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

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

1. Consider this definition for *Likelihood of Avalanches*. Please read carefully:
   Consider ANY avalanche path in the forecast region where the specified avalanche problem type is expected to exist. *Likelihood of Avalanches* is the chance of those avalanche paths releasing within the forecast time period, regardless of avalanche size.
   For example, PERSISTENT SLABS – BTL (below 1,900 m) on ALL ASPECTS, what is the chance of those paths releasing naturally or from human triggering?
   This definition includes the relevant spatial scale: any potential avalanche path. It automatically adjusts to whatever spatial scale is forecasted for. It also allows the translation of probability into frequency descriptions. For example, *"Persistent Slabs - Good Chance (10-30%) to size D3"* would translate to, *"On average 10-30 out every 100 potential paths will release deep slab avalanches."*
2. **Associating numerical probability ranges for each word in the scale that are more closely aligned with the underlying rates of avalanche release probability.**
   These probability ranges will be much lower than the results of the survey, and more similar to other natural hazards (e.g. Porter and Morgenstern, 2013). We propose numerical ratings that increase by a half order of magnitude in Table 1. As better data emerge for natural and human-triggered avalanche release rates, these probability ratings can and should evolve.
3. **Using chance terms to describe the probability of avalanches as these words are more intuitively associated with lower probabilities.**
   As evidenced in the survey results and literature, likelihood words are already commonly interpreted with underlying probabilities that are much higher than actual avalanche releases. Thus, we need words that can be easily associated with these lower probabilities for use by people working in the field. For example, it is not intuitive for most people to use the word "likely" with a probability of less than 50% (Mauboussin and Mauboussin, 2018). Suggestions are provided in Table 1.

APPLICATION

Table 1 offers forecasters a very different way of evaluating the *Likelihood of Avalanches* based on estimates of either avalanche frequencies or probability. When forecasters are evaluating a particular avalanche problem, they might (for example) imagine 100 avalanche paths typical to their area that could produce this type of avalanche and then estimate how many of these paths they think will release, both naturally and with human triggers. While the frequency estimate works for areas with many paths, it's not so useful when evaluating single paths or areas with only a few paths. In these cases, the subjective probability estimates or the chance terms are more appropriate.

TABLE 1: PROPOSED SCALE DESCRIBING THE *LIKELIHOOD OF AVALANCHES*.

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

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

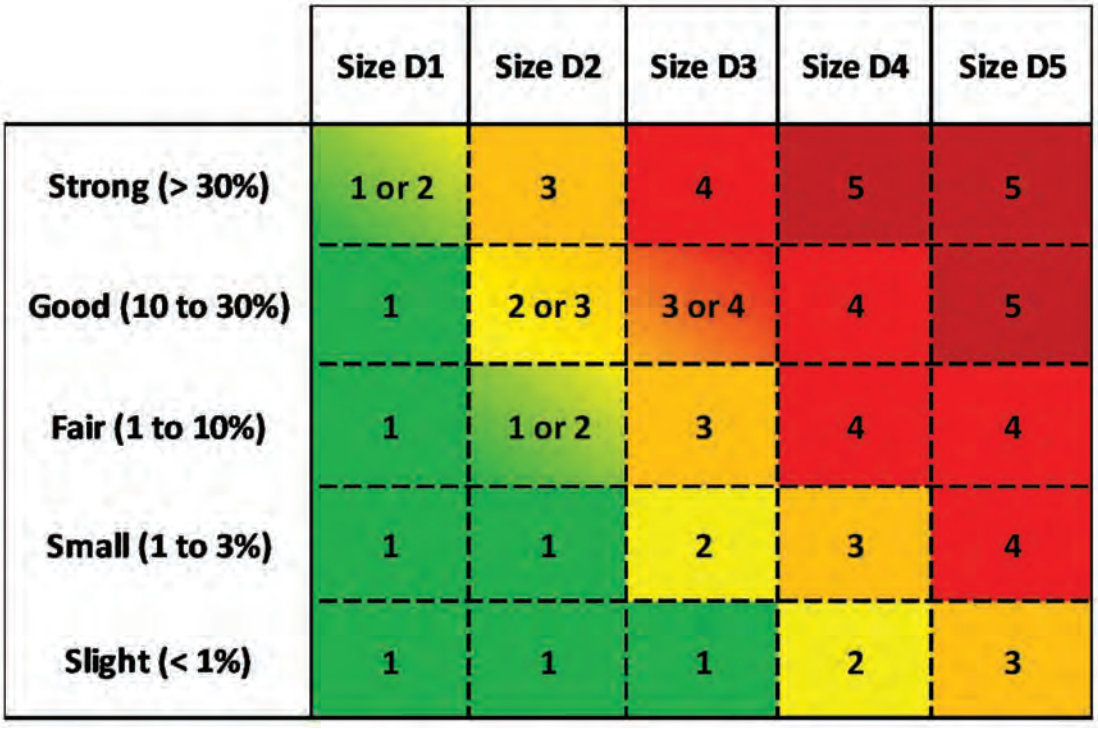


FIG. 2: GUIDANCE FOR COMBINING *LIKELIHOOD OF AVALANCHES* WITH AVALANCHE SIZE TO ASSIGN AVALANCHE HAZARD RATINGS (AFTER MULLER ET AL., 2016A; CLARK AND HAEGELI, 2018).

INTEGRATION WITH FORECASTING

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

CONCLUSION AND FUTURE RESEARCH

The surveyed data from avalanche practitioners showed wide variation in interpretation and use of likelihood terms when forecasting avalanches. Differing interpretations of likelihood terms has been shown to reduce forecasting accuracy and compromise decision making, thus we present ideas for improving risk communication when forecasting avalanches (Table 1 and new definition for the *Likelihood of Avalanches*).

We suggest these and any other terms used in the future should reflect underlying data for avalanche release probabilities. As an example, the important paper by Schweizer et al. (2019) attempts to establish the relationship between avalanche occurrence and the avalanche danger level. We strongly encourage future studies like this with robust avalanche occurrence datasets to better define probabilities of avalanche release.

REFERENCES

Beyth-Marom, R., 1982. How probable is probable? A numerical translation of verbal probability expressions. J. Forecast. 1: pp. 257-269.

Budescu, D., Broomell, S., Por, H., 2009. Improving Communication of Uncertainty in the Reports of the Intergovernmental Panel on Climate Change. Psych. Sci. 20: pp. 299-308.

Budescu, D., Por, H., Broomell, S., 2012. Effective Communication of Uncertainty in the IPCC Reports: A Nationally Representative Survey. Climatic Change 113: pp. 181-200.

Budescu, D., Por, H., Broomell, S., Smithson, M., 2014. The interpretation of IPCC probabilistic statements around the world. Nature Climate Change. DOI: 10.1038/NCLIMATE2194.

Clark, T., Haegeli, P., 2018. Establishing the link between the conceptual model of avalanche hazard and the North American public avalanche danger scale: Initial explorations from Canada. Proceedings International Snow Science Workshop, Innsbruck 2018: pp. 1116-1120.

Clarke, V., Ru n, C., Hill, D., Beamen, A., 1992. Ratings of orally presented verbal expressions of probability by a heterogeneous sample. J. Appl. Soc. Psychol. 22: pp. 638-656.

Fischer, K., Jungermann, H., 1996. Rarely occurring headaches and rarely occurring blindness: Is rarely = rarely? The meaning of verbal frequentistic labels in specific medical contexts. J Behav Decis Mak. 9:153–72.

Friedman, J., Baker, J., Mellers, B., Tetlock, P., Zeckhauser, R., 2018. The Value of Precision in Probability Assessment: Evidence from a Large-Scale Geopolitical Forecasting Tournament. International Studies Quarterly, Volume 62, Issue 2, June 2018: pp. 410–422. https://doi.org/10.1093/isq/sqx078

Fundel, V., Fleischhut, N., Herzog, S., Göber, M., Hagedorn, R., 2019. Promoting the use of probabilistic weather forecasts through a dialogue between scientists, developers and end users. Quarterly Journal of the Royal Meteorological Society. https://doi.org/10.1002/qj.3482

Gigerenzer, G., Edwards, A., 2003. Simple tools for understanding risks: from innumeracy to insight. BMJ 2003; 327:741. doi: https://doi.org/10.1136/bmj.327.7417.741.

Intelligence Community Directive 203, 2015. Analytic Standards. Office of the Director of National Intelligence United States of America.

IPCC: Mastrandrea, M., Field, C., Stocker, T., Edenhofer, O., Ebi, K., Frame, D., Held, H., Kriegler, E., Mach, K., Matschoss, P., Plattner, G., Yohe, G., and F., Zwiers, 2010. Guidance Note for Lead Authors of the IPCC Fifth Assessment Report on Consistent Treatment of Uncertainties. Proceedings from IPCC meetings at Jasper Ridge, CA, USA.

Jamieson, B., Schweizer, J., Shea, C., 2009. Simple Calculations of Avalanche Risk for Backcountry Skiing. Proceedings International Snow Science Workshop, Davos 2009: pp. 336-340.

Porter, M., Morgenstern, N., 2013. Landslide Risk Evaluation: Canadian Technical Guidelines and Best Practices related to Landslides: a national initiative for loss reduction. Geological Survey of Canada, Open File 7312, 21. doi:10.4095/292234.

Mauboussin, A., Mauboussin, M., 2018. If you say something is "likely", how likely do people think it is? Harvard Business Review.

https://hbr.org/2018/07/if-you-say-something-is-likely-how-likely-do-people-think-it-is

Muller, K., Mitterer, C, Engeset, R., Ekker, R., Kosberg, S., 2016a. Combining the Conceptual Model of Avalanche Hazard with the Bavarian Matrix. Proceedings International Snow Science Workshop, Breckenridge, Colorado, 2016: pp. 472 – 479.

Nakao, M., Axelrod, S,. 1983. Numbers are better than words. Verbal specifications of frequency have no place in medicine. The American Journal Of Medicine. 74(6):1061–5. PMID: 6859055.

Rapoport, A., Wallsten, T., Erev, I., Cohen, B., 1990. Revision of opinion with verbally and numerically expressed uncertainties. Acta Psychologica. 74: pp. 61–79. https://doi.org/10.1016/0001-6918(90)90035-E 000169189090035E.

