A Publication of the American Avalanche Association

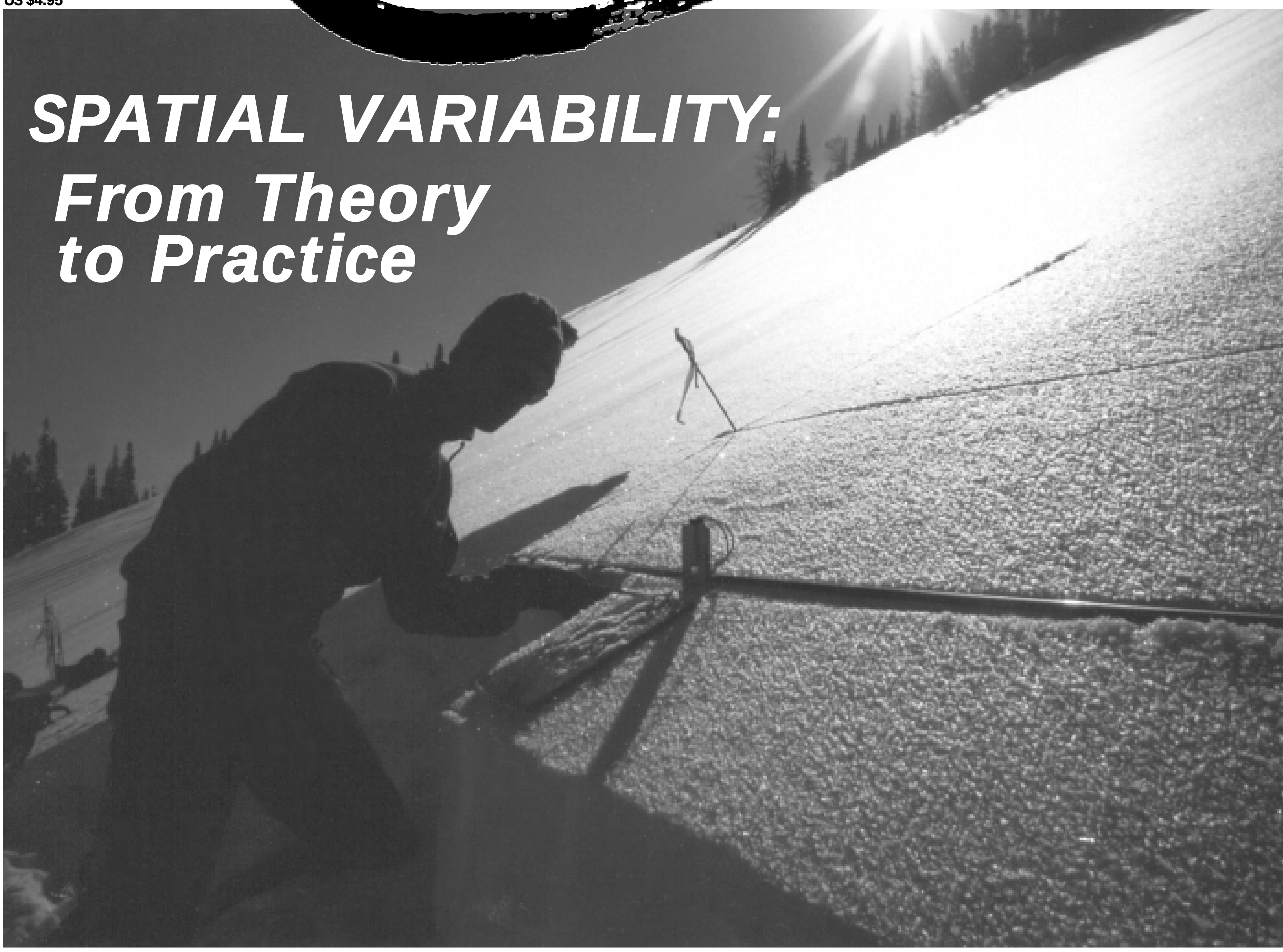
THE Avalanche REVIEW

VOLUME 22, NO. 4 • MAY 2004

Web site: www.AmericanAvalancheAssociation.org

US $4.95

SPATIAL VARIABILITY: From Theory to Practice



Jeff Deems conducts a Quantified Loaded Column test as part of spatial variability studies. Bradley Meadows, Montana.

photo by Chris Landry

The 2002 ISSW in Penticton, B.C., brought us a variety of reports on the topic of spatial variability—the concept that uniformity in snow cover is rare. We saw that stability tests such as the rutschblock or stuffblock performed next to one another on a slope often produce very different scores. As practitioners, this research left us confused and less assured of our ability to make good decisions in an unpredictable world. So, *The Avalanche Review* turned to a variety of researchers and practitioners who've been examining and operating effectively within the constraints of spatial variability for years. With the assistance of Karl Birkeland, we composed the question:

How does research into spatial variability, and your experience with that variability, affect the way you evaluate avalanche conditions?

and began an email round table to help translate theory into practice. Perhaps their perspectives can help us to determine where and how to sample the system in order to give us the most accurate representation of stability. *Continued page 15* ➡

In This Issue

…There is a sense of independence and self-sufficiency that you don't always get when you go with a man.

—Carol Ciliberti

Travelling in All-Women's Groups page 13

THE Avalanche REVIEW

MAY 2004 • VOL. 22 • NUMBER 3

The Avalanche Review is published each fall through spring by the American Avalanche Association, Inc., a non-profit corporation. The Avalanche Review welcomes the submission of articles, photographs and illustrations.

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The American Avalanche Association

The mission of the AAA is:

A. To provide information about snow and avalanches;
B. To represent the professional interests of the United States avalanche community;
C. To contribute toward high standards of professional competence and ethics for persons engaged in avalanche activities;
D. To exchange technical information and maintain communications among persons engaged in avalanche activities;
E. To promote and act as a resource base for public awareness programs about avalanche hazards and safety measures;
F. To promote research and development in avalanche safety.

Subscription: $20 per year (4 issues). The price of subscription is included with membership dues to AAA. See www.avalanche.org/~aaa for subscription and membership information.

Contributions: Please submit material eight weeks prior to publication date. Include address and telephone number. Please submit typed manuscripts by e-mail or disk (3.5", Zip or CD), using any popular word processing program. Submit any figures in B & W, or as a TIFF or JPG file (300 dpi resolution at 100%). We will return materials if you include a stamped, self-addressed envelope.

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

Layout & Design: Karen Russell, Fall Line Design, (208) 354-2000, karen@FallLineDesign.com.

FROM THE PRESIDENT: RUSS JOHNSON

The Christmas and New Year storms passed across the West leaving great skiing and significant avalanches as well. Burials were reported from Donner Pass and Alpine Meadows to the Sawtooths to the Wasatch. Almost all, of course, were preventable, which is what is so frustrating. Even out here in the Sierra, we have been seeing one to two avalanche deaths a season now for the last three or four years.

Partially in response to this increase and partially because we see the need for a full scale avalanche center, I attended a meeting at the Forest Service office of Bob Moore which was intended to get the ball rolling for just such a thing. Ah, the birthing pains of yet another avalanche center. Bob has been in something of a unique situation in Truckee as one of the Forest Service's last Snow Rangers. He has been independent of the National Avalanche Center's network. At the same time, he is in charge of overseeing the recreational activities of a large area and is not specifically charged with providing avalanche warnings. He has been doing this as a service when the avalanche danger is "considerable" or higher.

Bob covers the area from Sonora Pass just north of the small town of Bridgeport to Yuba Pass some 100 miles to the north. This job, forecasting for 100 miles of the Sierra, would be considered ludicrous as a one man job—even if it were his only job or even his primary job—were it not for the inherently stable nature of the Sierra snow pack. That said, there is no question that the area could use a real forecast center and thus the initial meeting in Bob's office.

The meeting was attended by only eight people. The good news is that one of them is a professional fund raiser for non-profit organizations. Another was Dave Beck, an old-time patroller and current educator and guide out of Lake Tahoe's south shore. Besides myself, there was a smattering of back country riders who are anxious for a more active avalanche center. Giving some impetus to the group is also the fact that Bob Moore will be retiring in four or five years and the area will need a replacement. What came out of the meeting was first (of course) the need for funds for one employee for five months. Fortunately, in our area there are at least two foundations with possible funding for this sort of thing. In addition, the Forest Service can partner with local businesses and provide web exposure for them. The American Avalanche Association may be able to help either directly or by passing the funding through our 501 3(c) status as we do with other friends groups. In addition, the new center can hold the typical fund raising events.

The initial goal is simple and attainable. Raise enough money to hire one person to help Bob. The job would entail meeting with ski area patrols from Bear Valley to Sugar Bowl to Mt. Rose and getting them to contribute weather and snow pack information on a regular basis, meeting the PR needs of the press which can be excessive after an avalanche fatality or big storm cycle, updating the web site daily and—oh yeah, did I mention? —get out in the backcountry and check it out. A big job and certainly one which could be bigger than one or two people, but you have to start somewhere. So, if things go well, look for a new, improved Sierra Avalanche Center next winter.

Not much else to report from the President's desk right now. The typical January preview of spring skiing in the Sierra is in full swing under clear skies and 50 degree temperatures. The AAA internet store is open and a steady stream of business is passing through its virtual door. Check it out on our Web site. All the best for the second half of the winter. ❈

FROM THE EDITOR: LYNNE WOLFE

As I sit down at my desk to write this editorial, the rain is dripping off the eaves into the yard. The rain line is up to 9000'; the Grand Teton is heavily rimed. I am thinking about the buried surface hoar from our January high pressure; it was half a meter down, 15 mm and standing straight up the last time I looked. That layer showed us all five lemons, and two days later an open pocket in the middle of steep trees pushed a friend waist-deep in debris into the creek. We've been tiptoeing around that surface hoar for a month now; will the rain flush out the slabs sitting on it? or heal it with some heat? I just know that I still don't trust it, and I want to ski with other folks who have a healthy fear of that unknown dragon, who say, "I wonder…," rather than, "I want…"

In planning avalanche courses for this winter I tried to translate some of the ideas from the AAA Education Forum and from Ian McCammon's *Heuristic Traps in Recreational Avalanche Accidents* (see TAR 22/2 and this issue, page 11) into action. This looked like presenting a variety of rule-based decision-making schemes to students, with the caveat, "If you choose to break the rules, you need to have science on your side. And the final unbreakable rules are the safe travel rituals." "Aha," they say, "we are starting to get it." Feedback from recent courses said that "choosing partners carefully" is one of the most valuable concepts they gained from the course. Perhaps that is the one best choice that can break a chain of bad decisions. (See Russ Johnson's *Breaking the Chain* in TAR 21/4.) A good backcountry partner knows the value of spirited discussion, the importance of ritual, humility, humor, self-awareness, chocolate, and a headlamp.

This year I've also been talking about the veto power of intuition. Dick Dorworth writes:

> **"I had a feeling of imminent danger too strong to ignore. I stopped immediately and searched for a sign to match my feelings. I saw nothing but spring skiing and great weather. Nevertheless, I insisted we abandon the run and take another way. This involved a strenuous hike up instead of a leisurely run down, and my skiing partner was both doubtful and unhappy about my resolve to change plans. Still, he came with me… When we emerged, the first thing we saw was that the face we had been skiing had avalanched to the ground while we were inside analyzing what had just happened."**

As instructors we acknowledge the power of intuition; in discussion someone might bring it up as "women's intuition," but hardened scientists and statisticians allude to intuition in their presentations as well. We try to describe it as data we don't have vocabulary for yet, best accumulated via mileage and the process of becoming old mountaineers. And now, as I finish up my class schedule for 2003-04, I am wondering how we canteach this intuition. Should we name its parts and the communication tools that make it up? Shall we present more and more sophisticated forms of pattern recognition, noting subtle differences, "one of these things is not like the other ones?" Or perhaps we teach people to build into their decision-making another ritual that calls for a pause to the constant monologue, and creates a cool, quiet, internal courtyard where, just for a moment, we can picture the buried dragons. ❈

The Avalanche Review: A Call for Submissions

- Seen any good avalanches lately?
- Got some gossip for the other snow nerds out there?
- Developing new tools or ideas?
- Learn something from an accident investigation?
- Send photos of a crown, of avalanche workers plowing roads, throwing bombs, teaching classes, or digging holes in the snow.
- Pass on some industry news.
- Tell us about a particularly tricky spot of terrain.

Write it up; send it to us. *The Avalanche Review* is only as good as the material you send. TAR is accepting articles, stories, queries, papers, photos. We can help if you're not sure how to write it up.

TAR Deadlines:
Vol. 22, Issue 4 is March 15, 2004
Vol. 23, Issue 1 is August 15, 2004

Send text as .doc or .rtf files.
Send photos as grayscale .jpg files.

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LETTERS TO THE AAA

Dear AAA Members,

I would like to thank the AAA for inviting me to speak on behalf of the American Institute for Avalanche Research and Education (AIARE) at the Education Seminar in Snowbird, Utah. I hope that I helped describe what our organization is about and made it clear to everyone that we are pro AAA.

During the course of the weekend, Steve Conger brought to my attention that the AAA Professional Membership as well as the AAA Certified Avalanche Instructor rating should be something we consider putting in our course leader qualifications. I agreed. This is something that was overlooked by AIARE in its initial draft. It is now included as a recommended qualification in our L1 and L2 Course Leader Qualifications.

I appreciated the many positive as well as constructive comments I received after the talk. I would hope that the AAA and AIARE could work together in making a difference in avalanche education in the future.

To look over some course material samples go to the link below. Log in is: ***course*** and pass is: ***samples***.

www.avtraining.org/samples/samplesmain.htm

I look forward to hearing from anyone with questions or interest in the program.

Sincerely,
Tom Murphy
Executive Director, AIARE
970-209-0486
info@avtraining.org

METAMORPHISM

Congratulations to these new **AAA Certified Avalanche Instructors:**

Dave Beck
Kelly Elder

AAA thanks the following members for contributing an additional donation to further our efforts:

Jerry Roberts on a "Tea Break" during a control day. Note Tetley Drawstring tea bag: *The Tea of Explorers*. The CAIC's British/Chilean intern Mark Rawsthorne has brought a new level of sophistication to avalanche work in Silverton.

photo by Mark Rawsthorne

EDUCATIONAL ENDOWMENT FUND

Russ Johnson
Dave Ream
Susan Hale
Jonathan Epstein
Dave Hendrickson

PATRON ($500-999)

Halsted Morris
Stuart Thompson

SUSTAINER ($250-499)

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Craig Wilbour
Steve Karkanen
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John Hereford
Roland Emetaz
Franz Kroll
Martin Radwin, M.D.

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Julie Hesse
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Dave Ream
Christopher Barnes
C.J. Ware
Backcountry Access
Rocco Altobelli
Stan Bones
Steve Hackett
Ted Cramer
Terry Chontos
Eric White
Rey Deveaux
Nicholas Grace M.D.
Joe Kanetsky
Randy Elliot
Margaret Holman

EVENTS

European Geosciences Union General Assembly

The European Geosciences Union (EGU) will include two sessions on avalanches at its General Assembly in Nice, France on April 25-30, 2004. The sessions will be part of the Natural Hazards and Cryospheric Sciences programme.

The Snow Avalanche Formation session is devoted to the latest results and views on snow avalanche formation from field, laboratory and numerical studies. Topics will include contributions on mechanical properties and texture of snow, snow cover simulation, contributing factors (including drifting and blowing snow), spatial variability, snow slab release mechanics and avalanche forecasting.

The Snow Avalanche Dynamics session symposium is dedicated to experimental, theoretical and numerical investigations of flowing and powder snow avalanches. It will emphasize granular flow dynamics, experimental techniques and sites, practical application of numerical models to predict avalanche runout distances, flow velocities and impact pressures, interaction with obstacles.