Reagan, R., Mosteller, F., Youtz, C., 1989. Quantitative meanings of verbal probability expressions. J. Appl. Psychol. 74: pp. 433-442.

Schweizer, J., Mitterer, C., Techel, F., Stoffel, A., Reuter, B.: On the relation between avalanche occurrence and avalanche danger level, The Cryosphere Discussions. https://doi.org/10.5194/tc-2019-218, in review, 2019.

Statham, G., Haegeli, P., Birkeland, K., Greene, E., Israelson, C., Tremper, B., Stethem, C., McMahon, B., White, B., Kelly, J., 2010a. The North American public avalanche danger scale. Proceedings of the 2010 International Snow Science Workshop, Squaw Valley, CA: pp. 117–123.

Statham, G., Haegeli, P., Greene, E., Birkeland, K., Israelson, C., Tremper, B., Stethem, C., McMahon, B., White, B., Kelly, J., 2018. A Conceptual Model of Avalanche Hazard. Nat Hazards 90: pp. 663–691. https://doi.org/10.1007/s11069-017-3070-5.

Theil, M., 2002. The Role of Translations of Verbal into Numerical Probability Expressions in Risk Management: A Meta-Analysis. Journal of Risk Research 5 (2): pp. 177–186.

Tremper, B., 2008. *Staying Alive in Avalanche Terrain*, 2nd edition. The Mountaineers Books, Seattle, Washington, USA: pp. 15.

Wintle, B., Fraser, H., Wills, B., Nicholson, A., Fidler, F., 2019. Verbal probabilities: Very likely to be somewhat more confusing than numbers. PLoS ONE 14(4): e0213522. ttps://doi.org/10.1371/journal.pone.0213522

Wyden, P., 1979. Bay of Pigs: The Untold Story. New York: Simon and Schuster

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THE RISK OF SKI CUTTING

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34 WHAT CAN VISUAL ANALYTICS DO FOR AVALANCHE FORECASTING?

// ANDY NICOLS

The Risk of Ski Cutting – Results From an International Survey

Bruce Jamieson[1], Karl Birkeland[2], Mark Vesely[3], Ilya Storm, John Stimberis[4]
[1] bruce.jamieson@snowline.ca, Snowline Associates Ltd., [2] USDA Forest Service National Avalanche Center,
[3] 6Point Engineering, [4] Washington State Department of Transportation

FIG. 1: PETER SCHAERER TRIGGERS A SMALL DRY SLAB AVALANCHE WITH A SKI CUT // BRUCE JAMIESON

INTRODUCTION

In avalanche operations, ski cutting involves an avalanche practitioner attempting to trigger an avalanche by skiing (or snowboarding) across the top of a slope. It is a basic skill that is widely used by avalanche practitioners. One of the competencies in the Canadian Avalanche Association's 2015 draft competency profile is "artificial triggering (excluding the use of explosives)." Some recreationists ski cut slopes, but this paper pertains exclusively to ski cutting by avalanche practitioners at work.

There are two types of ski cutting: test skiing to determine if snow is unstable, and mitigation to remove unstable snow before avalanches get bigger or before less skilled people (e.g. clients) get to the specific slopes. Looking at avalanche operations across North America, the number of slopes ski cut for mitigation in a winter far exceeds the number of slopes test skied.

To address the wide differences in the perceived risk of injury during ski cutting, we conducted a quantitative survey that helped practitioners estimate the number of ski cuts they performed over many winters and asked them to recall near misses and three classes of injuries. Over 150 practitioners completed the survey, with a combined total of almost 1.5 million ski cuts reported.

When the survey results are scaled to one million ski cuts, about 23 resulted in light duty, seven resulted in missed work, and three resulted in career-ending injuries. Practitioners at ski areas (ski patrollers) had lower risk for the same number of ski cuts than mechanized ski guides.

Advantages of ski cutting:

- Provides high strength and high weight evidence of snow instability, which is key information for avalanche forecasting operations. Many slopes ski cut but not triggered is an indicator of stability and can be of high weight if many representative slopes are ski cut.
- Intentional ski testing for unstable snow high on a slope is lower risk than inadvertently triggering unstable snow lower on the slope.
- Removes unstable snow before the avalanches get bigger during storms or before less skilled people get to the slopes.
- More effective for triggering loose wet snow avalanches than explosives.
- Faster than explosives when dealing with many start zones if only small avalanches are expected.
- Can be efficiently used in combination with explosive mitigation, i.e. ski cutting for the smaller or less severe slopes and explosives for the more severe slopes. Also, practitioners can remove small pockets of unstable snow that remain after explosive mitigation.
- Cost effective when there are many start zones and/or practitioners with related skills (e.g. guiding, first aid, skiing) who are consistently on site.
- Practitioners can learn about the spatial characteristics of unstable snow such as trigger points which are relevant to placing explosives, as well as snowpack variations over terrain that are relevant to avalanche release and route selection. Practitioners can also learn about the transient nature of snow instability, including storm slabs. This knowledge about the spatial and temporal characteristics of unstable snow is difficult to learn in the classroom.

Disadvantages of ski cutting:

- People can be injured and potentially killed while ski cutting.
- For operations with many small slopes and a few large slopes (or slopes with terrain traps), the efficiency of ski cutting can deter the use of lower-risk methods of avalanche mitigation, such as explosives, on more serious slopes.
- The risk for a particular ski cut cannot always be determined in advance. For example, on a day when ski cutting many shallow slabs resulting in D1 avalanches, practitioners infrequently trigger slabs that are deeper than expected, resulting in larger avalanches.
- A small number of ski cuts that do not trigger avalanches can be misleading, meaning they do not provide high-weight evidence of stability, especially for deeper weak layers. There have been three fatalities in the U.S. since 1980 during

ski cutting, according to records kept by the Colorado Avalanche Information Centre. There has been one in Canada in the same time period, according to the CAA and Avalanche Canada.

The objectives of this study are:

- To quantitatively estimate the rate of near misses and injuries from ski cutting and hence inform policies, practices, decisions, and discussions about ski cutting; and
- To quantitatively estimate the rate of triggering and being caught while ski cutting by avalanche size (D-scale; McClung and Schaerer, 2006).

This article does not identify practices to minimize risk while ski cutting. However, Stimberis (2008, 2018) and Wilbour (1986) identify low-risk practices for ski cutting. Richmond (1994) and Vesely (2014) identify patterns in near-misses and injurious ski cuts.

This article was shortened for the Avalanche Journal. The complete version is available at https://avalanche.org/wp-content/uploads/2019/08/19_Jamieson_etal_SkiCutRisk.pdf.

THE SURVEY

The links to the introductory video and survey were sent to avalanche practitioners through associations in the U.S., Canada, and New Zealand. Since the wording discouraged potential respondents who do limited ski cutting, the survey results better represent practitioners who frequently ski cut slopes.

The survey distinguished between five types of avalanche work (sectors): lift-based ski areas (i.e. ski patrolling), mechanized ski guiding, non-mechanized ski guiding, highways and resource industries, backcountry forecasting (for public avalanche warnings), and other types of avalanche work.

Each respondent estimated their ski cuts and injuries for one or two career phases in which they did the most ski cutting. Each phase was for one or more winters in a specified sector. For each phase, respondents were asked to recall and estimate their average number of ski cuts per winter, number of winters, and the number of their near misses and injuries.

As is common for analyzing the risk to workers, respondents were asked about four types of events:

1. A "near miss" is an unplanned event that did not result in injury, illness, or damage, but had the potential to do so.
2. "Light duty" refers to a period of one or more days in which the injured worker performs physically less demanding work.
3. "Missed work" refers to a period of one or more days in which the injured worker is unemployed.
4. "End of career" typically refers to a career-ending injury. Since the survey allows for a second career phase, such as forecasting for a highway avalanche program after working as a ski patroller, this type of injury is referred to as end of career phase.

RESULTS AND DISCUSSION

Out of 161 respondents, 50 had complete answers for a second career phase, giving a total of 211 career phases of data for analysis. The career phases ranged in length from one to 38 winters, with an average of 11 and a median of nine.

Since many probabilities in this study are small numbers, we report frequencies as n events per million ski cuts.

Number of ski cuts per winter per respondent for the various sectors

Table 1 shows the number of career phases, the number of ski cuts per winter per respondent, and the total ski cuts for the different sectors.

Risk to practitioners: Near miss and injury rates from ski cutting

The number of reported near misses and injuries for ski areas and mechanized guiding are presented in Table 2. Only seven and four injuries resulted in missed work or ended career phases, respectively, so interpretations and extrapolations based on such limited data for serious injuries should be made with caution.

Figure 2 shows the injury rate for mechanized ski guides per million ski cuts is approximately 2.5 times the rate for ski area practitioners. This may be due to:

- Ski area practitioners having better options for explosive use on more serious slopes or when the slabs are thicker;

TABLE 1: NUMBER OF SKI CUTS PER WINTER PER RESPONDENT AND TOTAL BY SECTOR

SECTOR	NO. OF CAREER PHASES (ALL RESPONDENTS)	NO. OF SKI CUTS (ALL RESPONDENTS)	NO. OF SKI CUTS PER WINTER PER RESPONDENT			
			Q1	Q2 (MED)	Q3	AVERAGE
Ski areas	128	1,081,962	199	400	810	661
Mechanized ski guiding	45	323,905	120	300	700	476
Non-mechanized ski guiding	15	11,189	63	90	158	108
Highways & resource industry	9	59,140	60	78	660	428
Backcountry forecasting	11	14,245	40	140	233	191
Other	3	5,380	40	60	130	93
All sectors	**211**	**1,495,821**	**120**	**300**	**700**	**539**

TABLE 2: SUMMARY OF SURVEY RESPONSES INCLUDING NEAR MISSES AND INJURIES BY SECTOR

SECTOR	NO. OF CAREER PHASES	NO. OF SKI CUTS	NUMBER OF NEAR MISSES AND INJURIES			
			NEAR MISS	LIGHT DUTY	MISSED WORK	END CAREER PHASE
Ski areas	128	1,081,962	444	19	3	1
Mechanized ski guiding	45	323,905	106	12	4	3

- The slopes ski area practitioners cut are often more compacted, reducing the frequency of deeper than expected avalanches;
- The technique – including start and stop locations – for specific slopes are more often pre-established and mentored for ski areas;
- The history of specific slopes and ski cuts is better documented at ski areas, allowing for more informed slope-specific decisions; and
- Ski area practitioners may have a long-prescribed list of slopes to ski cut when there is a small accumulation of new snow overnight (e.g. 5 cm) and the risk is very low.