The deadline for pre-registration is April 8, 2004. Additional details can be found at: **www.copernicus.org/EGU/ga/egu04/index.html.** ❊

14th World Conference on Disaster Management

The Canadian Centre for Emergency Preparedness (CCEP) is hosting the 14th World Conference on Disaster Management (WCDM) in Toronto, Canada from June 20-23, 2004. The WCDM is an annual event that addresses issues common to all aspects of disaster / emergency management. The conference program includes speakers from many parts of the world and provides excellent opportunities for training and networking among those in Emergency Planning / Management, Emergency Response, Disaster Management Research, Business Continuity, Risk Management, Security, IT, HR, Environmental, as well as for the organizations which supply and service these professions. The 2004 Conference is expected to attract over 1,200 delegates from Canada, the US and from around the world. The Conference theme will be: *The Changing Face of Disaster Management—Are We REALLY Prepared?*

For more details about the conference, go to **www.wcdm.org/.**

Contact Adrian Gordon at (905) 331-2552 or email: agordon@ccep.ca with any questions. ❊

5th European Conference on Applied Climatology (ECAC)

The European Meteorological Society (EMS) is organizing and hosting the 5th European Conference on Applied Climatology (ECAC). The conference will emphasize interdisciplinary topics such as instruments and methods of observations, atmosphere and the water cycle—a real-time look, computing in atmospheric sciences, and information provision and education. The applied climatology conference is a feature of the EMS Annual Meeting and will be held 26-30 September 2004 in Nice, France. For further information and input, please visit **www.emetsoc.org/ems_4th_annual_meeting.html**.

More general information on the European Meteorological Society is found at **www.emetsoc.org**. ❊

Ed LaChapelle Retrospective at Mountain Film

Ed LaChapelle, renowned North American Avalanche Pioneer and mentor to many avalanche professionals, will present a retrospective of his 50+ year career at the Telluride Mountain Film. The tribute will include insight into such notable pioneer endeavors as the Alta Avalanche Center, the Blue Glacier Project, and the San Juan Avalanche Project, as well as international collaborative work through consultation and his position at the University of Washington. The Telluride Mountain Film Festival is scheduled May 28-31, 2004.

More information is available at **www.mountainfilm.org.** ❊

ISSW 2004

The 2004 International Snow Science Workshop is scheduled for September l9-24, 2004, in Jackson Hole, Wyoming. Mark the dates and reserve your space now. Tuition is $2l5 until August 3l, 2004, and $235 after that date. Registration and information is available at **www.issw.net**. Organizers plan a field session on Teton Pass and Jackson Hole Mountain Resort for Wednesday, September 22. The Web site includes criteria for submitting presentations and posters. ❊

AAA NEWS

Proposal for AAA Operations Course

By Don Sharaf and Michael Jackson

There has been a rumbling in the U.S. avalanche community for some time about the need for a standardized, high-level avalanche class geared toward the beginning avalanche professional. Historically, avalanche education in the US has been offered by businesses and individuals with differing views on what is important in avalanche education. As such, each entity has taught their own curriculum resulting in a large variability in quality and comprehensiveness. Ski patrol directors, mechanized ski operations, and private guiding companies have often dealt with this issue by sending their employees to Canada to take Canadian Avalanche Association Training Schools (CAATS) courses.

Denny Hogan addresses this issue in comments to the AAA Education Committee: "Many Level 1 and Level 2 classes now being taught are poor courses. Standards have dropped, and the AAA is in a position to bring the standards back to a high level. Why do people want to go to Canada for CAATS courses? The answer is they know the classes are professional and at a very high standard. This same standard needs to be the goal of the courses taught by the AAA."

There is momentum in the States to develop a program similar to the CAATS programs for beginning avalanche professionals. Do you, as a member of the AAA, feel that this is an area that the AAA Education Committee should be putting time and resources into developing? It is a daunting task to contemplate, yet there is a pool of talented professionals willing to put their volunteer efforts into the course development.

Rod Newcomb, longtime avalanche professional and owner / operator of the American Avalanche Institute writes: "The AAA is in the business of certifying avalanche instructors. The next step is to put those instructors to work using their skills and experience to teach an avalanche course sponsored, organized and run by the AAA during those months when there is snow on the ground."

Through the input of members of the education committee, a mission statement, target audience and draft curriculum has been drawn up. In the next three months, we will continue to research the logistics, venues, and challenges associated with running an avalanche operations training course. In April, we will present a proposal to the governing board asking for their approval. If you would like to see the work in progress, it will be available for the review of professional members on the electronic patrol shack of **www.avalanche.org**.

The AAA needs to be as efficient as possible in our efforts, and any background information, insights or general comments the AAA membership could provide would help us along toward that goal.

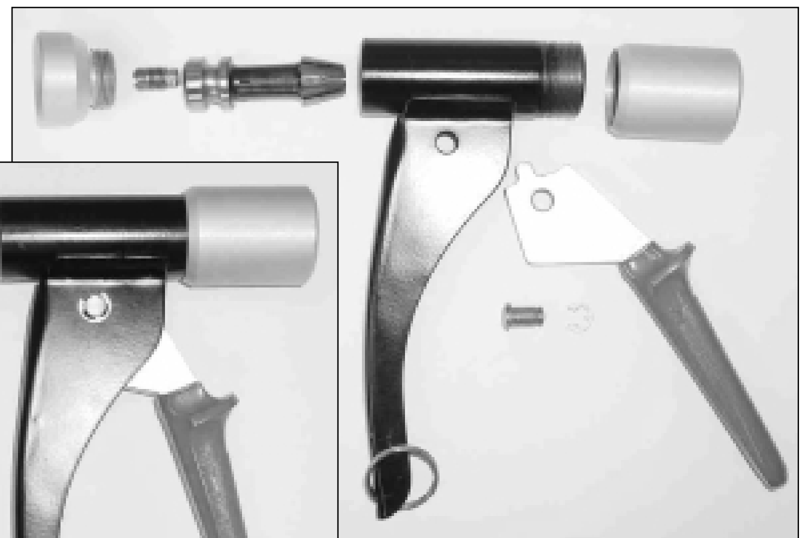
Please feel free to contact both Don Sharaf (don@tetonavalanche.us) and Michael Jackson (Powderhino@aol.com) with your comments. ❊

WHAT'S NEW

Inauen-Schätti Hand-held Crimper

Reviews & photos by John Brennan

Although the folks at Inauen-Schätti's Swiss factory have bigger fish to fry selling their Avalanche Guard (formerly Dopplemyer's Blaster Box) and other avalanche safety systems, they are also marketing a new hand-held crimper. The tool neatly triple crimps varying lengths of detonators to safety fuse. An attached key turns a small set screw to vary the penetration depth that a detonator can be inserted in the device. As with other bench style crimpers, the unit is designed to contain and redirect the energy of an unlikely pre-detonation. The unit will sell for approximately $225; direct inquiries to their U.S. based engineer, Oswald Graber, at ograber@seilbahnen.ch. Their other avalanche safety products can be viewed at: **www.avalancheguard.com** ❊



Left: the new Inauen-Schätti hand-held crimper.

Above: A disassembled crimper.

ISSW Video Library Now Available

A valuable teaching tool and memory aid

The ISSW Video Library is a box set of 8 tapes in VHS format. Cost is $89.99 (US).

For more information and the order form, please go to:

www.isswvideos.com

info@isswvideos.com

Kellie Erwin
250-344-5707

Ryan Gallagher
250-344-4666 ❊

TT 457 Training Transmitter

Avalanche educators face a common problem when teaching transceiver searches: how to demonstrate and practice the entire search procedure, from coarse search to pinpointing, in the confined space of a classroom. Ideally, such teaching requires a space of 50 x 50 meters.

Girsberger Elektronik's new TT 457 Training Transmitter enables educators to demonstrate search scenarios in a 5 x 5 meter area. Inside the TT 457's battery compartment are two rotary switches for selecting transmitting power and signal characteristics. You can configure the TT 457 to duplicate the pattern of a particular beacon, but at a signal strength which reduces the range by a factor of 10. The signal intensity at 3 meters will, for example, correspond to a signal at 30 meters for the actual beacon. This capacity allows educators to simulate various rescue scenarios, even multiple burials, in a classroom.

The TT 4577 is about the size of a matchbox and weighs 75 grams. It operates for more than 500 hours on a normal battery.

Contact Girsberger Elektronik A, Mettlenstrasse 33b, CH-8193 Egilsau / Switzerland, phone ++41 (0) 1 867 00 49, (0) 1 867 31 12. Email: info@girsberger-elektronik.ch, **www. girsberger-elektronik.ch**. ❊

Ortovox Donates to Colorado Avalanche Information Center

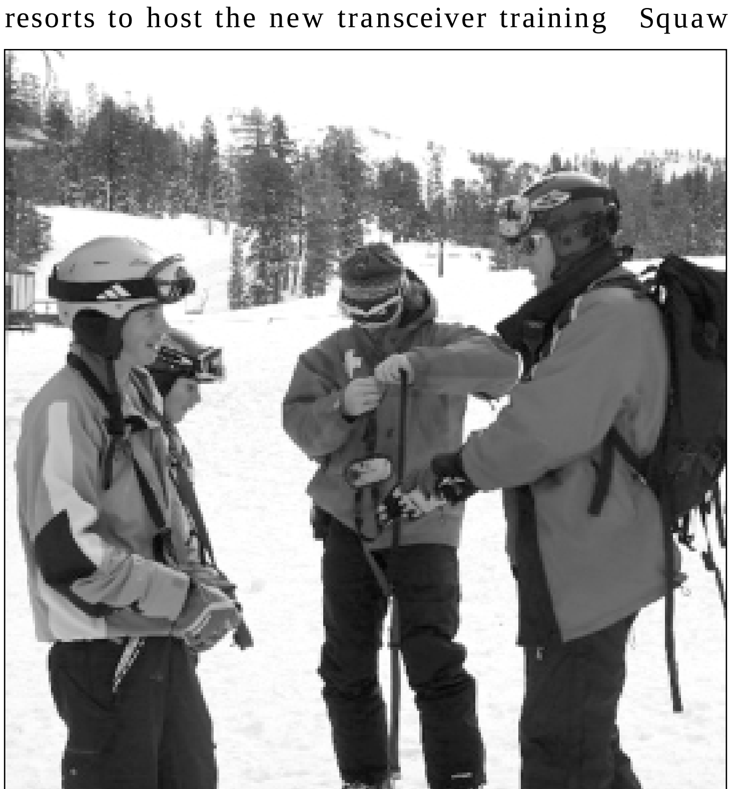
On December 3, 2003, Ortovox visited the Colorado Avalanche Information Center's (CAIC) Boulder office to donate funds and equipment. Marcus Peterson, General Manager of Ortovox USA, presented Knox Williams of the CAIC, with two Ortovox X1 transceivers and a $500 donation. "The CAIC looks to private donors to help provide funding and equipment," said Knox Williams, Director of the CAIC. "Ortovox's generous donations will subsidize education courses, teaching and help us purchase more equipment."

"The CAIC is a strong, knowledgeable group that is truly making a difference and saving lives in the state," said Marcus Peterson, GM of Ortovox. "Ortovox is proud to support this group and bring more people safely into the backcountry."

In the last decade, the CAIC has reached over 25,000 backcountry skiers, snowboarders, snowmobilers and enthusiasts with avalanche courses throughout Colorado. For more information regarding Ortovox and their range of avalanche safety products, visit the Ortovox web site at **www.ortovox.com**. ❊

BCA "Beacon Basin" Training Sites Go National

Backcountry Access (BCA) opened two more "Beacon Basin" training sites at the end of January, expanding its "Beacon Basin" transceiver education program to seven sites in the U.S. and Canada. Alpental, Washington and Arapahoe Basin, Colorado are the latest resorts to host the new transceiver training venues. They join existing sites at Kirkwood, CA; Stevens Pass, WA; Bridger Bowl, MT; Whitewater, BC; and Kokanee Glacier National Park, BC. Additional training sites are in the works at Alta / Snowbird, UT; Squaw Valley, CA; Canmore, AB, and Revelstoke, BC.



BCA launched the Beacon Basin program in 2002-03 with a pilot site at Loveland Basin, Colorado. The program's objective is to "raise the bar on transceiver education," according to BCA Vice President Bruce Edgerly. "With the revolution in digital beacon technology over the past five years, finding single transmitters has become a simple task," said Edgerly. "These training sites make it easier for recreationists to practice deep and multiple burials."By permanently burying the transmitters and controlling them remotely, trainers can eliminate the time-consuming process of excavating and re-burying transmitters between searches.

Depending on the site, Beacon Basin features 6 to 14 permanently buried transmitters wired to a central control panel. The panel consists of up to 14 switches for turning the transmitters on and off, plus a remote power supply consisting of 6 alkaline D cells. These sites are hosted by local avalanche professionals and managed by BCA technical representatives. To organize a transceiver training day at the Beacon Basin in your area, contact BCA at (303)417-1345 or Steve@bcaccess.com. ❊

Kirkwood hosted a Backcountry Access "Beacon Basin" transceiver training seminar this winter. The ski patrol instructed interested guests on how to use BCA transceivers as part of the resort's backcountry awareness program.

photos courtesy Kirkwood Mountain Resort, California

MEDIA

PowerPoint Presentations—Ideas for Using PowerPoint Successfully

By Don Sharaf

More and more people are embracing digital presentation, and Microsoft PowerPoint has rapidly become a common tool for avalanche educators and presenters across North America. Some people use PowerPoint for slide show presentations of their digital images, while others use the program as a digital chalkboard for their lectures. Over the past four years I have been converting my old 'visuals' into PowerPoint using scanned images of drawings and 35-mm slides. When I design a new class from the ground up, I now do it directly in PowerPoint using a library of scanned 35-mm slides that I have collected and taken. The addition of a digital camera this spring has greatly added to my avalanche library as well. For tips on digital photography and manipulating photo files, see Bruce Tremper's articles in the previous two issues of *The Avalanche Review*. The ease of finding the images I want and the ability to make changes up to the last minute make PowerPoint a useful tool for me.

My intention with this article is to point out some qualities of effective PowerPoint presentations, and also to illustrate some of the most common pitfalls I've noticed. Following these general guidelines, I'll offer some nuts and bolts tips for designing presentations. I am by no means an expert with the program, but I do have a few tips to share. First and foremost, realize that PowerPoint is no substitute for knowledge and experience. Teaching skills and field experience are paramount in effectively communicating your material.

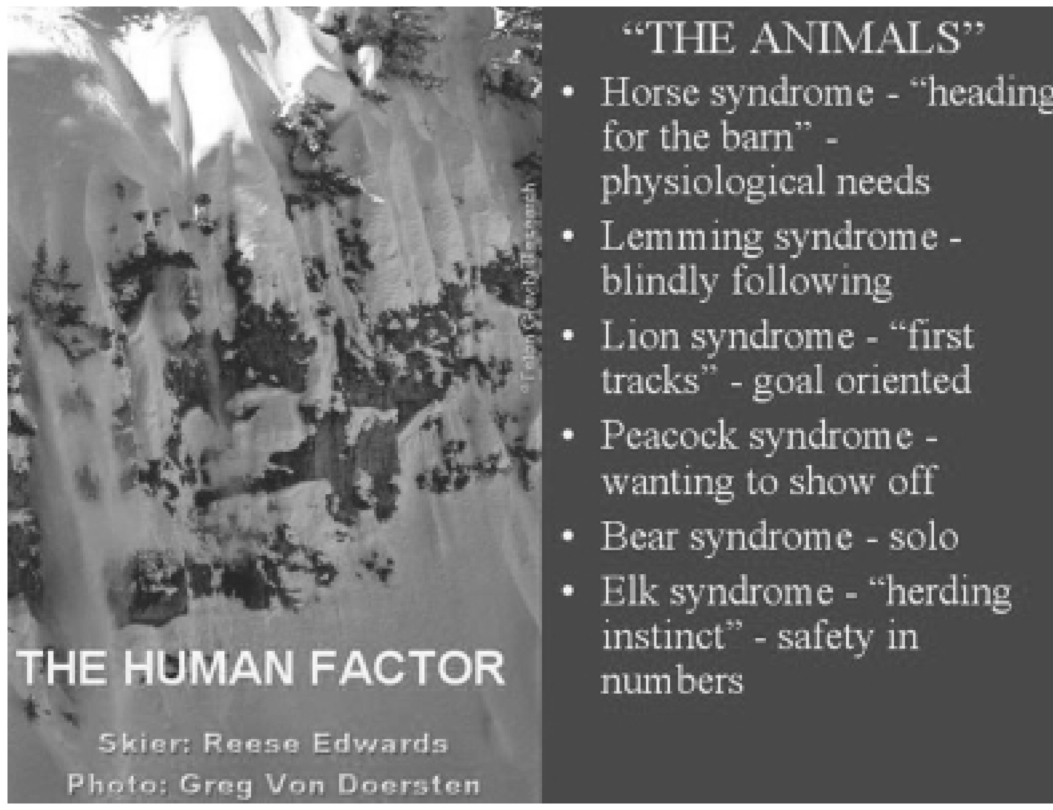


figure 1

Do's

Keep it simple! What I mean to say is, **KEEP IT SIMPLE!!!** There is often enough room to fit all your text for a topic onto a given slide (meaning page of the presentation). Don't do it! The less you use the screen as a teleprompter and the more you use it to enhance your point the more effective your talk will be. Marketing guru Seth Godin suggests no more than six words per slide…EVER! While I think that is a little limiting, his point is a good one. Attempt to make your point using as little text as possible on each slide. The goal for your slides should be for them to reinforce your words, not repeat them. *Figure 1* shows an example of too much text for the slide. *Figure 2* breaks down the "syndromes" of the first slide into one point/slide.

Make it legible. The pictures, illustrations, or graphs you use should be clear and legible at great distances. Virtually all slides will appear legible when you create them on the computer two feet away. Certain colors are much easier to see than others. The key to clarity is using large fonts and clear colors. The acid test is standing at the back of your presentation area and seeing how easy it is to read the text or view the image. Most avalanche classes will place students within 30 feet (9m) of the screen, but the audience for ISSWs could be up to 150 feet or more (45m+) away. To create a color scheme for your presentation, right-click on your slide in normal view and choose Slide Color Scheme, then choose the custom menu and design your own color scheme or choose one of the standard offerings.

Credit your sources. If you are using other people's photos (with their permission), then insert a textbox giving them credit. *Examples are shown in figures 1 and 6.* To add a text box, go to the Insert menu:Text Box, or click on the text box symbol of the drawing toolbar. If you are using scanned images from textbooks, journals, ISSW proceedings, etc., then you may be legally obligated to obtain the author's permission.

A few more words of advice:

- For dark rooms, a dark background with lighter text is easier to look at than a white background.
- Red is hard to read both as text and background—stay away from it whenever possible.
- Use a background color that has high contrast with the text. Commonly, I use a dark blue background with yellow and bright green text.
- Font size should be 30 or greater with 44+ for the title text. You can modify the font type and size on the slide master (View:Master:Slide Master).

Don'ts

A lot of the blame for poor PowerPoint presentations can be pinned on Microsoft itself. They have overloaded the program with atrocious design templates, dizzying animations, lame clip-art, and distracting transitions. Avoiding the whiz-bang products that come packaged within the program is a big step toward designing an effective presentation.

In the theme of keeping it simple, avoid cluttering your slide with **unnecessary backgrounds**. The PowerPoint design templates are notorious for detracting from the intended message *(compare figure 3 with figure 4)*. If you want the slides to be recognized as having been made by you or your company, you can insert a footer on the Slide Master. A large logo belongs on an introduction or credit slide and can be distracting if shown on every slide (*see Figure 7)*.

Don't let the ease of the PowerPoint format suck you into teaching material that you are not comfortable presenting. People may be generous with their presentations and allow you to use them. Realize that you must be intimately familiar with the material to avoid getting stuck somewhere in the presentation. **A seemingly random photo, inexplicable graph, or odd text** can all cause you to stumble. Most presentations are designed specifically to be taught by the designer—a picture that means nothing to anyone but the designer can be distracting unless you have the story that goes along with it. Think of how many avalanche pictures you have seen—they likely meant nothing until you heard the story associated with them.

Slide transitions, or the transfer from one slide to the next in the Slide Show mode, are another way to get your audience to think about the magic of computers instead of the topic at hand. Remember: Keep it simple!

figure 2

Navigation within PowerPoint

Moving easily between editing and presentation modes is helpful when designing a presentation. I find the easiest way to create the slides is in Normal View. I don't worry about the slide order until I'm finished creating the slides. Under the View menu of the main toolbar Normal View will show you an outline of the text on the left side of the screen with the actual slide image on the right. When you are done creating slides, you can organize the slides into order by going to Slide Sorter view. Slide Sorter is like looking at a light table of your 35-mm slides. Shuffling the slides is as easy as dragging them to the desired position with the cursor. The good news is that once you have created the slides successfully, none of them will be upside down or backwards. To see how the slides will present in a slide show, either go to View: Slide Show or simply press F5. To exit from the slide show, press the Escape key (Esc). I alternate between views many times in the process of creating a presentation.

Know how to move around the presentation when you're in Slide Show mode. If someone asks you to go back to a particular slide, or you clicked through too fast you should be able to go where you want. Become familiar with the Slide Navigator (accessed via a right-click of the mouse and "Go" on the menu, or by moving the cursor to the lower left hand side of the screen on Macintosh computers and clicking on the shadowed box). A very useful tool can be accessed by right-clicking on the slide, going to Pointer Options, and choosing Pen. The "pen" turns the cursor into a drawing tool allowing you to emphasize points on the slide (e.g. crown and flanks of an avalanche, tight isoheights on a weather map, especially nice ski tracks, etc.).

Animations and Drawing

Animating the introduction of text, graphics, or pictures is a double-edged sword. Animations can really help illustrate a point, or slow down the introduction of text. The downside is that it takes time, and some trial and error, to get everything to look as you desire. In figure 5 I have a picture of a slope to which I then add ski tracks (blue lines) with each mouse click. When the third "track" hits a weak zone (red oval) a shear fracture propagates… An effective illustration perhaps, but time consuming to put all together. Showing the "Seventh Skier Footage" could accomplish the same thing and the true techies could incorporate that footage into their PowerPoint presentation. In Figure 6, I used a photo as the page background (Insert Picture: From File) and then added some simple drawing (Drawing Toolbar) to illustrate the slope angle. Adding a text box with each point appearing after a mouse click completed the slide.

About animation of text:

- Choose simple animations. I prefer to have text and photos "appear." Having them fly into position from different positions, crawl, spiral, checkerboard… is more distracting than helpful. Your audience may be wondering more about which special effect will follow, rather than pondering the slide's content.

- You can layer photos and show a sequence of action using animations. The Order and Timing toolbar under Custom Animation will allow you to organize what picture shows when. When the animation becomes really complex, I prefer to use several slides where the text or graphic position remains consistent. Multiple slides are easier to edit than one elaborate animation sequence. If there are more than five animations on a slide, I will try to break it up into several slides.
- When you are using objects and lines from the Drawing Toolbar, it is often helpful to Group the objects together. You can do this by holding the Ctrl key down while clicking on lines, objects, photos, etc., that you want to be considered as one object. Once you have all the points clicked, hover the cursor over one of the points and right-click for Grouping and choose Group. Once you have a group, you can move it around the slide as a unit or animate it to appear or disappear as wanted.
- The drawing toolbar can also be used for aligning objects. Click on all the objects that you wish to align (vertically or horizontally), then click on the Draw box of the drawing toolbar. From there you will have many options to manipulate your objects or pictures including: nudge (move by smaller amounts than dragging with the cursor will allow), align, distribute, rotate or flip.
- Avoid animations with sound effects. If you have recorded sounds, interviews or sound bites then use them, but avoid the canned noises that announce the delivery of your next animation.

Pictures

Pictures and graphics are what can make a PowerPoint presentation more effective than simply talking or using a chalkboard / whiteboard / flipchart / pictographs. PowerPoint can be as simple as a slide show, but setting it up takes a little more knowledge than where the screen is and which side is the front of the slide (I never mastered this with 35-mm slides). Here are some tips for inserting digital photos into a PowerPoint slide show.

- Resolution. For the web the maximum recommended resolution is 72 dpi. I find that for projection that 300 dpi shows all the detail I want without being an enormous file size. If you have images in TIFF or RAW format save a copy as JPEG or BMP with lower resolution. Larger file formats will eat memory and take longer for the presentation to load.
- Background Color. If you don't change the background color to black or another dark color, vertical orientation slides will be surrounded by a zone of bright light (default is white). Make sure that you set background by either using the Slide Color Scheme in normal view (select apply to all before OK) or by adjusting the slide color scheme on the Slide Master.
- Resizing photos can easily be done by dragging the corners or sides in the appropriate direction. Dragging the corners will keep the proportions to scale, while dragging the middle, top or bottom will distort the image. Repositioning the photo on the slide is easily done by dragging the photo when the crosshairs appear after clicking on the border of the image. You can also crop the image using the Format Picture menu (available by right clicking on the image).
- Stock clip art and canned photos are rarely what you want. If you are searching for a particular image, considering paying for the images that you can find at www.corbis.com, www.clipartconnection.com or dozens of other media sources. They are well indexed and are high quality images *(see figure 2)*. Some excellent avalanche pictures are also available at www.avalanche.org / picturepage.htm for non-commercial educational purposes only. Always be sure to credit your sources.

Computer failures

Remember the days when the carousel jammed and the whole presentation came to a screeching halt until the Swiss army knife came out to save the day? I look back on those days fondly, in comparison to computer crashes, $150 bulb burnout, and software incompatibilities between computers. Recently my computer has had the same reliability as 5-day weather forecasts, so I've been thinking more how to create back-ups so a computer glitch doesn't mean the end of the show. Often I am working with several other instructors, who may also have laptops. If that is the case, I can burn all the PowerPoint presentations for the course onto a CD and run them from someone else's machine while my computer suffers in hard-drive purgatory.

ISSW 2004

Like it or not, all presentations at the upcoming ISSW in Jackson, Wyoming will be required to be in PowerPoint. Assistance will be available for presenters who need help translating their material into PowerPoint format, but the days of the overhead projector are gone. Presentation guidelines are outlined at www.issw.net / oral_guide.html. Generally speaking, the suggestions offered by this article follow the guidelines presented at the link above.

Conclusion

Some of the most memorable avalanche classes I have seen are the ones that were in the field. Classroom time is necessary and can be effective, but rarely is it as effective as the lessons we learn outside in the elements. In the classroom, I've seen more rapt attention paid to a recounting of a personal experience with avalanches than the best organized computer-generated presentation. I suggest using PowerPoint effectively when it is appropriate, but don't lose intimacy and interaction with your audience. Not only will it be a better learning environment for your students, but it will be more fun as well.

By publication time, Don Sharaf will have started his annual migration north, where he works for Valdez Heli-Ski Guides and anyone else that will pay him to ski steep powder, facets, and wind slab. When he returns south, he will terrorize nails, logs, and avalanche students to varying degrees for the remainder of the year. He serves as the Education Committee Chair for the American Avalanche Association and has been teaching avalanche courses at all levels for the past 12 years. ❊

figure 3

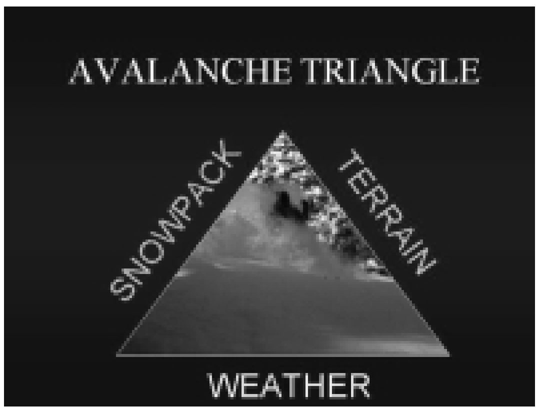


figure 4


figure 5

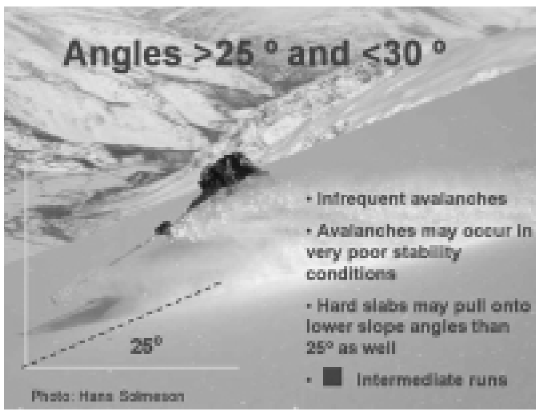
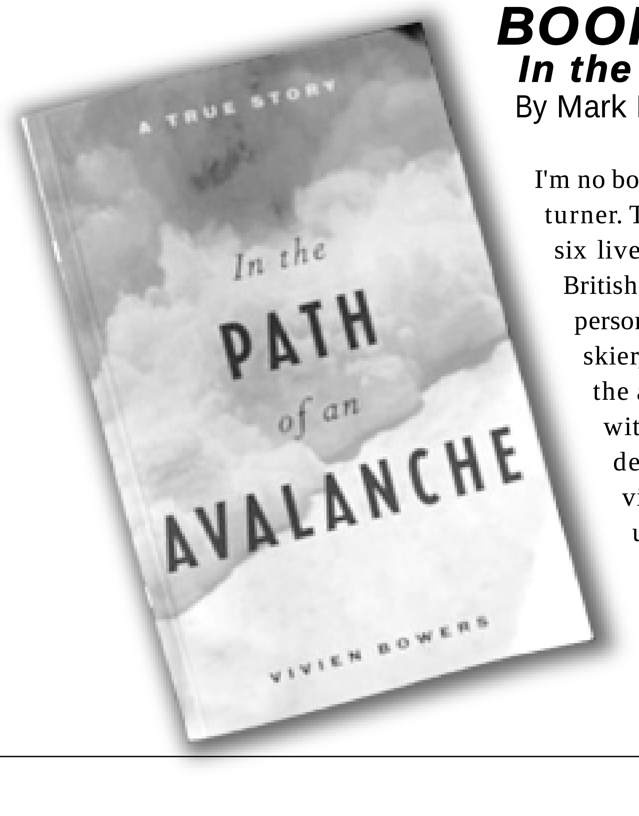


figure 6

figure 7



BOOK REVIEW:
In the Path of an Avalanche
By Mark Mueller

I'm no book reviewer, but I found this book to be quite good, a real page-turner. The book is an account of a fatal avalanche accident that took six lives on January 2, 1998, in Kokanee Glacier Provincial Park, British Columbia. None of the group of skiers survived, although one person who stayed at the hut did. Ms. Bowers, a local and backcountry skier, combines a compelling narrative of the events leading up to the accident, a probable accident scenario, and the rescue efforts with an insightful look at snow, avalanches, and our attempts to deal with them. It is particularly interesting in that most of the victims were locals, with a more than basic, even in-depth, understanding of avalanches, as well as the knowledge that snow stability at the time was poor. A very good book, recommended for everyone, including snow pros.

In the Path of an Avalanche, by Vivian Bowers, Greystone Books, 2004, ISBN 1-55054-513-3. ❊

CROWN PROFILES

Horses, Howitzers and Infrasonics on Teton Pass, Wyoming

By Evan Howe

Glory Bowl
photo by Evan Howe

"There was no sound but the creaking of the tug chains and the puffing of the horses, except, every now and then, the far-off slithering roar of a snow slide."
—Struthers Burt
Diary of a Dude Wrangler

On Thursday evening, May 11, 1932, Merl Swanson and ten passengers on the mail sleigh were descending Teton Pass toward Jackson Hole. All of them must have been concerned for their lives.

That morning, the Jackson Courier reported, "The worst blizzard in several years has swept this region during the past week blocking or practically blocking all roads. The Wilson road is blocked...From all reports the Hoback is closed for the remainder of the winter...The outgoing Jackson-Victor mail was snowbound between the summit and Victor Sunday...Late reports state there is 11 feet of snow on the hill and that none of the big slides have run as yet but the slides could be expected at any time."

Merl's horse team pulled the sleigh through the deep snow. They had crossed several avalanche paths, including Twin Slides, but still had to traverse past Rocky Gulch and Glory Bowl. Twenty-one years earlier the first avalanche fatality on Teton Pass had occurred near here. The second death occurred a few years later when an avalanche swept away several men, horses, and sleighs.