For ski areas and mechanized ski guiding, the average frequency of near misses and injuries per winter can be estimated from Table 2 and the estimated number of ski cuts per winter in Table 1. However, the reciprocal of average frequency (average number of winters per near miss or injury) is a more intuitive way of comparing infrequent events. Table 3 and Figure 3 show the average winters per near miss or injury for these two sectors. Table 3 shows the average winters per event increases with the seriousness of the injury. Also, the average winters per injury for mechanized ski guiding are less than for ski area practitioners because mechanized ski guides reported more frequent injuries.

The average number of winters per injury *within an operation* can be roughly estimated by dividing the numbers in Table 3 by the typical number of practitioners engaged with ski cutting. For example, for an operation with 50 practitioners, the average winters per ski cutting injury resulting in light duty would be 142/50, or about three years for a ski area, and 90/50, or about two years for a mechanized guiding operation. Avalanche operations can use this approach to check if their rate of near misses and injuries are roughly comparable to those in this study; however, the duration of near miss and injury records should preferably be at least three times as long as the average number of winters per near miss or injury in the comparison (an average of 10 winters per near miss is best assessed over 30 or more winters).

Discussion on the risk of death in an avalanche while ski cutting

This survey relied on each respondent's recollection and hence yielded no data on deaths. However, the probability of a practitioner being killed in an avalanche while ski cutting can be estimated based on U.S. data for the last 40 winters. Greene et al. (2014) estimated there are about 2,800 avalanche practitioners in the United States. Assuming two-thirds ski cut the average number of slopes per winter (Table 1), then there are about 1,000,000 ski cuts per winter in the United States, or 40 million ski cuts over the last 40 years. Since three practitioners have died in avalanches while ski cutting in the U.S., this suggests a probability of death of about 0.08 per million ski cuts. Allowing for uncertainty in the number of ski cuts per winter of half an order of magnitude on either side of this estimate, the range in the probability of death is about 0.02 to 0.2 per million ski cuts.

There are physical reasons why the probability of death while ski cutting should be lower than other activities in avalanche terrain. Practitioners performing ski cutting will have a low vulnerability because they are more often caught on skis while high in the start zone (which reduces avalanche mass above – and force on – the practitioner), the ski cutting teams are skilled in companion rescue, and the ski cutting occurs within operations with good rescue capability.

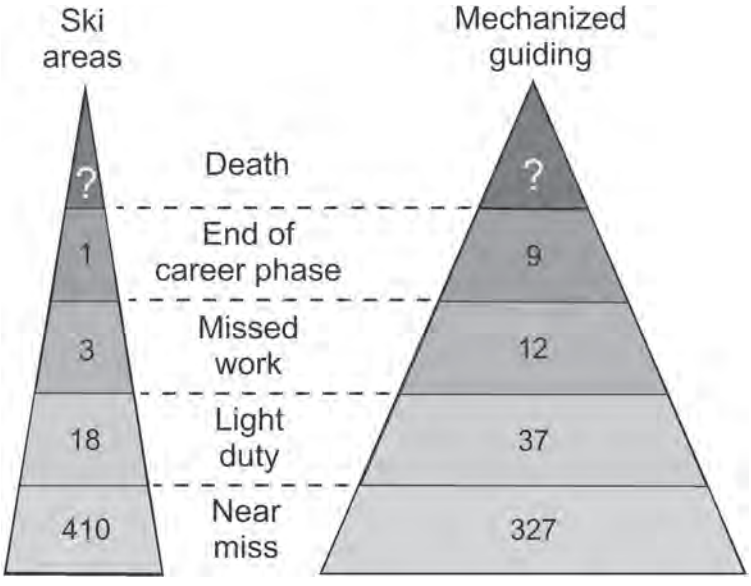

FIG. 2: RISK (RATE OF NEAR MISSES AND INJURIES) PER MILLION SKI CUTS FOR SKI AREAS AND MECHANIZED GUIDING. THE BASES OF THE TRIANGLES ARE SCALED BY THE TOTAL INJURY RATE (EXCLUDING NEAR MISSES) FOR THE SECTOR AS SHOWN IN TABLE 3.

TABLE 3: AVERAGE NUMBER OF WINTERS PER NEAR MISS OR INJURY FOR PRACTITIONERS WITH THE MEDIAN NUMBER OF SKI CUTS PER WINTER FROM TABLE 1

SECTOR	NEAR MISS	LIGHT DUTY	MISSED WORK	END CAREER PHASE
Ski areas	6	142	902	2,705
Mechanized ski guiding	10	90	270	360

RECOMMENDATIONS

We recommend operations keep comprehensive records of ski cutting and any injuries so recurring factors in near misses and injuries can be identified and mitigated.

While some avalanche operations have shared their ski cutting procedures, we recommend procedures be widely shared within sectors so best practices can be established.

We recommend a study of the risk of ski cutting for the sectors with limited survey responses in this study, specifically non-mechanized ski guiding (ski touring), highways & resource industries, and backcountry forecasting for public avalanche warnings.

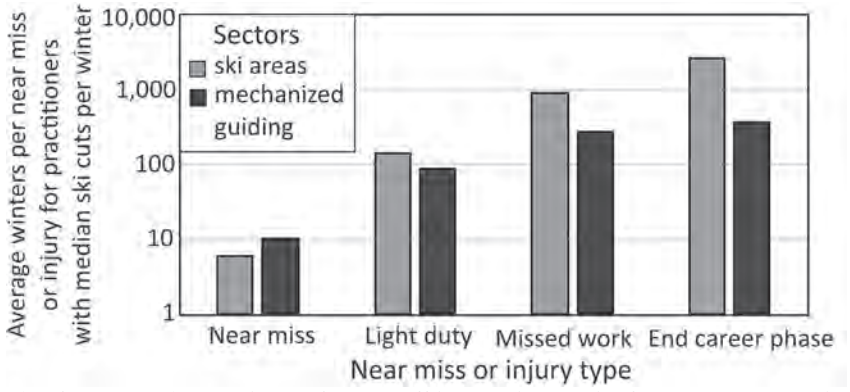

FIG. 3: ESTIMATED AVERAGE NUMBER OF WINTERS PER NEAR MISS OR INJURY FOR PRACTITIONERS WITH THE MEDIAN NUMBER OF SKI CUTS (TABLE 1). THE LEFT AXIS USES A LOG SCALE SO THAT SHORTER COLUMNS, E.G. THE AVERAGE WINTERS PER NEAR MISS OR LIGHT DUTY INJURY, ARE CLEARLY DISPLAYED.

ACKNOWLEDGEMENTS

We recognize the survey was difficult and are grateful to those who completed it.

Our thanks to Craig Wilbour, Steve Conger, Mark Klassen, Colin Zacharias, Forest Latimer, Scott Davis, Scott Savage, Mark Grist, John Buffery, Steve Parsons, and Bradford White for discussions on ski cutting and/or comments on the draft survey.

We would like to thank Dan Kaveney from the American Avalanche Association, Sarah Carpenter from the American Mountain Guides Association, and Alex Kittrell from HeliSki US for distributing the survey to their members.

We would like to thank the Canadian Avalanche Association, the Association of Canadian Mountain Guides, and the Canadian Ski Guides Association for distributing the survey in Canada.

Irene Henninger and Doug McCabe provided insights about the similarities in ski cutting practices between the U.S. and New Zealand.

Our thanks to Andy Hoyle and the Ski Areas Association of New Zealand (SAANZ) for distributing the survey in New Zealand.

REFERENCES

Greene, E., Jamieson, B., and Logan, S. 2014. Fatal occupational injuries of avalanche workers in North America, Proceedings of the 2014 International Snow Science Workshop. Banff, Alberta, Canada, 293-299.

McClung, D.M. and Schaerer, P.A. 2006. The Avalanche Handbook (3rd ed.), The Mountaineers, Seattle, USA.

Richmond, D. 1994. Repeated mistakes by avalanche professionals. Proceedings of the 1994 International Snow Science Workshop in Snowbird, Utah, USA.

Stimberis, J. 2008. Chinook Pass: 25 years on. Proceedings of the 2008 International Snow Science Workshop in Whistler, BC, Canada.

Stimberis, J. 2018. Perspectives on ski cutting. Proceedings of the 2018 International Snow Science Workshop in Innsbruck, Austria.

Vesely, M. 2014. Zen and the art of skier controlled avalanche release – perspectives on key risk indicators in ski cutting. Proceedings of the 2014 International Snow Science Workshop in Banff, Canada.

Wilbour, C. 1986. The Chinook Pass avalanche control program. Proceedings of the 1986 International Snow Science Workshop in Lake Tahoe, California, USA.