Merl and the passengers were about to enter the Rocky Gulch slide path when one of the horses stopped and refused to budge. Just as Merl was "arguing with [the horse] as to the advisability of getting on, Boulder Gulch snow slide ran, crossing the road in three places directly in front of the sled." Did the horse sense the avalanche? The Jackson Courier declared, "Balky Horse Saves 11 Lives." Earlier on that day, Merl's brother, Harry, had become the third avalanche fatality on Teton Pass when he was buried at Crater Lake from a Glory Bowl avalanche. The fourth and last highway-related avalanche fatality on Teton Pass also occurred at Crater Lake, in 1945.

Today, the Wyoming Department of Transportation (WYDOT) mitigates avalanche hazard on Teton Pass with an aggressive explosives control program. Galen Richards, WYDOT avalanche forecaster, stated, "Our goal is to reduce the size of avalanches coming across the highway, or not at all." By reducing avalanche size, WYDOT mitigates hazard and the amount of debris on the road, ultimately reducing highway closure time and maintenance costs. In terms of safety, there has not been a highway-related avalanche fatality in the past 58 years, although "there have been some vehicles hit [by avalanches] from time to time." This past fall, in an effort to further mitigate avalanche hazard, WYDOT installed Doppelmayr Avalanche Guard boxes on Teton Pass. They are also listening for avalanches with infrasonic sensors. This article will introduce the history of avalanche mitigation and infrasonic research on Teton Pass.

Efforts to keep Teton Pass open in the winter started in 1938, when the Wyoming Highway Department (since renamed WYDOT) initiated efforts to plow the Old Pass Road (WY Highway 22). Two years later, citing expense, they stopped. Citizens were outraged. Commerce over the pass was vital to the community and they were willing to take matters in their own hands. A meeting among some 200 Jacksonites led to the consensus, "By God, if the State Highway Department ain't gonna plow the road we'll do it ourselves." In mass, they went to the highway department equipment yard, commandeered the plows, and drove up the pass to clear the snow. WYDOT started plowing again. Today, social and economic pressure remains. In the winter of 2002, Teton Pass averaged 3236 vehicles per day. Former WYDOT avalanche forecaster Steve Kruse, summarized the local sentiment, "The public will just not put up with road closures."

The Old Pass Road was steep and difficult to maintain, so in 1969 the Wyoming Highway Department constructed a new road with a lesser gradient. Where the Old Pass Road crossed the foot of the Glory Bowl avalanche track, the new highway would have to cross mid-track. A 400-foot-ong bridge built over the avalanche track was thought to be high enough to allow avalanches to pass below, especially with explosive avalanche mitigation. A 75mm Pack Howitzer and an Avalauncher were purchased, but did not arrive in time for winter. On January 15, 1970, an avalanche twisted the decking of the partially completed bridge, depositing 10-12 feet of debris on the Old Pass Road at Crater Lake. The bridge project was abandoned and Highway 22 was simply reconstructed, using cut and fill, through the middle of the Glory Bowl avalanche track.

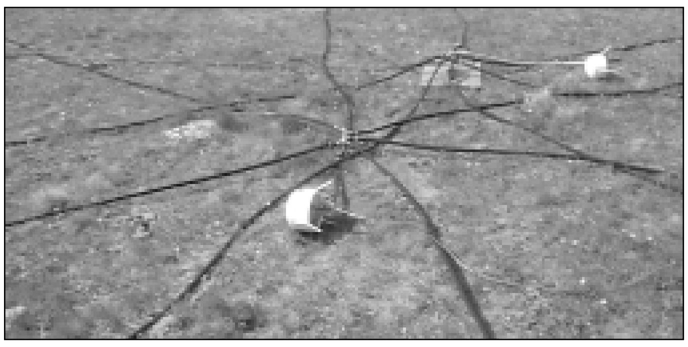
The next winter, finally armed with the Pack Howitzer and Avalauncher, WYDOT started explosive control. Avalanche mitigation was generally successful. Since then, Kruse said, there have been fewer large slab avalanches compared to "Glory Bowl back in the '60s [that] used to have crowns ten feet deep." However, the Avalauncher proved to be inaccurate, especially in the wind, and was soon replaced by a 105mm recoilless rifle. In turn, the rifle was plagued with its own problems. Steve Kruse explained, "The tracer rounds often did not ignite in deep snow-packs in late May and March due to the fact that they did not have a point-initiating fuse. The tracer rounds had a more rounded nose which made them prone to divert in varying directions when entering the snow-pack, thus, commonly, the base detonator was not fully actuated."

In addition to detonation problems, control during the 1970s and 1980s was compromised because forecasters required some visibility to safely fire rounds. Kruse explained, "It was not until the 1990s that bearings and artillery elevations were refined through coordinate systems, and enhanced aiming telescopes and instrumentation." Initially, WYDOT was not able to control unless they could see, and during large sustained storms this strategy proved to be insufficient.

During a twelve day storm in 1986, Teton Pass received about 1" of water equivalent daily. Without adequate weather windows, WYDOT couldn't keep up with the storm. Snow and avalanches closed the pass for 19 days. WYDOT needed the capability to control at any time in any weather.

In 1992, WYDOT installed two Gazex tubes: one in Twin Slides and one in the middle of the Glory Bowl. These installations, in which propane and oxygen are mixed and ignited, are permanently aimed at the starting zones. After some initial complications, the Gazex have provided a safe, reliable and more efficient alternative to the propelled munitions. Richards explained, "Now we could close the road and in 28 minutes, if everything goes right, deliver a blast equal to a 50 pound bomb." The Gazex proved to be effective but the 7-acre starting zone required additional control. The next fall, two additional Gazex were added to

A Gazex tube sits poised over the Twin Slides starting zone. Doppelmayr Avalanche Guard boxes are indicated by the arrow. Two infrasonic sensors tuck into the trees at the middle left and lower left of the avalanche path.
photo by Evan Howe



Porous garden soaker hoses filter background noise for the Infrasonic sound collectors. *photo by Ernie Scott*

F-521811 On January 15, 1970, an avalanche twisted the steel girders of the unfinished bridge spanning over Glory Bowl's avalanche track. *photo courtesy US Forest Service*

Glory Bowl: one each to the north and south of the first exploder.

WYDOT could now control Twin Slides and Glory Bowl with the four Gazex, but still needed a mobile and reliable gun to control other slide paths on Teton Pass and in the Hoback and Snake River Canyons. As the rounds for the 105mm Recoilless Rifle became rare and remained unreliable, WYDOT obtained a 105mm M102 Howitzer in 1998.

This past fall, a research grant from the State of Wyoming allowed WYDOT to add four Doppelmayr Avalanche Guard boxes to its arsenal. Each box holds 10 3kg charges that are propelled by varying amounts of black powder. Positioned next to the Twin Slides and Glory Bowl starting zones, the Avalanche Guards can dispense charges to areas not affected by the Gazex. WYDOT can now conduct more extensive explosive control on Twin Slides and Glory Bowl without having to wheel out the M102, and they have a backup to the aging Gazex. Kruse summed up the modern strategy, "We are going to hit [the slide-paths] on a regular basis and try to hit at times it is not going to affect the traffic. On the other hand, if we have to close the pass [during the day] we'll close it."

On Friday afternoon, December 26, 2003, WYDOT issued a press release: Teton Pass would close at 3am for avalanche control. It was the first of three closures during an 11 day, 76" storm. Richards ordered the first use of the newly installed Avalanche Guard in conjunction with the Gazex. The Avalanche Guard geophones confirmed detonations but WYDOT observers did not see any avalanches hit the road. Infrasonic sensors also detected the detonations and then, several seconds later, an avalanche event.

Ernie Scott, with Inter-Mountain Labs, Inc., has developed and installed the only infrasonic avalanche detectors in North America. This year, Scott installed infrasonic sensors on Teton Pass, in Hoback Canyon, and at the Jackson Hole Mountain Resort (JHMR). Although still in its infancy, infrasonics could provide forecasters, researchers, and motorists with valuable information. Bob Comey, Bridger-Teton National Forest Avalanche Center forecaster, explained, "Most avalanches go unrecorded during a storm when it is snowing and blowing so hard, [an avalanche detection system would also] allow us to confirm what we expect to see. We could come in to the lab in the morning and see if avalanches are happening overnight." An automated avalanche detection system has many other potential uses, including a short-term alert that could trip warning lights on a highway.

Four years ago, Scott obtained his initial research grant from the National Oceanic and Atmosphere Administration. Scott and his team of researchers set up an infrasonic system at the Bridger Bowl Revolving Door avalanche path. Basically, the system included a wind-noise reducing filter, a single "ultra-sensitive pressure" sensor and a data-logger. After one fateful avalanche event, Scott was able to identify an avalanche signal. This research led to a second two-year grant from NOAA whereby Scott established single-sensor systems at Alta, UT; Bridger Bowl, MT; and Jackson, WY. He found Class III or IV avalanches were easily detected, but data from smaller events could be obscured by strong winds. Scott needed a stronger avalanche signal to distinguish it from wind noise. "We moved the sensors closer to the targeted slide path and we started getting good data." However, single-sensor systems remained inadequate to detect avalanches during high winds, when avalanches often occur. Scott decided to pursue additional funding for multiple-sensor systems.

In this fourth year of research, Scott and his cohorts have received two more grants: one from The National Science Foundation (NSF) and one from WYDOT. Both projects have single-sensor and multiple-sensor systems. The Teton Pass project is focusing on using separate sensors at different locations to cross-correlate avalanche signals. There are two single-sensor systems on Twin Slides, while Glory Bowl contains three sensors placed among the trees along the left flank of the avalanche track *(see photo on page 8)*. Scott explained the multiple-sensor system, "Hopefully the [avalanche] signal shows up on all the sensors but the noise is not correlated. So, if you correlate the data on the three sensors the avalanche signal will pop up and the noise will go away." However, the snowpack has been rather stable this year and avalanches have been minimal. Scott lamented, "We haven't been able to get any data this winter."

The NSF project, located at the JHMR, is designed to provide avalanche location information: five sensors are used to acquire directional data. In addition, there are two other single-sensor systems, one in Tensleep Bowl and one at the mid-mountain Study Plot. Looking over data from an event in the Hourglass Couloir, Scott found that cross-correlating different sensors would detect an avalanche even in high winds.

The other WYDOT project is in Hoback Canyon. Richards and Scott are testing a single infrasonic sensor across the road from the "Cow-of-the-Woods" avalanche path to see if it could be used to warn motorists on the highway. Currently, a mercury switch system triggers warning lights on either side of where debris hits the road, but it succumbs to its own wind problems. If proven reliable, an infrasonic monitoring system may replace the mercury system.

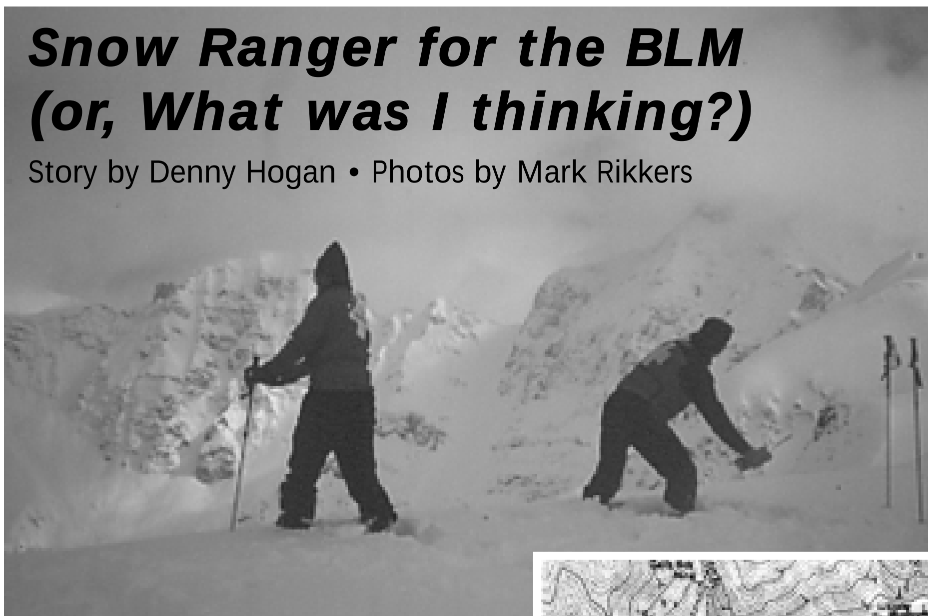
Avalanches will always disrupt winter commuters on Teton Pass. Were it not for WYDOT's dedicated crew over the years, there would certainly have been more tragedies since 1945. Avalanche hazard continues to increase on Teton Pass as more and more people cross its avalanche tracks daily. The research by Scott, WYDOT and others will not only help us learn more about avalanches; perhaps it can eventually give motorists, like the horse in 1932, one last chance to balk.

Ernie Scott will be presenting his infrasonic research this fall at the 2004 ISSW in Jackson, WY.

Evan Howe teaches avalanche education for Jackson Hole Mountain Guides, and is one of the founders of Jhsnowobs.org, a public snow and avalanche observation web site serving the Teton Area. ❊

Snow Ranger for the BLM (or, What was I thinking?)

Story by Denny Hogan • Photos by Mark Rikkers

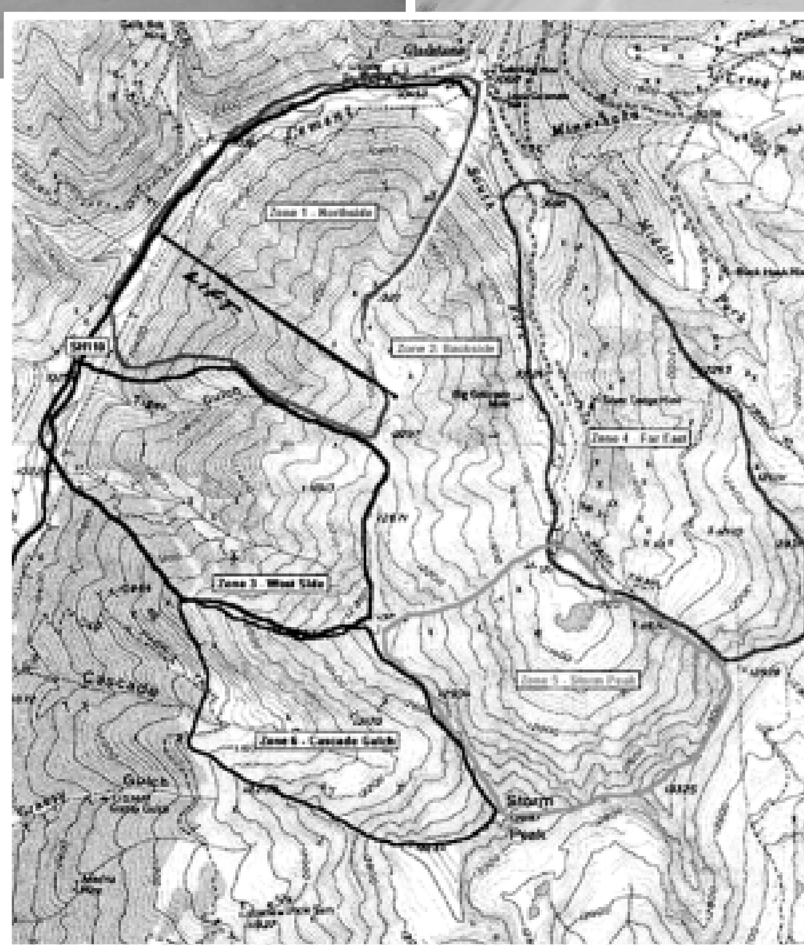


"Why take this job?" I asked myself as I filled out the government paperwork for a Bureau of Land Management (BLM) snow ranger job. The BLM was formed in 1947 as the federal agency to protect the rangelands of the West. The agency manages some 270 million acres in the West, typically the lower, drier, sagebrush-dominated desert slopes. Read: poor skiing! I figured the BLM knew more about grazing and mining policies than snow and ski area policy. But this job was as a snow ranger for the proposed Silverton Mountain ski area in Colorado, which had applied to use 1300 acres of BLM land located in an alpine setting six miles north of Silverton. The land was adjacent to the proponent's private land, where they had installed a chair lift. It was in an area of the San Juan Mountains with deep snows and good skiing! An area I have worked in before and to which I longed to return! It just so happened to be a former mining area that was under BLM, not Forest Service (FS), management. The BLM and Forest Service had joined in a partnership to work with the ski industry at the proposed area. The BLM would administer this ski area permit application while Forest Service ski area policy and procedures provided the BLM with a proven model.

First, some background, much of which I've learned since accepting the job in January, 2003. Forest Service snow rangers pioneered avalanche forecasting and control techniques in the early days at many western ski areas, with Alta being one of the best examples. The agency—in partnership with the ski industry—has a long legacy of providing skiing opportunities for the public benefit. Ski areas on USFS and BLM lands provide economic benefits to local economies by supporting businesses and generating jobs. Today's snow rangers continue to monitor education and training programs and snow safety plans at ski resorts nationwide.

The extreme terrain and weak continental snowpack found at the proposed ski area site were among the major concerns of the BLM before issuing a ski area permit to Silverton Outdoor Learning and Recreation Center (SOLRC), the owners and proponents of the new ski area. Snow safety was identified as one of the proposal's major issues through early discussions / internal review and public comments in 1998 and 1999. The BLM adopted the FS requirements for a snow safety plan for this proposed new ski area. SOLRC paid for and prepared a snow safety plan. This document evaluated the avalanche hazard of the area and outlined forecasting procedures and protocols under a BLM-administered snow and avalanche study permit. This snow safety plan has guided SOLRC's snow safety program for the past three seasons, since 1999. The BLM has allowed guided skiing with small groups under an annual Special Recreation Permit. The permit allows 40 clients per day last season and continues this season with 80 clients allowed per day for guided skiing and outdoor education programs only.

The BLM also directed the preparation of an EIS to provide the agency decision makers and the public with comprehensive environmental impact information related to the proposed ski area. SOLRC is responsible for the cost of the EIS. The Draft EIS came out in September of 2003, and the BLM State Director's office will choose the proposed action or one of the three proposed alternatives sometime in 2004. To learn more about this document and alternatives, please go to the BLM Web site: **www.co.blm.gov/sjra/solrc_eis**



Silverton Mountain Ski Area, Colorado

The BLM and several avalanche-expert consultants carefully reviewed the SOLRC snow safety program in the DEIS. In summary, all agreed that the proposed area had a very high percentage of avalanche terrain and all the proposed terrain would require a considerable amount of study prior to opening as part of a normal ski area operation, guided or un-guided.

With that information as background, let's get back to the snow ranger duties at the proposed new ski area. Implementation of the SOLRC snow safety plan is currently the main issue here, and the BLM has hired a snow ranger to monitor this implementation for this winter season. The BLM can, of course, require changes to the plan or procedures at anytime. Among the safety issues being addressed with the BLM and SOLRC management are the following: the ability of Silverton Mountain to effectively manage the avalanche hazard in the project area for guided skiing; the level of expertise and effort needed to maintain a major snow safety and forecasting program; whether adequate early season skier compaction in certain Zones could be achieved to stabilize the snowpack; and to bear the costs of such a program and any liability for any avalanche injury or death for guided groups on the mountain. Failure to adequately provide for snow safety will be grounds for permit revision or revocation at Silverton Mountain.

Silverton Mountain's terrain has been divided into six Zones of operation *(see map above)*. SOLRC's Snow Safety Director, Pat Ahern, and his snow safety team open a Zone only after extensive snowpack study and stability testing (ski and explosive) and continued documentation of each area. SOLRC's avalanche hazard evaluation / forecasting program has continued to improve during the last four seasons and has set the stage for a more effective snow safety program for this current season.

Some observations after last season on Silverton Mountain and my monitoring efforts there: Zone One and part of Zone Two are the most feasible for a safe, guided skiing operation at this time. They offer the most manageable situation for guided "runs" on this mountain because of greater skier compaction and straightforward avalanche control with hand charges from routes off of the ridge. These approaches have proven to be effective and safe in this area. The guided groups are then allowed to ski in this Zone of the mountain. The remaining parts of Zones Two and Three require more extensive control efforts and of course have less reliance on skier compaction. These larger and more complex starting zones are controlled with avalaunchers and hand-charge routes and complete closures during periods of high hazard. Last season this snow safety team was one of the busiest in the State, using 6,584 lbs of explosives (both hand charges and avalauncher rounds) on 74 days of control work.

Based on a belief it will take a minimum of 3-5 seasons to develop a strong snow safety program, the BLM / FS and the SOLRC staff / management together are working hard to review and implement a safe program each season. Last season, (2002-03), Silverton Mountain skied over 2,700 clients. This season their Special Recreation Permit will allow up to 80 clients per day on the mountain. Guide to Client ratios are 1 to 8 minimum. The cost for a day of guided skiing is $119. Visit the Silverton Mountain web site for more details: **www.silvertonmountain.com**.

In summary, Silverton Mountain is doing a good job of implementing the Snow Safety Plan as written and provides a unique, safe guided ski experience for its clients. Stay Tuned! The EIS decision will be documented in a Record of Decision (ROD) later this winter season and released at the conclusion of this EIS process.

Denny Hogan works as the BLM/FS Winter Sports Specialist/Snow Ranger in Silverton, CO. His past experience includes work as instructor, course director and then Winter Program Director for the Colorado Outward Bound School (1972-1982); Vail Ski Patrolman (1982-1992); CAIC/CDOT Hwy 550, Red Mountain Pass Avalanche Forecaster (1992-97); and CAIC Boulder weather and avalanche forecaster and CAIC educator (1997-2002). He is interested in talking to any other BLM snow rangers or any snow ranger support group out there. You can e-mail him at snowise@montrose.net. He is also currently reading up on the latest BLM alpine sheep grazing policies. ❇

SNOW SCIENCE

Heuristic Traps in Recreational Avalanche Accidents: Evidence and Implications (Part 2)

By Ian McCammon

In part 1 of this article, we saw that the vast majority (93%) of recreational avalanche accidents were triggered by the victims themselves, often in the face of ample evidence of avalanche danger. We looked at how victims' decisions to enter the avalanche path might have come about through a flawed dependence on situational cues, or heuristic traps, that are tempting because they work so well in other areas of our lives. In part 2, we'll look at four more heuristic traps, which victims were most susceptible to them, and what this all might mean for avalanche education.

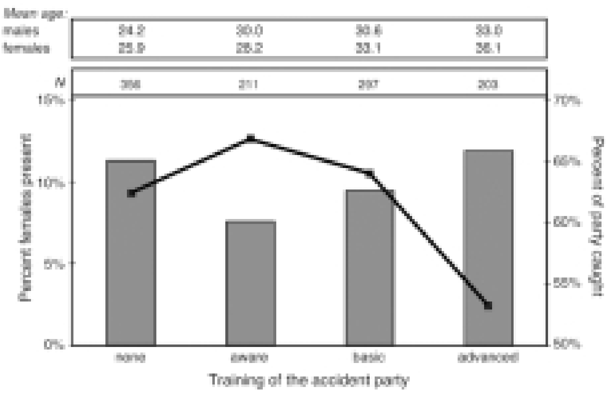


Figure 6. *Percentage of females present in accident parties (columns) and the average percent of each party caught (line graph). Women appeared to avoid those groups where they had the highest chances of being caught.*

Trap #3: Acceptance

The acceptance heuristic is the tendency to engage in activities that we think will get us noticed or accepted by people we like or respect, or by people that we want to like or respect us. We are socialized to this heuristic from a very young age, and because we are so vulnerable to it, it's no surprise that it figures prominently among the heuristic traps embedded in advertising messages.

One of the more familiar forms of this heuristic is gender acceptance, or engaging in activities that we believe will get us accepted (or at least noticed) by the opposite sex. For men, this heuristic often translates into engaging in certain types of risk-taking behavior, particularly during adolescent and early adult years. Various studies have established that under certain circumstances, men in the presence of women will behave more competitively, aggressively, or engage in riskier behaviors than when women are absent.

To see if the gender acceptance heuristic may have played a role in avalanche accidents, I compared the exposure scores from accidents involving mixed-gender parties (245 cases) with those of all-male parties (632 cases). Across all groups, accident parties that included women had a significantly higher exposure score ($p_H < 0.0001$). At the 95% confidence level, accident parties with women present exposed themselves to 0.5 ± 0.2 more obvious indicators of avalanche hazard than parties of men only. This difference in exposure score did not vary by group size ($p_t > 0.12$ for pair-wise comparisons across all group sizes). Parties with awareness of the avalanche hazard but no formal training (the "aware" training category described in part 1 of this article) showed a significant increase in exposure scores when women were present ($p_H = 0.05$).

The increase in exposure score of accident groups that included women does not appear to be a result of those women taking more risks. Of the 1355 individuals present in avalanche accident parties during the study period, about 10% (136) were female. Of the 1196 individuals caught, 9.1% (109) were female. In other words, females had a slightly lower chance (about 9%) of being caught in avalanches compared to males, all other things being equal.

Further evidence that the increase in exposure by mixed-gender groups is not due to risky behavior of the female members is shown in Figure 6. Here, we see that the average proportion of women present in an accident party is a minimum at the "aware" level of training (and in fact seems to rise with training of the group). But compared to other levels of training, the "aware" group had the highest percentage of the entire party caught in the accident. In other words, women appeared to minimize their participation in the groups where they had the highest probability of being caught. Thus the increased exposure of mixed-gender parties must be due to some other factor than risk-taking behavior of its female members.

The increased exposure of mixed-gender accident parties may well be due to the reliance on the gender acceptance heuristic by the male party members. In other words, males may have been more willing to expose themselves (and other party members) to greater avalanche hazard when there were women in the group because such behavior was viewed by the men as being more likely to gain the respect or acceptance of the women in their party. Certainly, this behavior matches conventional wisdom regarding the conduct of some avalanche victims, as discussed by Fredston, Fesler and Tremper (1994) and Tremper (2001, p. 226). It is also consistent with recent findings on the behavior of men in the presence of women (see, for example, Roney, et al 2003).

Figure 7. *Variation of exposure scores by training and leadership. Leaders with little or no avalanche training appeared to make worse decisions than did groups with leaders.*

Trap #4: The Expert Halo

In many recreational accident parties, there is an informal leader who, for various reasons, ends up making critical decisions for the party. Sometimes their leadership is based on knowledge and experience in avalanche terrain; sometimes it is based on simply being older, a better rider, or more assertive than other group members. Such situations are fertile ground for the expert halo heuristic, where an overall positive impression of the leader within the group leads the group to ascribe avalanche skills to that person that they may not have.

To see if there was evidence of the expert halo heuristic in recreational avalanche accidents, I compared the exposure scores of parties that had a clear, identifiable leader (133 cases) with the exposure scores of parties that had no identifiable leader or the leadership was unknown (465 cases). Across all groups, there was a significant difference between parties with and without (or unknown if they had) a leader ($p_t < 0.0001$). Groups with a leader exposed themselves to 0.7 ± 0.2 more avalanche hazard indicators than groups with no leader or where leadership was unknown.

In cases where the training level of the group (typically defined by training level of the leader) was known, there were important differences in exposure score. As shown in Figure 7, differences were greatest among those parties (leaders) with the lowest levels of training. In these cases, leaders appeared to make choices that were significantly worse than parties that had no leader, or where leadership was unknown. Presumably, a consensus decision process in these parties yielded decisions that had a lower overall exposure to avalanche hazard. Decisions by leaders with basic and advanced avalanche knowledge appeared to be no different than consensus decisions made by the group. This finding is not so surprising, since leaders with little avalanche knowledge can be expected to make worse decisions, on average, than leaders with extensive avalanche knowledge and experience. What is surprising is the apparent willingness of unknowledgeable leaders to expose their groups to greater avalanche hazard than groups that probably made their decisions through a consensus process. Such behavior is evidence that the expert halo heuristic may be at work—a misplaced faith in their leader's avalanche knowledge may lead untrained groups to expose themselves to more hazard than they would otherwise choose.

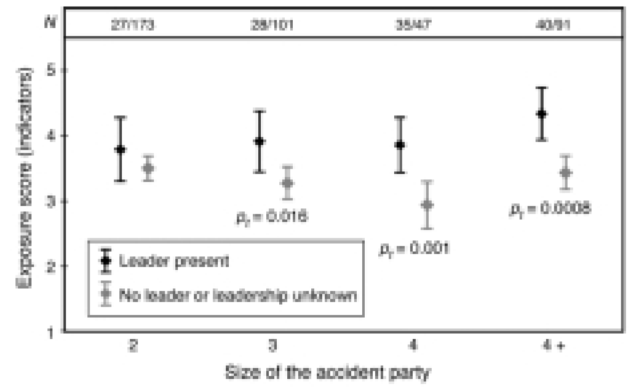


Figure 8. *Variation of exposure scores by group size and leadership. Decisions by leaders in recreational accident parties appeared to get worse as group size increased, compared to the no-leader condition.*

Evidence for the expert halo heuristic also appears when we look at exposure scores by group size. As shown in Figure 8, leaders appeared to make riskier decisions (decisions that exposed their parties to more avalanche hazard) as the group size increased. In the case of parties of more than four people, leaders chose to expose their groups to 0.9 ± 0.5 more hazard indicators than groups who had no leaders (or groups where the leadership was unknown). These results are consistent with the classic research in conformity, which has shown that pressures to conform in a group increase most significantly when there are majorities of two to four people.(Asch, 1951; Plous, 1993).

This data suggests that the expert halo heuristic may have played a role in decisions leading up to avalanche accidents, particularly in large groups and in groups led by individuals with little avalanche training. In general, it appears that groups with little avalanche knowledge were better off utilizing a consensus decision process rather than relying on the decisions of a perceived "expert," particularly when that expertise did not include avalanche skills. As they say, many heads are better than one. Leaders with avalanche training; however, did not make decisions that were significantly worse than those made by trained groups through a consensus process, a result that suggests that leadership by a well-trained individual will result, as we would expect, in more cautious behavior by the party in avalanche terrain.

Trap #5: Social Facilitation

As winter backcountry recreation becomes more popular, more people venture into avalanche terrain, and encounters with others become more common. We know that more people on avalanche slopes means more triggers and more avalanche accidents, but does the very presence of other people change the way that people behave in avalanche terrain?

To explore this question, I compared the exposure scores of avalanche parties under four conditions: 1) meeting other people prior to the accident, 2) having other people nearby when the accident happened, 3) observing tracks on the slope that avalanched, and 4) observing tracks on nearby slopes. I compared these conditions, along with their absent states, in 92 Boolean combinations to find the conditions that showed the greatest mean difference between present and absent states. The goal was to find out which of these social conditions correlated with the highest levels of avalanche exposure. Two trends emerged; the first is described below; the second is described in the next section.

In the 92-element pair-wise comparison, the largest difference in exposure score occurred between accident parties that had met other people (211 cases) and those who did not (97 cases). Overall, parties that met others exposed themselves to 0.5 ± 0.3 more hazard indicators than parties who met no one ($p_t = 0.001$). For accidents where the group size was known, the difference was greatest for parties of three people (marginally significant at $p_t = 0.1$) and parties of four people ($p_t = 0.04$), suggesting that these group sizes were the most sensitive to the presence of other people.