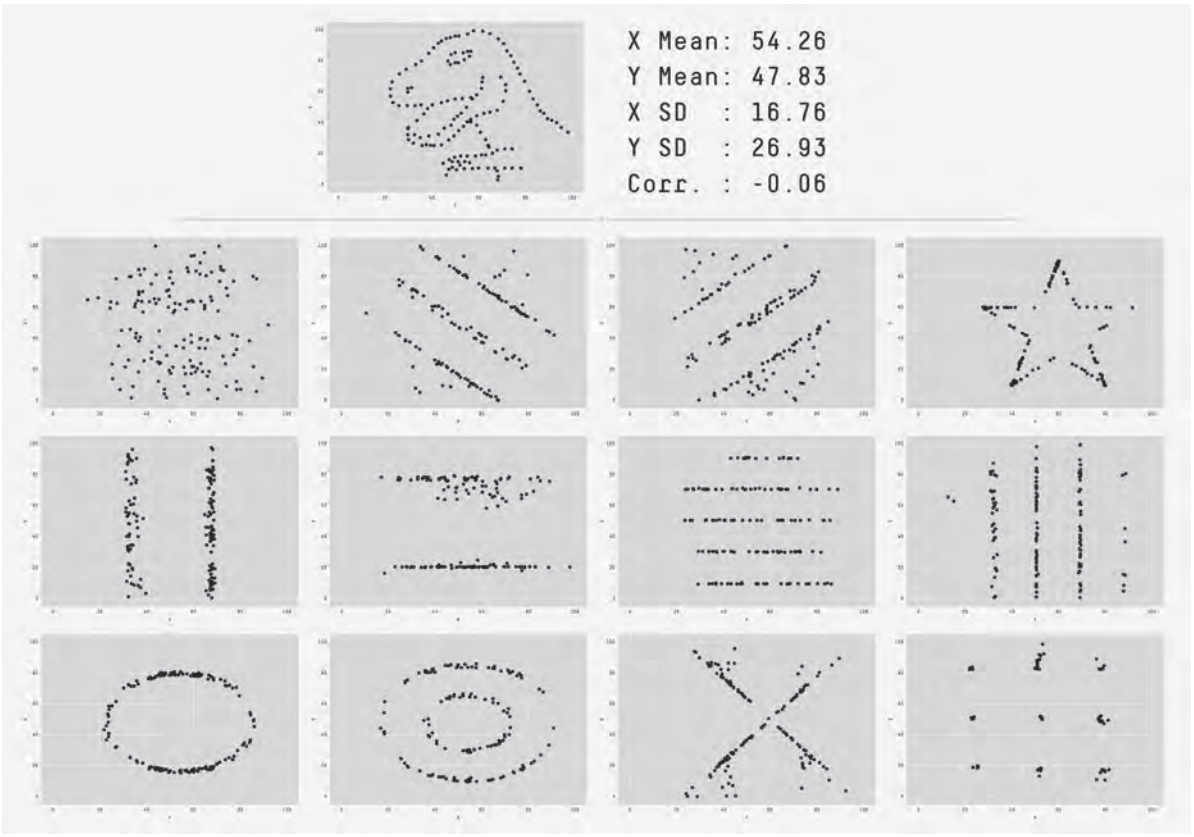

FIG. 1: THE DATASAURUS DOZEN: EACH DATASET IS DIFFERENT IN APPEARANCE, BUT IT HAS NEARLY IDENTICAL SUMMARY STATISTICS (MEAN, VARIANCE, CORRELATION ETC.). // WWW.AUTODESKRESEARCH.COM/PUBLICATIONS/SAMESTATS

What Can Visual Analytics do for Avalanche Forecasting?

Stan Nowak

VISUAL ANALYTICS

In the early 2000s, the newly formed U.S. Department of Homeland Security (DHS) faced a challenging scenario. Using the tools they had at the time, they could not assess potential terrorist risks given the complexity of data and the time constraints they faced (sound familiar?). These problems could not be solved using computational and statistical methods alone. Human analysts, with their ability to reason about really complex problems, and computers, with their abilities to crunch numbers fast, had to come together in order to meet these challenges.

The way to do this was through interactive visual interfaces. The DHS funded a new research direction, and the field of visual analytics was born. Formally defined as "the science of analytical reasoning facilitated by interactive visual interfaces," the new field brought together researchers in psychology, information visualization, computer science, machine learning, and design, among others, to meet the challenges of complex and large datasets.

You might be wondering what is so special about visualization? Our visual system has evolved to detect all sorts of patterns in our environment to ensure our survival. It's our best sense. We "hack" our visual system and our innate abilities all the time.

Consider the following problem of arranging letters: D is between A and R, G is between D and A, C is to the right of G, and R is to the right of D. You could try to solve this in your head, but it is much faster and easier to draw a diagram. Reasoning using external representations and vision is way faster and more reliable that mental reasoning. We think of this as offloading part of the thinking to a visual form and using it as a thinking tool.

We try to do the same thing by summarizing information with statistics. This makes information a bit easier to digest, but it can gloss over important patterns that can entirely change the interpretation of a situation. Take my favorite example, the Datasaurus dozen (Fig. 1). You see a bunch of datasets that have the same summary statistics (mean, variance, correlation, etc…). If we just look at the numbers, they are nearly identical, but when visualized we see they are

unique and have meaningful patterns. Visualization let's us see the structure of the data. It can help us see patterns that would otherwise remain hidden. It empowers us as thinkers to see what is there, what isn't, and start asking informed questions.

Interaction is equally important and lets us ask questions with the data. It allows us to manipulate the visual form of the data to give another perspective and reveal potential insights or hidden patterns. This is very powerful when dealing with very complex data. Visual representations help us see patterns in the data that would otherwise take tremendous investments of time and effort to see. Visualization can also highlight what we don't know and the complex uncertainties in data. Interaction then let's us quickly ask questions about those patterns.

AvID

Avalanche Canada has an ambitious new project, AvID (Avalanche Information Distribution). The goal is to create tools that help make its work more streamlined. These tools are being created for it but have the potential to benefit many different types of operations across the industry. A component of the project I have had the privilege to be part of is a tool that aggregates all of the disparate data sources forecasters use (weather stations, InfoEx, Mountain Information Network, etc...) and puts them in one place. Having all of the data at arms-length is great, but how it is presented opens even more opportunities to help forecasters save time and see patterns they might not otherwise. I want to tell you about how carefully designed visual analytics tools can help avalanche forecasting.

There are many out-of-the-box visualizations or tools that are meant to be one-size-fits-all, but avalanche forecasting has unique challenges and practices. Such tools are often doomed to fail because they don't address actual needs, or they demand far too much change and training to be successfully taken up. I spent the spring of 2019 studying how forecasters work to inform the design of visualization tools that build on and enhance the work that forecasters already do.

I was thrilled to find, but also not surprised, that forecasters are a very visual bunch. From the appreciation of aesthetic ski lines and the stark contrast of crown lines, to making sense of dense and complicated meteorological visualizations, forecasters are very visually adept. This quality makes avalanche forecasters leaps and bounds more capable of adopting visualization tools than other user groups I have worked with.

I also found forecasting is comparatively incredibly complex. Creating mental models of current conditions from disparate sources takes a tremendous amount of experience, time, and effort. It is very demanding work that requires forecasters to remember and hold on to a bunch of information to make their assessments. Detecting patterns from this data takes a significant amount of experience and great memory, not to mention the ever-present uncertainty that requires sage-like abilities to extrapolate patterns across time and space. Reasoning through complex problems is really hard, but luckily there are tools that can help.

The AvID project is at too early a stage to present anything final, but I want to show you a simple example to demonstrate the power of interactive visualizations. In Fig. 2A, we see three visualizations showing temperature data

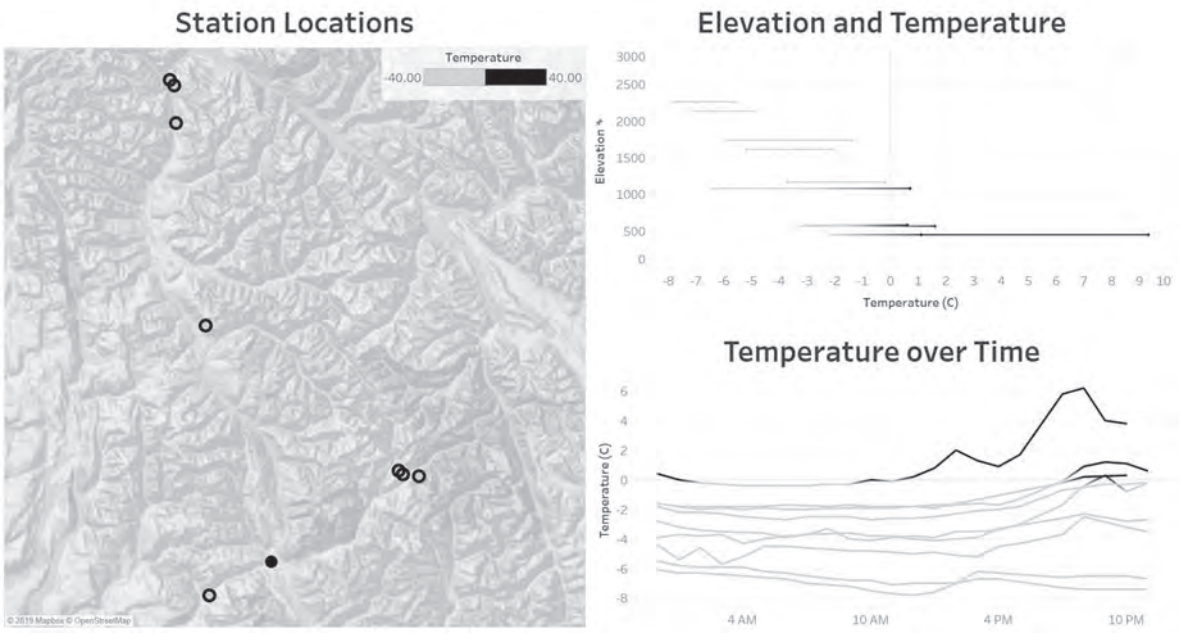

FIG. 2A: THIS DASHBOARD SHOWS WEATHER STATION TEMPERATURE DATA FOR A DAY IN A REGION. TEMPERATURES ABOVE FREEZING ARE SHOWN IN BLACK, WHILE THOSE BELOW FREEZING ARE SHOWN IN GREY. THE MAP (LEFT) SHOWS STATION LOCATIONS AS CIRCLE. THE BARBELL CHART (TOP RIGHT) SHOWS THE MINIMUM, MEDIAN, AND MAXIMUM TEMPERATURES (RESPECTIVE POINTS ON EACH LINE) FOR EACH STATION (EACH LINE) BY ELEVATION. THE LINE CHART (BOTTOM RIGHT) SHOWS TEMPERATURE CHANGE OVER TIME FOR EACH STATION (EACH LINE).

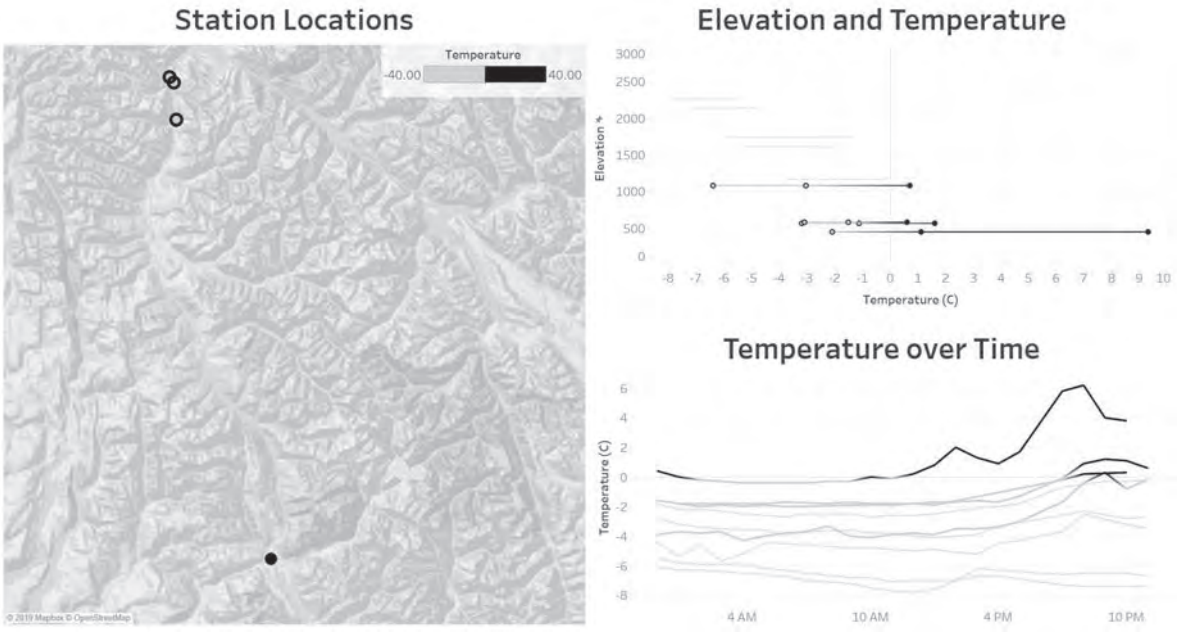

FIG 2B: SELECTING THE STATIONS WHERE TEMPERATURES WENT ABOVE FREEZING (ELEVATION AND TEMPERATURE CHART) HIGHLIGHTS THOSE STATIONS IN BOTH THE OTHER VISUALIZATIONS AND SHOWS WHEN AND WHERE TEMPERATURES CHANGED. THROUGH SELECTIONS AND HIGHLIGHTING, A LINK BETWEEN EACH INDIVIDUAL STATION ACROSS TIME, GEOGRAPHIC LOCATION, AND ELEVATION CAN BE MADE TO QUICKLY UNDERSTAND THE COMPLEX STORY OF A WARMING TREND WITHIN A REGION.

from weather stations on a particular day. Some questions we might have are:

1. "What elevation was the freezing level at?" (Top-right chart showing minimum, maximum, and median temperatures for each station on that day and its associated elevation)
2. "When/for how long did it change?" (Bottom-right chart showing temperature change over time for each station)
3. "Where are temperatures above freezing?" (Map on the left showing station locations and whether median temperatures went above or below freezing by color).

We can start to answer parts of these questions through each of the visualizations alone, but we can't really put the complex story that link all three of them together without interaction. In Fig. 2B you can see all of the stations that went above freezing are selected and are then highlighted in the map and line chart. We can see where, when, and for how long temperature changed. Each of the visuals are interactive and we can ask different questions by selecting any one of them. For example, by selecting points on the map, we can ask how temperatures changed for stations in that particular area and at what elevation.

Imagine how long this would take by scanning tables of text. This visual is powerful not only because of how it allows us to see these patterns and helps form a mental picture very quickly, but also because it shows what information is not available. We see the stations, where they are geographically, and at what elevations, but we also see the information that is missing. This data has blind spots for large swaths of elevation and geographic space. This can tune how we can and should interpret this data.

Temperature from weather stations form a very small and specific component of the information ecosystems that forecasters live in everyday. Visualizations like these can incorporate much more information and allow forecasters to pick out patterns at a glance rather than through enormous amounts of mental effort and memorization. They allow forecasters to ask questions from different perspectives to better tune mental models of conditions. They can also highlight what is uncertain and make it easier to reason about this uncertainty.

The preliminary targets for AvID are focused on a core set of daily operational interactive visualizations. The first blends weather actuals from weather stations and reports to give forecasters an understanding of real-time and recent weather patterns at a glance. The second is focused on visualizing reports of avalanche observations, which are highly complex and multi-dimensional.

While these are designed for a birds-eye view of Avalanche Canada's forecast regions, other operations may find them useful for understanding conditions that their nearest neighbours are experiencing. Additionally, these visualizations are being designed to scale across long time periods, allowing forecasters to quickly and flexibly explore data associated with persistent avalanche problems.

By creating these tools, we hope to help make avalanche forecasting data more accessible to all that use them. Visual analytics as a domain is particularly well suited to meet the challenges of forecasting. It is an exercise of very complex reasoning that depends just as much on the experience and mastery of forecasters as it does on the quality of information. By making the information more accessible, we are aiming to empower forecasters to spend more time applying their vast knowledge and abilities and less time memorizing data points from tables.

snow globe

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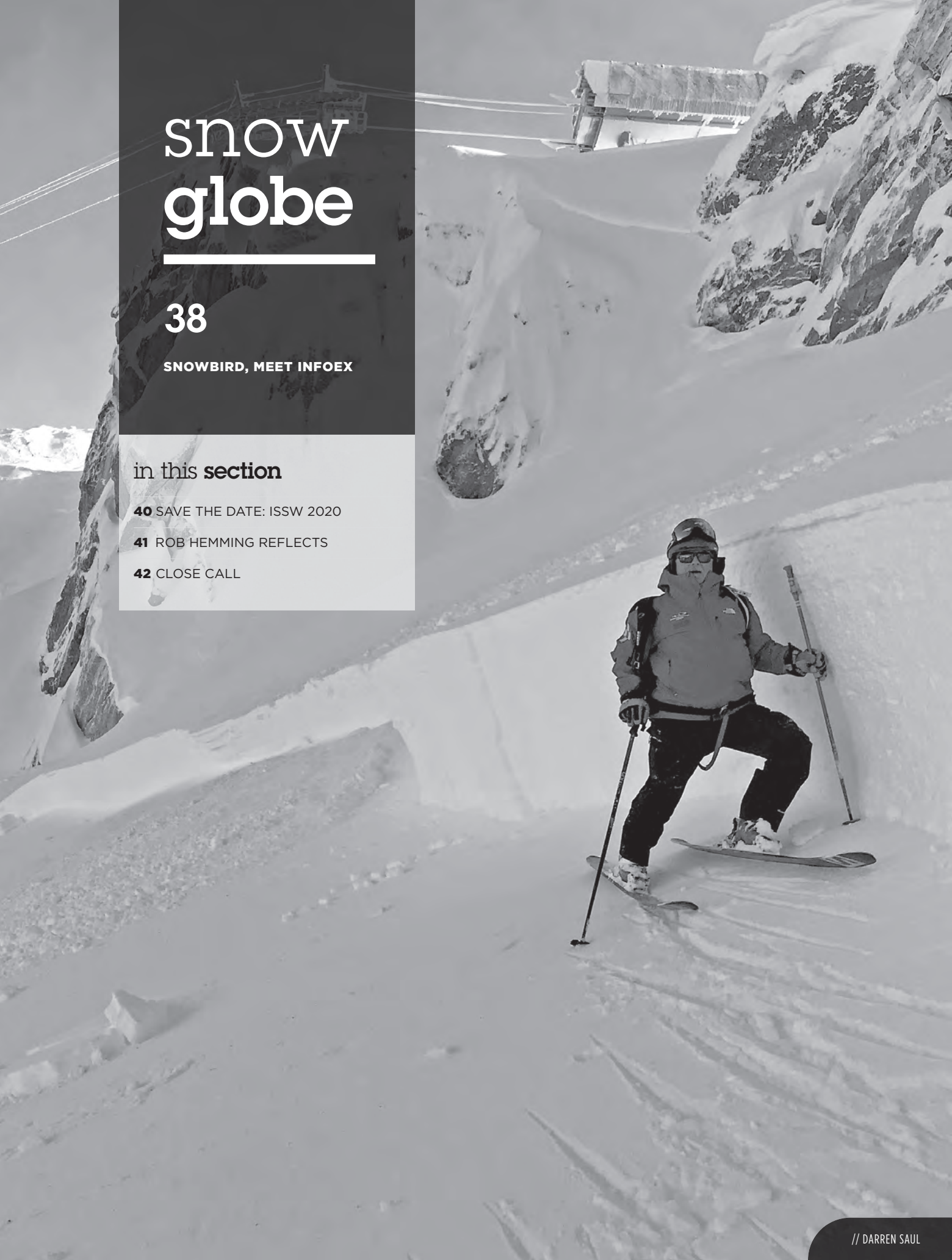


// DARREN SAUL

Snowbird, Meet InfoEx

Intro and conclusion by Sean Zimmerman-Wall, Body by Chris Bremer

Editor's note: An earlier version of this article appeared in the Spring 2019 issue of The Avalanche Review.

SNOWBIRD SKI PATROL CONDUCTS AVALANCHE CONTROL WORK WITH AN AVALAUNCHER IN THEIR MINERAL BASIN ZONE. // JAY DASH

DURING A PROFESSIONAL LEVEL avalanche course years ago, a sage instructor with a wealth of experience told us, "Data isn't information, information isn't knowledge, and knowledge isn't wisdom."

To this day that quote sticks with us and is profound in its simplicity. It is a subtle reminder that when we collect things like sky cover, temperature, surface form, boot pen, or other SWAG-y bits, it is important to keep them in perspective of the big picture. Writing things down is a powerful memory aid, but what should we do with the stacks of field books or endless reams of paper to better ourselves as forecasters and practitioners? How can we actually improve our operational working memory?