In accidents where the level of avalanche training was known (238 cases), the difference in exposure scores was striking. As shown in Figure 9, groups with no formal training ("none" and "aware" categories) showed a slight decrease in exposure score in the presence of others

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HEURISTIC TRAPS, PART 2

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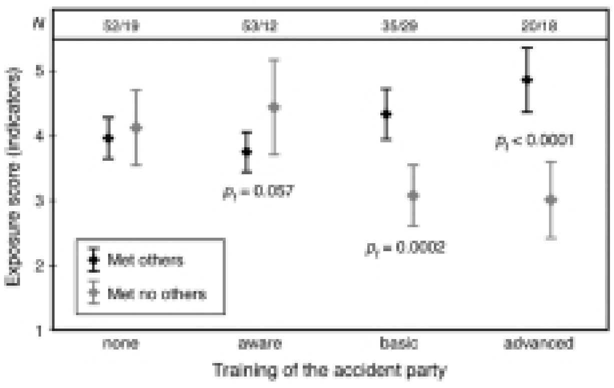

Figure 9. *Exposure scores by training for accident parties that did and did not meet others prior to the accident. The bidirectional variation in mean scores is strong evidence of social facilitation effects.*

(the combined drop in exposure score was marginally significant at pt = 0.09) but groups with formal training ("basic" and "advanced" categories) showed a substantial increase in exposure scores in the presence of others (pt < 0.0001). In other words, parties with no formal avalanche training took fewer risks after meeting other people than did similar groups after meeting no one. But parties with formal avalanche training took substantially more risks after meeting others. Why?

One explanation is that the behavior of accident parties was altered by the presence of other people, a phenomenon known as social facilitation. Numerous studies have shown that well-practiced skills in risk-taking are enhanced in the presence of others, while poorly-mastered skills are attenuated (Plantania and Moran, 2001; Zajonc and others, 1970). In others words, if you already do something well, you are likely to do it even better when you think other people are watching (Ever notice how the best moguls often form directly below a ski lift?). But if you do something poorly, you are likely to be worse at it when you think people are watching than when you are alone. Social facilitation thus comprises a decisional heuristic where the cue is the presence of other people and the response is enhanced or attenuated risk-taking, depending on your level of skill.

Avalanche victims who had taken formal avalanche classes (the "basic" and "aware" categories) took substantially more precautions (such as carrying rescue equipment, exposing one person at a time, having a plan, etc.) than victims with no formal training (McCammon, 2000). Almost certainly, formally-trained victims had a high level of confidence in their mitigation skills, as evidenced by the fact that most of them proceeded into the path that avalanched in the face of ample evidence that it was dangerous. The presence of other parties appeared to have facilitated riskier decisions in these groups. In contrast, avalanche victims with no formal training took fewer precautions, and were likely not as confident in their mitigation skills. Thus, when they met others, their risky behavior was attenuated through social facilitation and they became more cautious.

It is worth pointing out that areas where avalanche victims met others prior to the accident were probably popular, frequently visited areas. Slopes in these areas would have received more traffic and may have been stabilized to some degree by heavy usage. Thus it seems that the social facilitation heuristic may have some basis in fact—areas where you are more likely to meet others may in fact be safer than areas where people rarely travel. But given the fact that a majority of accidents (at least 63%) occur in well-traveled areas, it is clear that such areas are not categorically safer. Like other heuristic traps, social facilitation appears to work often enough that it lulls its victims into feeling safe, even when the avalanche danger is obvious.

Trap #6: Scarcity

Among parties that had met other people prior to the accident, there was a marked difference in exposure scores between accidents involving tracked and untracked slopes. There were 211 cases where parties had met others prior to the accident and the slope that avalanched was known to be tracked or untracked. When the slope was untracked, exposure scores were significantly higher (pt = 0.05) than when the slope was tracked. The difference was largest among groups of 3–4 people (pt = 0.06). Importantly, there was no measurable difference in victims' behavior regarding tracks on the slope when accident parties met no one prior to the accident.

In other words, these victims appeared to take more risks when they were faced with the opportunity to make the first tracks on the slope that avalanched. Because the effect disappeared among parties that had no social encounters, it is possible that the presence of others was a cue to this type of behavior. For those familiar with the "powder fever" that descends on recreationists after a big winter storm, this finding comes as no surprise. It is simply evidence of the ubiquitous scarcity heuristic, or the tendency to perceive opportunities as more valuable when they are less available (Cialdini, 2001).

It is worthwhile to note that when scarcity cues were present, the posted avalanche hazard was significantly higher than when cues were absent (pt < 0.0001). Thus, the scarcity heuristic works exactly contrary to personal safety; it becomes a more tempting decision-making trap as the avalanche hazard rises.

Sensitivity to Heuristic Traps

So far, we've looked at evidence that six heuristic traps may have contributed to decision errors in avalanche accidents. In part 1 of this article we looked at familiarity and commitment traps, and in part 2 we looked at gender acceptance, expert halo, social facilitation and scarcity traps. We've seen that the presence of cues for each trap correlates with different behaviors depending on group size and training levels. But what are the cumulative impacts of such cues, and is there evidence that some groups are more susceptible to heuristic traps than others?

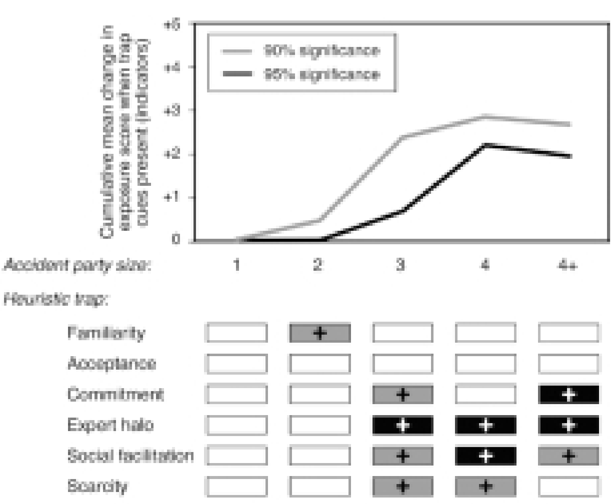

Figure 10. *Cumulative mean changes in exposure scores for various group sizes when heuristic trap cues were present. The apparent influence of each trap varies, but overall sensitivity to traps appears to increase with group size.*

Figure 10 shows how heuristic trap cues correlate with increased avalanche exposure for different party sizes. Small parties of one to two people appear to be relatively immune to heuristic trap cues. In part 1 of this article, we saw that very small party sizes exhibited a higher overall exposure to avalanche hazard at the time of the accident. Thus, any increase in risky behavior in these parties was most likely due to factors other than the heuristic traps examined here. Groups of three to four people, on the other hand, appeared to be increasingly sensitive to trap cues, especially those for expert halo and social facilitation traps (in the table portion of Figure 10, the "+" indicates that the presence of trap cues correlated with a positive increase in exposure score, at the level of significance shown). Larger groups (more than four people) appeared to be especially sensitive to commitment and expert halo traps. It is interesting to note that there is a general trend towards increasingly risky behavior in the presence of heuristic trap cues with group size. In other words, the larger the group, the more heavily it seemed to rely on flawed decision making based on its goals or the choices of a leader, even when that leader had little training and was making poor choices. There is safety in numbers in avalanche terrain, it seems, but only when a group has flexible goals and is lead by an experienced and prudent leader. Figure 4 (Part 1, TAR 22 / 2) showed that there is evidence of a risky shift based on group size in avalanche accidents. The results shown in Figure 10 suggest that sensitivity to heuristic traps may play an important role in that risky shift.

Figure 11 shows how heuristic trap cues correlate with increased avalanche exposure for different levels of avalanche training. Victims who had no avalanche training or awareness of the hazard showed little sensitivity to heuristic trap cues, save for their reliance on the "expert" member of their party. Such low sensitivity to heuristic traps isn't surprising for these victims, since they had no hazard recognition or mitigation skills they could choose to use or not use based on their perception of avalanche conditions. Victims with awareness of the hazard but few skills to mitigate it showed a greater sensitivity to heuristic traps, most notably to expert halo and acceptance traps. It appears that victims in this group valued decisions by more experienced friends, were concerned about impressing the female members of the party, but lacked confidence in their own mitigation skills. Victims with basic avalanche training (the equivalent of a recreational level 1) showed a decreased sensitivity to heuristic cues, but seemed to overestimate their ability to mitigate avalanche hazard in the presence of others (the social facilitation trap). It is interesting that sensitivity to heuristic traps appears to go down slightly with the advent of formal training—perhaps avalanche education has the effect of re-focusing people's attention on avalanche conditions rather than on social cues. Victims with advanced avalanche training showed a disturbing tendency to place a lot of faith in the cues of familiarity and the presence of other people. Of all the heuristic traps we have looked at, these two are the only ones that probably have some basis in fact—cues for these heuristics may in fact correlate with safer avalanche conditions. But what is most striking is the degree to which victims with advanced training apparently relied on these heuristics. In the presence of familiarity and social facilitation cues, these victims exposed their group to, on average, three to four more obvious indicators than when these cues were absent. This suggests that these cues may have represented informal rules of thumb for victims with avalanche training, even in the face of evidence that the cues were grossly misleading.

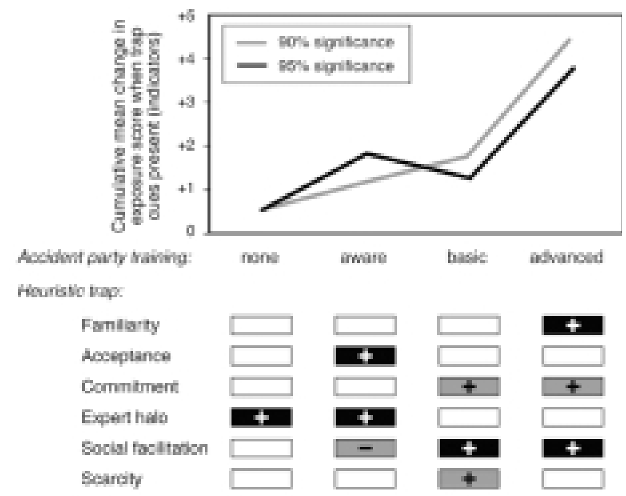

Figure 11. *Cumulative mean changes in exposure scores for various training levels when heuristic trap cues were present. The graph suggests a learning process that moves from a flawed dependence on others to an overvaluation of their mitigation skills.*

The overall trend in the graph of Figure 11 implies a disquieting learning curve among avalanche victims. It seems that social cues play an important role in novice decision making, while those with more expertise place far too much faith in familiar terrain and the presence of other people. These results have important implications for avalanche education. First, however, we need to review some of the limitations of this study.

Limitations of this study

The goal of this study was to examine some of the reasons why avalanche victims chose to ignore obvious signs of danger prior to accidents that were triggered by themselves or members in their party. By studying 32 years of avalanche accidents, I have hoped to develop preliminary hypotheses that may assist others in more focused investigations. But because this study relies on accident data, it has a number of notable limitations that should be considered by those who wish draw conclusions from my results. Among them:

- The study has identified correlations, not causations. The statistical methods used have demonstrated that significant correlations exists between the cues for heuristic traps and greater exposure to avalanche hazard. Such an approach cannot establish causation—there may actually be many alternative causes other than those discussed here. Causation is most commonly established by experiment; in lieu of experimental results on human behavior in avalanche terrain, I have relied on well-established experimental results from various areas in psychology to support my conclusions. Further exploration of the heuristic traps described in this study is highly warranted.
- The study focused on accidents, and thus can only identify what factors were present when accidents occurred. Such a study cannot, by itself, identify factors that were present when accidents did not occur, or what factors may lead to accidents not occurring. Such information is of course critical to successful avalanche education.
- Because the non-event factors are unknown, the uniform

weighting of hazard indicators in calculating the exposure score may introduce statistical artifacts that do not accurately reflect the actual behavior of avalanche victims. Nonetheless, one trend is certain: the majority of avalanche accidents happened when the hazard would have been obvious even to someone with minimal avalanche training.

Implications for Avalanche Education

Despite the limitations of this study, there are a number of important implications for avalanche education:

1) There is little evidence that trained avalanche victims in this study had taken avalanche courses so they could be safer. Indeed, it appears that these individuals were in the business of trading off the risks of being in avalanche terrain with the perceived benefits of engaging in their chosen activity. It is telling that there was no overall decrease in exposure scores with training; victims apparently wanted to maximize their benefits from risks they saw as acceptable. Avalanche courses aimed at teaching people how to avoid avalanche hazard would have little utility to such victims and would probably not affect fatality rates in this population significantly. These victims would benefit most from courses that provided risk management tools for balancing hazard exposure with recreational objectives. A sobering implication is that such courses would be more successful at extending students' mobility in avalanche terrain and limiting the number of victims than reducing the total number of avalanche accidents.

2) If victims did in fact rely on heuristic cues to make decisions in avalanche terrain, these accidents were probably not isolated incidents of heuristic thinking. Most victims had probably learned to rely on such cues from past experience when avalanches did not occur, and came to associate the cues with safety. Thus heuristic thinking that usually worked well in social situations was further reinforced by experiences in avalanche terrain, even though the cues were, at best, peripherally related to the actual avalanche hazard. This poses a challenge to the avalanche educator, since the default heuristics of the students are fast, convenient and accurate most of the time (i.e. most of the time people don't trigger avalanches). Knowledge-based decision tools are often slow, tedious and ambiguous. Given a choice, most students will likely opt for the quick decision tool, even if it is not universally correct. The challenge for educators is to offer practical alternatives to heuristic traps.

3) Teaching about human factors probably won't eliminate avalanche deaths among recreationists with avalanche training. If trained victims were ignoring such obvious clues as recent avalanching and terrain traps, adding more information to the avalanche curriculum about human psychology is unlikely to change behavior. The problem was not that these victims didn't have enough knowledge to make good decisions; the problem was that they didn't know how to apply the knowledge that they did have.

If the goal of avalanche education is to reduce avalanche deaths, then the challenge to the avalanche educator goes beyond simply imparting information. The challenge is to encode knowledge in simple, easily-applied decision tools that can compete with the heuristic traps described here. Luckily, such tools don't need to be perfect to save lives. They just need to be more accurate than the social cues that most avalanche victims apparently rely on.

Acknowledgements

The author would like to thank Dale Atkins and Knox Williams for granting access to the records of the Colorado Avalanche Information Center. Dale Atkins, Don Sharaf and Allen O'Bannon provided valuable insights during many late-night discussions. And thanks to everybody who bought a copy of the *Snow and Avalanche Field Notebook* by SnowPit Technologies: you helped support this research.

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Traveling in All-Women's Groups: Experience and Anecdotes from Professionals

Compiled by Lynne Wolfe

After reading part 2 of Ian McCammon's *Heuristic Traps,* I noted the data from all-men's and mixed groups. I called Ian to ask him if he had data about all-women's groups. He apologized that he had none, and said that he'd love to know how all-women's groups in the snowy backcountry make their decisions. So I sent out the following set of questions to a disparate group of women snow professionals. Here are some perspectives and anecdotes from their experiences.

- ***Have you/do you travel in all-women's groups in avalanche terrain?***
- ***How about teaching/ managing any type of all-women's groups***

CAROL CILIBERTI: I have done a lot of outdoor activities with all-women groups, including backcountry skiing, mountain biking, ice climbing, rock climbing, including a couple of big walls. The skiing part did take place in avalanche terrain. While working as an avalanche forecaster I assisted in teaching a number of workshops, but all the groups included both men and women.

NAHEED HENDERSON: To be completely honest I find that I am usually the lone female in a tour group. Perhaps once a year I travel in an all-women's group and these tours will often only involve yellow-light terrain.

- ***Do women's learning and/or decision-making styles differ in single sex or mixed groups?***
- ***How about learning/ decision-making styles in all-women's groups?***

CAROL CILIBERTI: Regarding learning styles in all women -vs- mixed groups…I may not be much help because I have only taught mixed groups. However, I suspect that some (many?) women might feel more comfortable learning outdoor stuff without men around. This is because some men can be controlling, or have the need to protect or take care of women, with the result of either pushing too hard or holding someone back. In mixed groups women might be more focused on how they are performing and how the men perceive them, rather than simply trying to learn at their own speed.