One solution came to us from the Canadian Avalanche Association by the name of InfoEx. Through continued partnership with the firm Tecterra, InfoEx is being offered to those outside Canada in an international version. This is our story of how this program was used during its trial year in the United States.

IN EARLY 2018, the avalanche data entry computer program we were using at Snowbird suddenly reached the end of its lifespan. It had served us well, but because of its demise we were forced to record our avalanche observations on paper for the remainder of the season. Fortuitously, CAA representatives appeared at the National Ski Area Association conference at Snowbird later that year. InfoEx manager Stuart Smith and Executive Director Joe Obad were there to discuss the international version of the exemplary InfoEx system. Much of what was shown in that brief overview escapes me, but I reported favorably when I returned to my supervisors.

In the spring of 2018 we hosted several exchange ski patrollers from Whistler and Revelstoke who gave us insight into their experience with InfoEx. It

was during the Whistler patrollers' visit that Peter Schory, Snowbird's mountain operations director, and Todd Greenfield, the snow safety director, were sold on the benefits of InfoEx. Their decision to implement the platform gave me much to occupy my time over the summer.

Once the ski season ended in May, I began building out our location catalog. This entailed roughly drawing out Snowbird's many avalanche control routes and avalanche paths. Our recording in the past had centered around shot placements, so it was these locations that I was most meticulous in cataloguing. Change is slow in any industry, and the ski industry is no exception, so while filling out our InfoEx profile, I made it a point to closely replicate the systems we had used previously. This helped ease our patrol's adaptation to the system and ensured continuity with the data we had been collecting for the past 47 years.

Over the summer, I dedicated just over a month to the build-out and fine tuning of the system. The location catalog and the selection of representative photos took the greatest portion of this time. Morning and afternoon workflows were created to provide a structure to what we had historically recorded daily, like weather reporting and assigning avalanche control routes. Incorporated into these workflows were features new to us at Snowbird and unique to InfoEx. such as database-driven persistent weak layers tracking and snowpack summary. InfoEx also provided an elegant way to generate forecasts using the conceptual model of avalanche hazard.

In October, Stuart Smith returned to Snowbird to spend a day advising and answering any lingering questions. This being our second sit down, I gained a greater understanding of the system. Without any actual avalanche or weather data due to that pesky thing called summer, our InfoEx profile was still a hollow shell. Stuart showed me operations with several season's worth of data and how the embedded maps and charts were auto-populating from the data entered. During this meeting and since, Stuart has been very receptive to suggested changes and improvements to International InfoEx based on our use, with many of those suggestions already implemented in subsequent updates.

DATA COLLECTION BEGAN in early November and by mid-December, the snow safety department was very happy with the ease of use and speed that could generate useful and meaningful morning forecasts and afternoon summaries and route lists. The greater ski patrol became well versed in avalanche control route recording thanks to a few early storm cycles.

During the latter part of the 2018-19 winter, we integrated the platform into our backcountry guiding program as a means to conduct our morning and evening meetings. Options like the run list feature allowed our guides to categorize terrain into operating zones and systematically select where we would go and where we would avoid. This feature in particular holds great potential for our operation and gives us insight into how we use our terrain.

We can also list our strategic mindset for the day and hold ourselves accountable for the way we approach our field operations. Being able to view what other operators in our area are seeing is perhaps the most useful tool for the guiding side of things. At this time, one other backcountry guide service in our area is actively using InfoEx and we benefit from sharing observations and daily hazard assessments.

Over the summer of 2019, we developed a strategy to utilize InfoEx's email distribution lists in our PM workflow. This will allow us to send our team members the plan for the next day. We also created reports for each of our avalanche routes that will allow patrollers, at the click of a mouse, to view the previous week of avalanche work performed on their specific route. Future steps we are hoping to take beyond next season entail importing historic Snowbird avalanche and weather data into the database with the help of the creator of our previous recording software.

A formalized system of information exchange is a sea change for our industry here in the United States and it represents a cultural shift in how we document. Overall, it is helping turn data into information and knowledge, which enables us to connect the dots and make evidence-based decisions. Wisdom, as they say, will only come with time.

Save the Date:
ISSW 2020 Less Than a Year Away

Mary Clayton

THE INTERNATIONAL SNOW SCIENCE WORKSHOP (ISSW) is a gathering for people who love snow. This week-long conference is held every two years in a location that alternates between the U.S., Canada, and Europe. The next ISSW will be held in Fernie, B.C., from Oct. 4-9, 2020, which means it's a great opportunity for all of us in western Canada who work – and play – in the snow to attend.

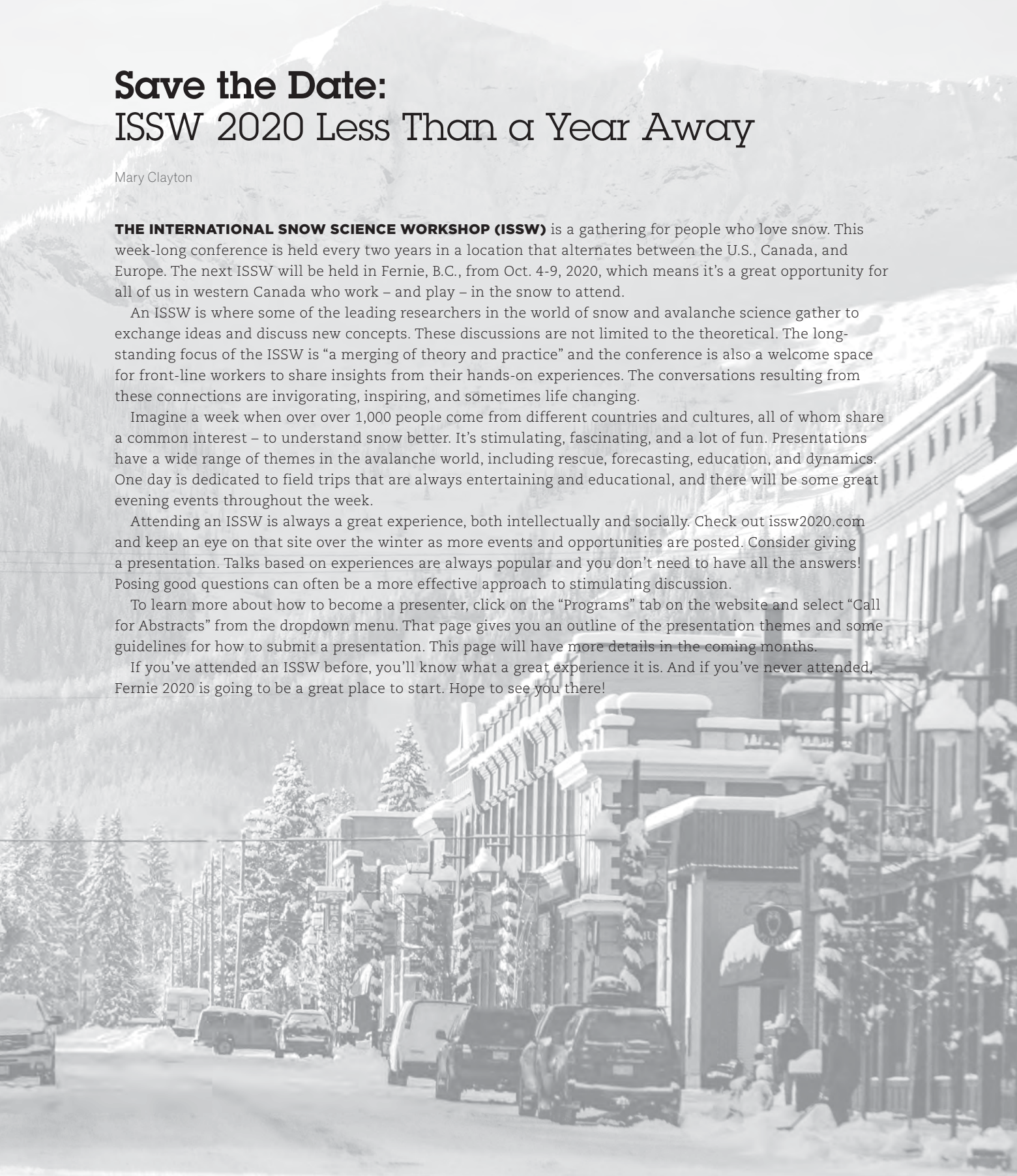
An ISSW is where some of the leading researchers in the world of snow and avalanche science gather to exchange ideas and discuss new concepts. These discussions are not limited to the theoretical. The long-standing focus of the ISSW is "a merging of theory and practice" and the conference is also a welcome space for front-line workers to share insights from their hands-on experiences. The conversations resulting from these connections are invigorating, inspiring, and sometimes life changing.

Imagine a week when over over 1,000 people come from different countries and cultures, all of whom share a common interest – to understand snow better. It's stimulating, fascinating, and a lot of fun. Presentations have a wide range of themes in the avalanche world, including rescue, forecasting, education, and dynamics. One day is dedicated to field trips that are always entertaining and educational, and there will be some great evening events throughout the week.

Attending an ISSW is always a great experience, both intellectually and socially. Check out issw2020.com and keep an eye on that site over the winter as more events and opportunities are posted. Consider giving a presentation. Talks based on experiences are always popular and you don't need to have all the answers! Posing good questions can often be a more effective approach to stimulating discussion.

To learn more about how to become a presenter, click on the "Programs" tab on the website and select "Call for Abstracts" from the dropdown menu. That page gives you an outline of the presentation themes and some guidelines for how to submit a presentation. This page will have more details in the coming months.

If you've attended an ISSW before, you'll know what a great experience it is. And if you've never attended, Fernie 2020 is going to be a great place to start. Hope to see you there!



THE MOUNTAINS LOOM ABOVE DOWNTOWN FERNIE // MATT KUHN

Rob Hemming Reflects

Andrew Jones

ROB HEMMING // PARKS CANADA

THIS FALL, CAA Professional Member Rob Hemming retired from his position as a senior avalanche forecaster with Parks Canada in Rogers Pass. Rob's career in the avalanche industry spanned 36 years in many different locations. We have been fortunate and are thankful Rob spent the last decade working with the avalanche control section at Rogers Pass. On behalf of the ACS crew, I would like to thank Rob for sharing his professional experience, friendly mentorship, and love of the mountains. Before sending Rob off into what I'm sure will be a fun-filled retirement, I asked him to share some memories of his career in the avalanche industry.

SNOW SAFETY

In the mid-1980s I had a close call with a deep slab release just out of bounds near the Lake Louise ski resort that really got my attention. At the time I was working on the pro patrol there. I could see the park wardens go on ski cutting missions, heli-bombing, and shooting their Avalauncher at the side of the mountain and I thought, "That looks really interesting. I want to do that."

Luckily for me, snow safety operations at the resort were transitioning from Parks Canada to Skiing Louise. It was the beginning of a new era. Some of us interested patrollers got picked to be part of a new snow safety team that consisted of park wardens and Skiing Louise employees, all reporting to Clair Israelson.

THE DREAM JOB

After a couple of winters at Lake Louise I lucked out again and got a job at Whitewater Ski Resort as the assistant to the snow safety supervisor Tom Van Alstine. Unfortunately, Tom blew a knee just before the start of the season and I found myself at the wheel. I had two winters there and it was an incredible experience. It snowed so much compared to what I was used to. I recall a 4.5-metre-plus snowpack at the treeline study plot there one spring. Heaven on earth, I thought at the time.

HIGHWAY CALLING

In November 1990 I was successful in convincing John Tweedy to hire me as a winter seasonal avalanche technician in the Ministry of Transportation highway avalanche control program at Kootenay Pass. I learned and experienced a lot in the winters I was there. It seemed like I had jumped from the frying pan into the fire.

Then, a full-time job came up in Stewart, B.C., with the MOTI Bear Pass Highway program. I was hired as the assistant to forecaster Tony Moore and my education continued as I came to grips with coastal snow. I was a new dad that year and I remember driving up to Stewart in the fall to clean the house and get things ready. My partner Janet came up a couple of days later with our newborn baby girl.

After four years in Bear Pass, I was beginning to settle into small town life in Stewart but there wasn't much for my wife and kids to do and so I began looking for opportunities elsewhere. A position opened up suddenly in Revelstoke so I contacted Bruce Allen and I told him, "Bruce, I've worked for the rest and now I want to work for the best." It worked and my family has made Revelstoke home ever since.

ROGERS PASS

In 2009, a forecaster's job opened up with Parks Canada in Rogers Pass. I applied, was successful and here I am today. I still have trouble believing it. I had always fantasized about working at the Pass but I assumed it was never going to happen for me. I could see you needed to start at the bottom and work your way up through the ranks after years of toiling in snow pits and data caves. But my timing was good once again as the avalanche control program at Rogers pass was in the process of a transition that included a modern succession plan and extra positions at the leadership level.

THANK YOU

How can I express my thanks to everyone who helped and supported me along this long run? My family, friends, mentors, co-workers and avalanche researchers – thank you so much. The quality of the people I worked with was just outstanding. I feel so proud to have been a member of the avalanche community and the CAA. I hope to see you all again sometime where the slope is steep and the snow is deep.

Close Call

A great day skiing amongst friends nearly turns tragic when one of them is buried three metres deep, despite deploying an airbag

Felixe Camire

ON THE MORNING OF JANUARY 27, 2018, I set out with three friends for a day of ski touring in Kootenay National Park. We hoped to catch up on the skin track and get some nice turns in the recent snow. It didn't go as planned.

I'm an ACMG ski guide and my friends have several years of backcountry skiing experience. We headed to Mt. Simpson, all equipped with avalanche safety gear and three with airbags. Our only objective was to explore the area and have fun.

The avalanche forecast for the day was rated as considerable/considerable/moderate, with the headline, "We have reached the tipping point for avalanches. Natural activity has slowed down, but the snowpack is perfectly primed for human triggering. Step way back in terms of your terrain use and exposure."

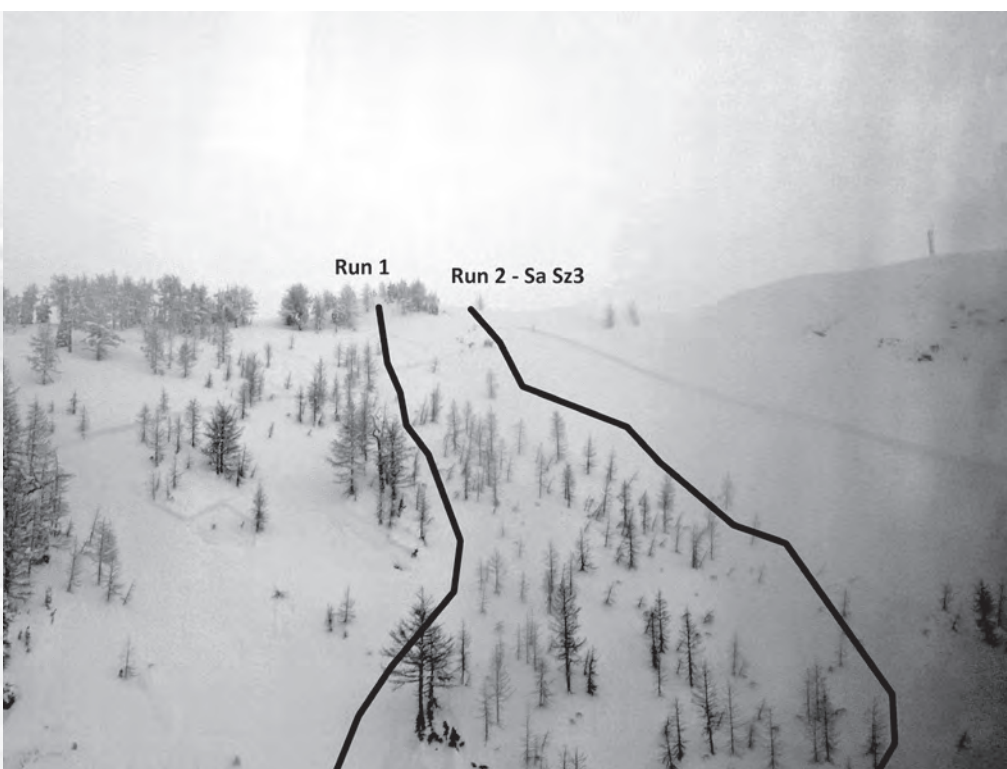
The problems were persistent slabs at alpine and treeline, with three weak layers within the previous three weeks, and wind slabs at alpine and treeline, with 75cm of snow in the previous nine days. In hindsight, perhaps this should have been enough to keep us away from most slopes.

We followed the regular uptrack from the road to about 2,100m. There was some whumpfing up to about 1,900m but above that things were quiet. Upon reaching the upper ridge at around 2,300m, we decided to ski a line in a large northeast avalanche path facing the road, entering it from a low-angled area below the steeper start zone.

The skiing was really good. There were no signs of instability in the path and we went back up for a second lap. Spirits were high as we summitted and headed for the upper northwest bowl. For run two, we chose a gladed line that seemed relatively conservative as it appeared well supported and not very steep.

We were somewhat headed into the unknown as we couldn't see the whole run to the bottom; however, the skiing was excellent and we found a fun line all the way down. We went one at a time and re-grouped once on a bench, and again at the bottom of the bowl.

Our next uptrack somewhat followed our descent as options were limited. Spacing out felt like the right thing to do in this convoluted terrain. There were no signs of instability as far as we could tell. We did not dig a snow pit.



LEFT: A RESCUER DIGS FOR THE VICTIM IN A HOLE THAT INDICATES JUST HOW DEEP THE BURIAL WAS.
RIGHT: AN IMAGE OF THE AVALANCHE, SHOWING THE GROUP'S FIRST AND SECOND RUNS IN THAT ZONE. // FELIX CAMIRE

Back on the ridge, we discussed two options: head back to the car via a line similar to our first run, or ski another shot close to our second. It did not take long to decide on the latter – the skiing was really good, we had enough time, and an uptrack was in place.

We lined up on the ridge about 50m left of our second run. The slope was a lot more open and was definitely attractive. For the first time that day, I did not ski first. I don't know why, it just happened. My friend dropped in and did three turns when the whole slope ripped wall to trees – a decent size two minimum. We watched him deploy his airbag, stay on top, and then turn and disappear around a corner towards a gullied feature.

"This couldn't be happening! What a nightmare!" I thought.

We instinctvely switched to rescue mode. We skied down quickly as we were worried of trauma due to the cliff bands, gullies, and trees on the lower slopes. The victim was nowhere to be found, with no surface clues. The fracture line spread across the bowl and the debris field was huge. The avalanche was much bigger than I thought!

The transceiver search started about two minutes after burial and it took less than a minute to complete the fine search. The minimum reading was 2.9m and we did not get a probe strike. We dug down about 75cm and did another quick transceiver search that indicated a sideways burial. The digging promptly exposed the inflated airbag, then a hand with moving fingers. That was positive!

The digging took a very long time and by the time the victim's face was exposed, there was no signs of breathing. More frantic digging followed to make space and expose the chest area.

The victim started breathing again. We all breathed sighs of relief and called for rescue with our InReach. We extracted him from the deep hole and he slowly re-gained consciousness, but was very cold. We supplied him with heat warmers, a new tuque, new gloves, and several layers of clothing, sat him on a backpack, and wrapped him in a tarp. The burial lasted 15-20 minutes.
It was an amazing feeling to see our friend alive.

I used my radio to call Parks Canada Public Safety but they had already received the call from the InReach and were mobilizing. The radio made it easy to organize the rescue. The helicopter arrived 20 minutes later and the victim was flown to the Banff hospital. He was discharged later that evening and has fully recovered.

Some thinking was required as to why the victim ended up buried so deep in such large and widespread avalanche debris with a deployed airbag. At first, it did not make sense; however, I believe I know what caused the full burial with the inflated airbag.