As far as decision-making styles, I have definitely noticed that the dynamic can be different when you are skiing with men, or a group of both men and women, rather than a group of women. When men are involved often times one (or more) of them wants to be in control. Oftentimes this has an adverse effect on decision-making because there is less discussion. As an avalanche forecaster I think my interaction with men in mixed groups was probably a little different than what other women experience. I think that I had an interesting effect on men in this situation. Some of them seemed to resent the fact that I was a supposed expert while they were not…and didn't want to listen to suggestions I had about where and what to ski. Needless to say I didn't spend much time in the backcountry with guys like that. Some guys seemed to respect me and enjoy the status of having me as a ski partner. Others were simply great friends that I enjoyed spending time with, making decisions together without any problem. Skiing with other women was great in that there was always a lot of discussion. I would never "take charge" unless someone suggested something that I thought might be dangerous (which almost never happened). So that meant we talked about where we wanted to go, what we all felt comfortable with, what the safest routes were, etc. There were no egos to uphold, or agendas that had to be met. I always found it very easy and enjoyable to ski with my women friends. I always knew that I wouldn't feel any push toward skiing something I felt uncomfortable about. That's a feeling that can be very stressful, and is one that I don't like to experience.

KELLIE ERWIN: I believe it depends on the experience of the individual women. Speaking for myself I am not an abdicator, but this comes from years of experience and seeing the decisions I have made in the past and the consequences of these decisions. I feel comfortable now about speaking up because my experience has shown me what can happen if I don't. There is no doubt education, experience and familiarity with the terrain all affects your decisions. Education and experience are huge in building a solid foundation for being comfortable in communicating what is your level of acceptable risk. I believe this acceptable risk changes with the group you are with, whether you are guiding, what terrain you are in, and how comfortable you are with your partner's skills if something goes wrong. For me, I will be honest, I probably take more risk when I am with a mixed group or with all guys, but this would be a group of older and experienced men whom I would trust. This would not be the same for a group of young guys with less experience and more risk-taking qualities. I believe women that are educated make better decisions whether they are in a mixed group or all women's group. Age and experience traveling and making decisions in avalanche terrain factor into this.

I was just out with a group of women at Sorcerer Lodge; we were doing setup for the lodge and I felt like I was the most conservative. The group was pretty well balanced in terms of experience and a little knowledge. Three of us were guides and one was a ski patroller; the other two were less experienced. I believe I would not have been as conservative if I were more familiar with the terrain, like the two women that were less conservative. We had a 10 -20 cm basal faceted layer with about 50 cm dense one finger mid-pack, and about 30 cm of wind slab on top. Boot penetration was to the ground. The day before we got there, there had been a huge wind event and things were extremely cross-loaded, especially on the moraine features. They wanted to go up a roll that would require us to cross a steep roll that, if it had released, would have put the person into a gully. I did not believe it was worth the risk especially since the skiing was not that great up high. So this brings up another question—motivation. Would have I made a different decision if I would have been with clients, after six days out and this was the last day and we had not gotten that much great skiing in?

GEORGIE STANLEY: I've been making decisions in avalanche terrain with my boyfriend and my girl friends. Outside of my immediate set of friends, which has several very capable female leaders, I don't see many women taking part in decision making, except to add that they are nervous or psyched. Women who have taken avalanche courses are interested to watch me dig a pit, but do not act as if this is part of their set of skills (many males I have skied with do not seem to use pit tests to make decisions either). On a women's avalanche course I taught this winter, the women seem to ski with their boyfriends in the backcountry and tend to go to a ski area when those guys are not available to ski with. Hoping to be independent of their boyfriends and other male friends was the number one reason for taking the course. I can imagine after working with them for only three days that they will not trust their judgment and will defer to their male friends; this will slow their learning curve and the time it takes to be self-reliant.

It sounds as if mixed groups might have some hormones involved in their decision-making. Another reason women

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WOMEN'S GROUPS

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might be getting avalanched more in mixed groups is if women are relying on their friends for leadership and are not as educated or practiced, they could be making route-finding mistakes like picking a line on a more leeward side of a bowl. Perhaps these women aren't as good skiers or they aren't getting out as much, so they are more tired and falling in difficult terrain and in strenuous snowpacks. There are infinite scenarios, but if the woman falls behind because she is not as aggressive a skier, she could make a bad call and get lanched. Are the men in these groups taking care of less-experienced women? Is everyone assuming that you are all set after you take an introductory or Level 1 class?

NAHEED HENDERSON: I think that all-women's groups tend to make most decisions by using consensus. I find that women will value everybody's decision without wanting to disregard any thoughts. This often makes for very conservative decisions and very lengthy processes. However, when women are in a mixed gender group I think it is very easy for them to take a back seat and be a passive member of the decision making team. I find that often women might question a decision but still go along with it laying faith in the male confidence and knowledge. I find that if I am not careful I too can fall into this pattern. I often have to remind myself of my knowledge base and that I am a valuable member of the decision making team. I often find that it is easiest for me to listen to everybody's thoughts and simply add my thoughts if they vary or will add a significant piece of info. However, I certainly have no problem turning away from a slope!

Women need positive reinforcement to the utmost. We can never get enough of it. I find that women do not like to make a mistake and will therefore stay on the conservative side of things. Often this makes an all-women's team stray from challenging terrain.

- ***Anecdotes/informal thoughts, especially relating to women making decisions in avalanche terrain***

NANCY PFEIFFER: Here are a few thoughts off the top of my head on women's groups. I've got a couple of girlfriends and we have been getting out skiing regularly this winter. Often we go out for one run on a workday w / the goal of getting out, getting exercise, getting some sun on your faces, (if there is any)(she lives in Alaska), having fun and getting back to work later in the day. One of them worked an avy class w / me early in the season, and we talk about snow a lot, both the safety for the day and just observing and hypothesizing because it's fun and interesting. Sometime we ski something steep, sometimes not. It doesn't feel much different than going out with the guys I ski with regularly. I think that says more for those guys with whom I choose to ski than anything else. Although there is another group of guys that I ski with occasionally, I make the conscious decision to ski in that crowd only on stable days because I don't want the stress of calling something off when I am the only one who doesn't like it.

NAHEED HENDERSON: Thoughts: women are often not the first skier on the slope due to fear of slope testing. I wonder how many women feel practiced enough in rescue skills to be a primary rescuer? I think the gray zone—where there are not obvious correct decisions—is a very uncomfortable place for women.

CAROL CILIBERTI: Years ago when I first started climbing and skiing I had men, usually boyfriends, who would "take" me out to do these things. I became frustrated when I couldn't find a guy to take me climbing one day, and worked up the guts to go out with a girlfriend and lead a climb myself. That started me on the path of learning how to do outdoor things with other women, by myself sometimes, and most importantly—FOR myself. Doing fun, exciting and potentially dangerous things with other women has been a great thing for me and has helped me learn stuff like how to communicate and cooperate under stress. There is a sense of independence and self-sufficiency that you don't always get when you go with a man.

Editor's Note:

LYNNE WOLFE: *I have been working quite a few all-women's avalanche and backcountry courses in the last few years. The women in these courses are adamant that their voices are better heard in all-women's groups, and that they are more willing to experiment in those groups. They seem to need experience translating their instinct and emotions into data, using new vocabulary words in sentences; "I think that the snowpack is RED because I heard whumphing, got a R3, Q1 in my test pit, and know that the weak layer is surface hoar from before Christmas." This translation seems to give them confidence, power, and credibility. The scary step for these women is going out together, without someone (male or female) who is more experienced to fall back on. As they have success time after time, gain skills and have more confidence in their choices, the issue of gender becomes less important than the issue of choosing compatible backcountry partners with similar communication skills and risk tolerance.*

CAROL CILIBERTI *worked as an avalanche specialist for the Utah Avalanche Center for many years. She is an accomplished skier and climber. She currently works as a meteorologist with the National Weather Service in Eureka, California, and thinks more about swells and gale warnings than snow.*

KELLIE ERWIN *is a mountaineer, ski patroller, and guide who makes her home in Golden, B.C. As a videographer, she has traveled to Fiji, Everest, and the wilds of Los Angeles. Her talent and motivation prompted her to start the ISSW video library.*

NAHEED AHMED HENDERSON *is a skier by passion and profession. She calls Victor, Idaho, home and Jackson Hole Mountain Resort her home ski mountain. Spring 2003 was topped with an expedition to the Chinese Altai Mountains with numerous first ski descents. Naheed spends much of her time coaching ski camps around the U.S. and Canada, backcountry skiing, and exploring mountains around the world.*

NANCY PFEIFFER *teaches avalanche education for the Alaska Mountain Safety Center and for Alaska Pacific University. She just completed a tour of avalanche education programs throughout the West, and wishes to extend Alaska couch privileges to all her friends in the lower 48.*

GEORGIE STANLEY *is a mountaineer, backcountry skier, and avalanche educator in the Tetons. She has been part of all-women's Himalayan expeditions to Cho Oyu and Baruntse. Recent interests include solar power, organic gardening, and snowmobiling.* ❊

SPATIAL VARIABILITY: From Theory to Practice

continued from cover

Mt. Ogden Flank avalanche. Snow Basin Ski Area, Utah.
photo by Karl Birkeland/NAC

How does research into spatial variability, and your experience with that variability, affect the way you evaluate avalanche conditions?

Chris Landry
Executive Director, Center for Snow and Avalanche Science
November 9, 2003

First, let's agree that it's difficult to separate spatial variation from temporal variation, and that spatial variation varies with time, but we'll reduce the complexity of this discussion by sticking to spatial variability at a given moment in time. Then I'll assume that we're addressing, primarily, the problem of local slope-scale variability, setting aside the better-understood (or at least more clearly documented) variability produced by larger-scale geographic factors like changes in aspect and elevation. That said, it would be fair to say that my ever-increasing appreciation of the challenge presented by spatial variation in snowpack properties, including stability, has dramatically increased my admiration for the skills of heli-skiing guides, and I feel their pain trying to cope with it!

Chris Landry conducts a Quantified Loaded Column test while doing spatial variability research. Lionhead, Montana. *photo by Karl Birkeland/NAC*

As a young ski mountaineer, I probably learned the most about spatial variation at small, local scales through my feet, post-holing into pockets of weak snow, tearing up my ski bases in areas of thin snow, sensing variations in the snow surface texture with subtle changes in aspect, and like kinds of experiences that we've all had. My eyes taught me too, seeing surface hoar here but no there, riffles here but not there, polished wind slab there but not here, etc. Even our ears got clues—hollow sounding here, but not back there. It all registered in an increasing memory / vocabulary of variability and was primarily applied in a forecast of the quality of the skiing, sometimes at very local scales (i.e., within a turn or two). But it would be a stretch to claim that local spatial variability, as such, was a major factor in my stability evaluations, at least not in the same conscious, formal sense that I looked at snow profiles and other field observations.

Later on, having survived my twenties and thirties, I suddenly found myself doing "for hire" forecasting work, with a seven-year stint of forecasting natural avalanches threatening a mine road in Colorado. Interestingly, this came prior to (and directly led to) doing formal research on spatial variation in snow stability when my client finally (and perhaps mercifully) went broke. Coping with spatial variability in the lower Yule Creek valley was a conscious, semi-formalized, real and significant part of my work, at certain scales. As anyone would have, I attempted to estimate larger-scale variability created by changes in aspect, elevation, ground cover, and prior avalanche activity. Later on, as the Yule Creek Valley was "discovered," even the influence of ever-increasing numbers of ski tracks in starting zones was a consideration. What I did not attempt to formally estimate, since I was forecasting natural avalanches and not the effects of a skier or explosive, was the variation in stability at the local scale in parts of specific starting zones, where all those larger-scale factors above were apparently constant. Still, evidence of local variations was inescapable, in snow profiles, stability tests, and in the natural avalanche activity itself. Yet, as luck would have it, on a couple of occasions my study slope stability test results jived so well with the subsequent critical loading leading to avalanches in nearby terrain that I was compelled to spend three years in graduate school methodically investigating the reliability of stability test results.

The following five years of my own and others' research on spatial variability at the scale of single slopes, and on apparently uniform single slopes in my case, has certainly increased my appreciation of the complexity of snowpack properties and processes. My MS project in Bozeman, *Spatial variations in snow stability on uniform slopes—implications for extrapolation to surrounding terrain*, has, as my advisor Karl Birkeland put it, "confounded our understanding of spatial variation." In short, using uniform sites that should have optimized consistency in stability test results, we found that some slopes on some days exhibited the uniformity

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SPATIAL VARIABILITY

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in stability that I had blundered upon at multi-slope scales in Yule Creek, whereas the same (and other) slopes on other days produced statistically significant (and sometimes dramatic) variations in stability measurements within our 30 m square sampling area. The amount and location (within our 900 m2 test plots) of variability was often surprising, and unpredictable. And, that variability did not exhibit any consistent or typical scale, although interesting general patterns were observed. The research being done by Kyle Stewart and Cam Campbell with Bruce Jamieson, in Canada, has also found similar confounding patterns of variability and uniformity in their results. Still other research in Switzerland by Kalle Kronholm and Chris Pielmeier has looked at the characteristics of particular layers at a range of spatial scales, down to the bond scale, also showing that spatial variation varies.

So—returning to the original question—what's the upshot? Do I still ski? Yes, more carefully. Do I still dig pits? Yes, certainly. Do I still do stability tests? Yes, sometimes. How would I apply all this if I were back in Yule Creek forecasting again?

Given my new appreciation of local-scale spatial variation in stability, I've gained a renewed interest in digging level pits and using my experience to extrapolate, in broad brush strokes, how the snowpack would vary on slopes with different aspects and elevations (than my flat pit site). Then, given the recent discussions and investigation of shear quality and fracture propagation, when I do a pit and / or stability test on a slope I perhaps place the most emphasis on the nature of a stability test fracture and the nature of the fracture plane (thickness), usually more emphasis than on the input force required to obtain the fracture (unless I get a particularly weak test result). Given my sense of the snowpack's general layering properties (some of which is based on or has evolved from my flat pit), and the nature of my stability test fractures, I like to speculate on the potential spatial extent (or scale) of similar layering and fracture propagation characteristics. I ask myself, "…if a fracture starts in the slab / weak layer interface, will the scale of variation in the properties of the snowpack allow it to propagate, or cut it short?" Then I ask myself if variations in the slab make it more or less likely that I (or my partner, or his dog) will find vulnerability while skiing and initiate a propagating fracture. And then I'll opt for the lower-angle run anyway, unless the evidence is overwhelming that getting a fracture to propagate is highly unlikely.

If I were to return to forecasting in Yule Creek, I would now be informed (and confounded) by the ongoing confusion about how natural avalanches initiate, and now wondering whether the initiation process has less to do with strength / stress relationships and local weak spots at the weak layer and more to do with the fracture toughness of the snowpack. In my prior work in Yule Creek, the strength / stress conception of stability told me that I could look at natural avalanches as a product of gross loading at comparatively large spatial scales—starting zone scales—and that the initial fracture process (of a natural avalanche) would take care of itself at some spatial scale that I didn't need to be particularly concerned with. Under that view of stability, it seemed possible to sample strength-stress relationships at carefully selected sites and then estimate what a critical load might be at the larger scale, "fudging" conservatively to account for presumed (weaker) variations in the strength-stress relationship in starting zones.

But now, my still-simplistic understanding of the emerging fracture toughness approach to avalanche release seems to suggest that sampling fracture toughness properties—fracture propagation, fracture quality, weak layer thickness, slab thickness, and the like—and estimating the spatial scale of my sample's results is more important than a strength / stress ratio measurements. Interestingly, the significant variability in strength / stress ratios that we found in my research project was almost always much smaller-scale (sometimes on the scale of single turns) than the variability we observed in other properties like shear quality or slab thickness. Shear quality (and slab thickness) was often very consistent throughout a slope even when strength / stress measurements were quite variable at the scale of a single pit, or from pit to pit. Local measurements of fracture toughness properties may—emphasize ***may***—show somewhat more spatial reliability than measurements of strength / stress ratios, but sampling fracture toughness will probably still be subject to poor site selection and inadvertently skewed results. Spatial variation still, undoubtedly, determines the role of fracture toughness in avalanche release.

All that is to say, post-research, that I would now approach a job as a forecaster with an even higher level of uncertainty than ever, as a more-or-less direct consequence of the confounded understanding of spatial variability (and of the concept of stability) that my own and other research has yielded. On the other hand, I'd have some new "tools" too: a better grasp of the problems inherent in stability sampling, the notion of targeted sampling (looking for the worst case), the notion of fracture toughness and the importance of observations of shear quality, and a new geographic lens through which I view the snowpack and the processes occurring at multiple spatial (and temporal) scales, yielding variability (and uniformity on occasion). And I'd be looking for methods to objectively and reliably sample and measure parameters like shear quality and fracture propagation. So, while I might be more confused and still wishing I had more data to reduce my uncertainty, I think I'd also be more alert to the ramifications of spatial variation (at all scales), and that has to be a good thing.