The avalanche was a size 2-2.5, but it was split halfway down by a rock fin/buttress. The skier's left went towards steep terrain that we did not ski. The skier's right side went toward our previous run. By the time the initial avalanche stopped in the run-out zone, the victim was possibly only partially buried. However, a sympathetic avalanche came down and completely buried the victim and previous debris. The combined slides produced the equivalent of a size three avalanche.

Moreover, even though the runout zone was wide and uniform, a large portion of the debris was concentrated in three deep and longitudinal piles. This is due to terrain characteristics above, such as gullies and rock buttresses, funneling the debris in specific areas. Finally, there was a fairly steep transition between the track and runout zone, possibly contributing to deeper debris where the victim was buried.

Here are some lessons I learned from the incident:

1. The avalanche bulletin can provide valuable information, don't overlook it. Contributing factors to us doing this were:
   a. The bulletin, for many days prior, had higher danger ratings (high/high/considerable then high/considerable/moderate) which most likely made it look safer than it was since the snowpack appeared to be healing.
   b. Moreover, the forecast in the Rockies is (too) often considerable, which made that forecast look somewhat "normal" that day – if you don't ski when it is considerable, you'll never ski.
2. Digging a snow pit might have provided clues indicating to not ski some lines. Taking 5-10 minutes to dig one might have changed our day.
3. Multiple and different communication devices, distributed in the group, can be useful.
4. Even if the victim was deeply buried, the airbag might have saved him by keeping him less deep than possible.
5. The debris pile was very rounded and probing perpendicular to the slope surface would have most likely helped fast-track the probing and digging.
6. Carrying a transceiver in your pants' back pocket is not ideal. We feel very lucky it was not damaged or stripped from our friend's body.
7. Carry lots of heat packs and extra gear. Even when going light, it can be essential to re-warm someone in the backcountry.

Thanks to our friends at Parks Mountain Safety for the fast and professional rescue.

The Avalanche Journal wants you!

WE'RE ACCEPTING submissions for upcoming issues of *The Avalanche Journal*. We welcome articles relating to the professional avalanche industry, public avalanche safety, teaching tips, research papers, avalanche accounts, book reviews, historical avalanches, gear reviews, hot routes, global updates, event listings, interviews, letters to the editor, humorous stories, and anything else interesting or relevant to those involved with avalanches. We are also seeking winter mountain photography: avalanches, terrain, touring, skiing, snowboarding, sledding, backcountry recreation or avalanche awareness activities.

Please email managing editor Alex Cooper at acooper@avalancheassociation.ca with your ideas and submissions.

The Avalanche Journal is published three times per year in March , July and November.

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February 14 (winter issue)
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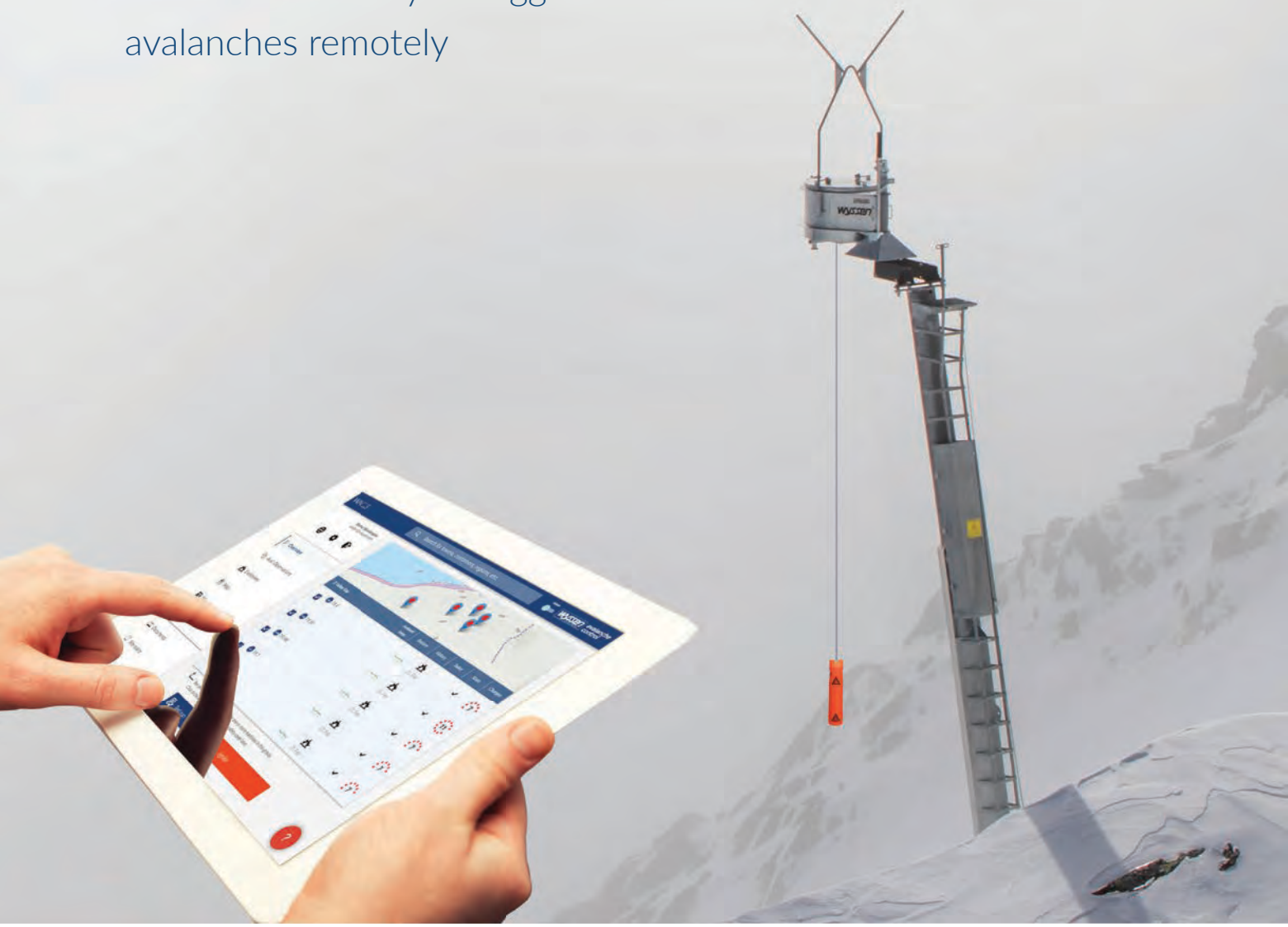

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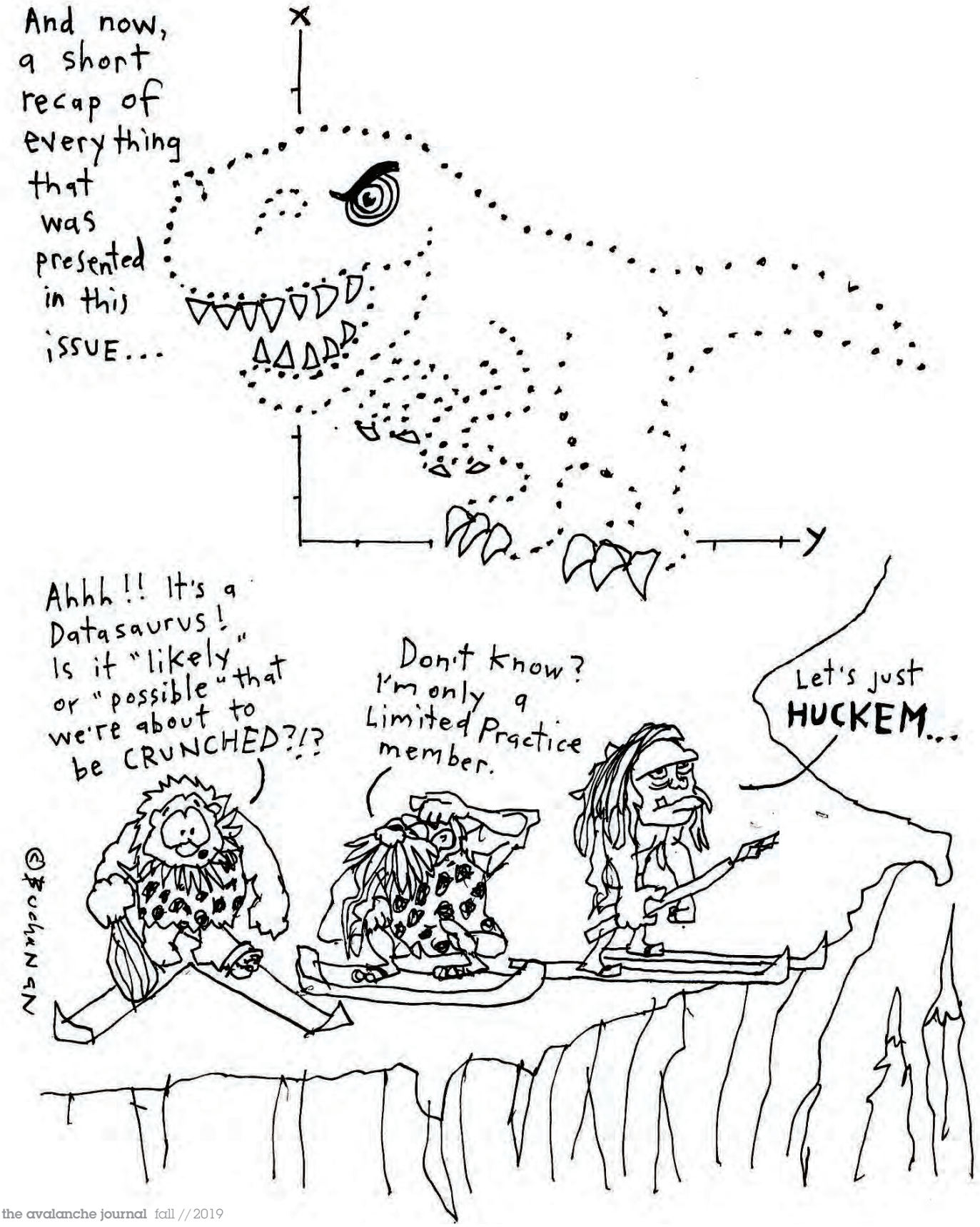

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