Drew Hardesty,
Avalanche Specialist
Utah Avalanche Center
November 9, 2003

The thing about variability for me is the increasing importance placed on the "q" factor from Montana. It's almost a foregone conclusion that there will be variability in the snowpack due to loading and terrestrial inconsistencies, but I like the idea of the consistency of shear quality as an important indicator regardless of what my "stability" score is. For so long, we have concentrated on the weak layer. It's clearly more than this. Of course it's about the relationship between the slab and the weak layer. This is fundamental in looking at propagation potential, "bridging," and skier triggering. The weak layer is weaker here, but the slab is stronger there—so how does this affect the "stability?" Aha! Good question. This is why we go into the field.

Dave McClung examines the shear quality and fracture character of a stability test. Cariboos, Canada. *photo by Karl Birkeland/NAC*

Dave McClung
Professor
University of British Columbia
November 21, 2003

The answer depends on the forecasting scale of interest. Spatial variability in forecasting on the small scale demands high accuracy and frequent sampling: the small scale meaning on that for which backcountry travelers must evaluate. The only way to do it is with a high density of sampling targeted toward the expected worse case. For decisions made in the backcountry, snowpack models and avalanche danger scale bulletins must be supplemented by on-site evaluations. For larger scale problems where accuracy does not matter so much, only a broad general assessment is given and the forecasts should be treated as such. For the intermediate scale, e.g. highway and ski area forecasts, local experience coupled with good weather station data win the day. As the forecasting scale decreases the need for better accuracy increases. However, the above is always ruled by cowboy logic: "When you find yourself in a hole, stop diggin'!" —another independent proof that skier triggered avalanches much deeper than a meter are extremely rare.

Bruce Tremper
Director, Utah Avalanche Center
November 22, 2003

I don't think any of the research has affected the way I do field work. The research confirms what I have been finding in the snowpack for years, that snow varies sometimes quite a bit from place to place and you need to dig lots of holes in lots of places to get a consistent picture and find the pattern distribution. Each kind of weak layer has different characteristic patterns. I tried to put much of this information into my book, *Staying Alive in Avalanche Terrain*. The bottom line is that you NEVER decide to get married after the first date. You need to gather lots of information from a lot of different places.

Ian McCammon
Avalanche Educator
and Researcher
November 22, 2003

Spatial variability seems to be a hot topic these days. There has been some excellent work on how snow hardness, shear strength, stability scores and other snowpack properties vary over time and space. These results are important because they put numbers on what field folks have known for a long time: that assessing the snowpack is a tricky game if you only rely on a handful of snowpits. But one big problem is that we don't really know how all these snowpack properties are related to avalanching. If one parameter like shear strength or hardness varies over a slope, how does that affect avalanching, which seems to be a complex interaction of many parameters? Certainly things like stability scores are helpful but they clearly don't tell the whole story. The work by Bruce Jamieson, Paul Föhn and others on avalanches under false stable conditions tells us that much. So just because there is spatial variability in snowpack properties doesn't tell us everything we need to know about how likely it is that someone will trigger an avalanche.

I think the work by Dave McClung, François Louchet and others on fracture mechanics in snow points to a way out of this dilemma. They've shown that it's not just the strength of the weak layer that matters, but slab properties related

Examining the quality of shears can help to reduce uncertainty associated with variable stability test scores. Here a Q1 shear shows clean displacement of the slab. *photo by Doug Chabot*

to fracture propagation. In other words, things like slab stiffness, weak layer depth and fracture toughness seem to be at least as important as stability test scores in assessing stability.

In practical terms, this means that I don't put as much faith in stability scores alone as I do in their combination with quality of shears and lemons (a tool for measuring structural instabilities). For example, if I'm consistently getting Q1s and Q2s and finding 4-5 lemons in all my snow pits, that sends up a red flag for me no matter what my stability test scores are. In short, when I'm dealing with spatial variability in the field, I usually pay attention to the fracture propagation potential as well as weak layer strength. Of course, big picture stuff like weather and terrain is always a factor in evaluating conditions.

Janet Kellam
Director, Sawtooth National Forest Avalanche Center
November 23, 2003

Documentation of spatial variability reinforces the importance of multi-faceted stability evaluation. Again we see that it is essential to go back to basics and incorporate the overall characteristics of an area in any evaluation—

1) Terrain features

2) Snowpack (among many other observations or data—important considerations for us include what type of snow grains are present, quality shear and pattern of the instability, and we ask ourselves what is the ability or potential of the slab to propagate a fracture)

3) Weather (historic, current & future)

I feel that spatial variability studies confirm that deficit zones or trigger points must be considered with certain types of snowpack conditions. And…there are still no absolutes until an avalanche occurs. Spatial Variability has always been a part of forecasting considerations, even before it has been more closely studied and given a name.

Spatial Variability also means that my friends don't like to go out skiing with me anymore as I am wandering, poking and digging more than ever!

Brad Sawtell
Forecaster, Colorado Avalanche Information Center (CAIC)
November 24, 2003

I do not have much experience in actual research on spatial variability, however, I do think about it a lot while in the field and making choices.

First of all, I truly believe that there is a definite fine line when route finding in avy terrain. Really feeling the snow under my feet, reading the surface for clues of different wind loading and or scouring. Sticking to the at times quite subtleties of ridges. I try to perform stability tests in areas where I might find the most unstable snow…thinking of the variability.

Additionally, I ski down slopes with similar things in mind. For example, I avoid weighting my skis (making a turn) in areas that may look or feel suspect and or on areas that may be slightly convex in shape. Other times I may weight the slope in those areas to test them.

Also, if your gut were able to perform stability tests, I'd really pay more attention to it. I do not know how to explain it, but I really do believe that after years of b/c skiing, I do listen to my gut. It usually says something to me when I am in areas where I feel that conditions are more variable than what the beauty in a field or a slope of white can possess.

Lastly, I have often been amazed how much variability I have gotten when performing stability tests at the same aspect/elevation but a good distance apart. Last season, after several tours in the Saints John Drainage, near Keystone, I came to the conclusion that it was the most inconsistent snowpack in the county. The terrain is amazing, but I chose to not go there 'til spring because of the variability. I have many thoughts on why it was that way ranging from wind to just the geology of the area to the amount of mining that took place in the area.

Craig Sterbenz
Telluride Ski Patrol Director
November 24, 2003

The recent research into "s.v." is a little confounding. One would hope to find a little uniformity somewhere out there. How else can we try to understand such a complex subject but to simplify it, to recognize commonalities or patterns? We should expect to find somewhat uniform conditions on a uniform slope. But alas, the research reminds us that no simple solutions are to be had.

I think we've known all along how much the snowpack varies over space as well as over time; we just didn't really want to admit it. For years students have been taught to dig pits on slopes that should have similar conditions to the larger more dangerous slopes in question, but they've also been taught that a snowpit is really only representative of the conditions where it has been dug. I think the research really serves to verify what we already suspected about how variable the snow can be. And, now it would seem, a pit on one slope is just as likely to represent conditions on a similar slope as it is elsewhere on the same slope…

Anyway, I don't think the research has significantly changed the way I evaluate avalanche conditions. I may dig more pits now than before, but I think that's just because my knees are old and I'm almost mature enough to take the time. I like to think I've always tried to make a conscious effort to include "s.v." into my hazard evaluation, especially on the macro-scale. Which zones or which slopes have conditions that vary from other zones or slopes? Or is the weakness widespread through all zones and on all slopes? Last New Year's Eve we had over a foot of 4% snow that blanketed every aspect at every elevation with goose feathers. After a month of cold, dry weather, that fluff turned into a layer of NSF grains that was responsible for most of the avalanches that occurred on any slope in every zone for the remainder of the winter. Spatial variability played a very insignificant role in that macro-scale forecast. However, I do think that recent research into "s.v." has influenced my hazard evaluation more on the micro-scale. It has made me a lot more cognizant of looking for those small defects in the blanket—the deficit zones that may serve as trigger points.

Liam FitzGerald
Utah DOT
Avalanche Forecast Supervisor
November 25, 2003

The idea that the distribution and structure of the snowpack throughout an avalanche starting zone varies from place to place, seems quite believable when one thinks of the complexity of the terrain in those areas during the summer months. All the subtle differences in roughness, aspect, steepness, and terrain features contributing to increased or decreased snow deposition, that occur on the micro scale would reinforce the idea that things can be quite different

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SPATIAL VARIABILITY

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from "here" to "there." What is perhaps harder to grasp is the idea that all these variables contribute to subtle differences in strength or weakness, and perhaps, to the mercurial concept of areas of Increased Stress (invisible and difficult to prove, but it seems likely they exist). And if one accepts the idea that there could be areas of Increased Stress within the boundaries of the slab, then the idea that areas of Greater Strength exist within the boundaries of the slab (it must have something that holds it onto the side of the mountain) also seems plausible. In the world of the avalanche control worker and the back-country skier, these ideas are likely to be important, even if hard to grasp.

It is likely that these conditions exist constantly during the winter months, but they seem to become most important (at least in the snow climates where I have done most of my work) during those winters (or portions of winters) when faceted grains are the predominant layer in the snowpack. The winter of 2002-03 was one of those winters in the Wasatch, and I must admit that last year, because I had so many uncertainties regarding snowpack stability, I had a strong aversion to skiing upper-elevation northerly facing slopes unless they were quite "skied-up." I just couldn't trust them!

When I was a ski area avalanche worker, I thought that the combination of a significant layer of faceted snow, a previously un-compacted slope, and avalanche activity relating to that layer on other slopes with similar characteristics, suggested that spatial variability might play a significant role in determining the safety of certain areas that the public hoped would soon be open. Under these conditions it seems that the dreaded "post-control avalanche" became more likely. In these events, the usually reliable explosive test had suddenly become unreliable. This unreliability may result from the inability of the explosive shock to reach any, or enough of, the randomly spaced critical areas of Greater Stress to tip the scales and initiate fracture—or perhaps even worse, it may weaken the slope (by overloading or breaking down just enough of the randomly spaced Areas of Strength) to the point where the slope is now closer to fracture and release. After being burned more than once by this phenomenon, I became somewhat paranoid, and intrinsically suspicious. To address this, it seems that much more thorough control work becomes necessary. Once the practice of "air-blasts" became a part of our program, these events seemed to become less frequent (perhaps due to the distribution of the explosive shock over a greater area). We would also do an endless amount of ski cutting (once the slope had been thoroughly shot) using proper procedures, looking and listening closely for any signs of instability. If they were observed (seen, heard, felt, etc.) we would keep the area closed, re-shoot it and then resume the extensive ski cutting process. Even after the slope had been thoroughly shot, and chopped-up by numerous ski cutting teams, I still might feel a little unsure of my decision to open the area to the public, and would often plant myself (sometimes with one of the rescue dogs) in a vantage point where I could safely observe the area for the first hundred or so skiers. As you can tell from this lengthy answer, I am totally unsuited for the job of avalanche person, and am headed for the anxiety disorder clinic!

Kalle Kronholm (foreground) and Spencer Logan conduct shear frames for an ongoing spatial variability research project at Montana State University. Bear Basin, Montana. *photo by Karl Birkeland/NAC*

Karl Birkeland
Avalanche Scientist
Forest Service National Avalanche Center
November 25, 2003

One thing we need to define before we discuss spatial variability is our scale of interest. I think it is well accepted that avalanche conditions vary at large scales (i.e., between snow climate zones and between mountain ranges) and that within mountain ranges there are broad patterns of stability based on things like elevation and aspect. All of this is spatial variability. But the spatial variability that is a primary concern to avalanche workers and that has attracted the most research attention recently is spatial variability at the scale of individual slopes.

For me, the research into slope-scale spatial variability, and my experience with it, has emphasized one key point: there is sizable uncertainty when assessing snowpack stability, and spatial variability is one of the biggest reasons for that uncertainty. This uncertainty has further reinforced some of the ideas that Doug Fesler and Jill Fredston have been teaching for years and that Dave McClung wrote about in a recent article on avalanche forecasting when he said that a stability assessment is a targeted search for instabilities. In other words, we always need to be looking for the most unstable snow or the worst-case scenario on a particular slope. A stable stability test score may tell us little about the stability of a particular slope, but an unstable score may speak volumes about the situation we are facing.

This lack of certainty about how stability test scores correlate to avalanche activity has not reduced the number of snowpits I dig. If anything, I would suggest digging more pits, but making sure you do not spend too much time in any one pit. I also believe that there are some tools out there that may be helpful for augmenting stability test scores and helping to reduce uncertainty, like keeping track of the shear quality (or fracture character) of your tests and noting snow-structure characteristics that are associated with instabilities (as documented by McCammon and Schweizer at ISSW 2002). Shear quality and snow structure may be less spatially variable than the stability test scores, so high scores associated with Q1 shears should make folks sit up and take notice. Ultimately, however, I think we need to understand that there is still considerable uncertainty with assessing the snow stability. This is why a holistic approach is needed for avalanche forecasting, whereby we supplement stability test scores with evaluations of the snow structure, analyses of meteorological data, knowledge of recent avalanche activity, and knowledge of the terrain.

Scott Savage
Snow Safety
Big Sky Ski Area
November 25, 2003

Lone Mountain (Big Sky, MT) is either blessed or cursed (depending on your point of view) with a healthy amount of spatial variability for its size. With roughly a couple-hundred slide paths spread over complex alpine and forested terrain in a windy part of SW Montana, we observe spatial variability on several scales: cirque to cirque, slope to slope, starting zone to starting zone, pit to pit, and column to column. In a nutshell, the spatial variability I encounter affects what tools / techniques I use to evaluate stability and how much weight to give each tool / technique for the given avalanche conditions at a particular time and place. I'll primarily consider the evaluation of deep slab instability associated with thin, persistent weak layers (with little or no ski compaction in the weak layer) on large alpine paths as this is the perplexing and interesting situation we frequently encounter.

Being in a ski area setting, we need to quickly come up with many "close it" or "open it" decisions with minimal uncertainty. Explosives and ski cutting, combined with some quick hand / pole pits, are the tools of choice for evaluating current stability. But do we even need to go look at a given slope before opening it? Which slopes should we check? And where on each particular slope should we concentrate? Are there locations where, given a new load, we should be suspicious of negative results from explosives testing? I rely on a combination of probing, digging pits, and performing stability tests to attempt to evaluate potential future deep slab instabilities.

Probing a slope gives me a decent handle on the distribution of various weak layers, slabs, crusts, etc. With practice / experience, it is possible to get a reasonably accurate view of "the big picture" on a given slope in this manner. I find this technique to be extremely valuable in determining which starting zones / slopes I should investigate further, where I should dig pits, and identifying potential future shot placements. Attention to the season's avalanche and meteorological data, experience from past years, and comparing "probing results" from several paths dictate how much you can extrapolate a given path's "probing result" to other paths—spatial variability due to terrain features often prevents much extrapolation.

After probing, I dig pits and perform stability tests, usually either stuff blocks or compression tests with a shear quality score. Experience leads me to believe (I think?) that, regarding potential future deep slab instability, the presence of a persistent weak layer (probing a slope sheds light on the distribution of this weak layer) tends to be a better indicator than the qualitative stability test scores. Additionally, given a widespread (on a given slope) persistent weak layer, I tend to worry more if I see consistent very clean (Q1) shears associated with high stability test scores rather than consistent dirty (Q2+/3) shears associated with low scores.

Spatial variability and research into this topic strongly influence how we evaluate stability at Big Sky. We don't utilize study plots here because the degree of spatial variability we see on a slope-to-slope scale renders them nearly useless (concerning the larger alpine paths). Probing individual slopes/starting zones gives me some information about the degree of spatial variability on a given slope. Spatial variability affects pit observations and, even more so (I think?), stability test results. Field experience with spatial variability and research into this topic are continually tweaking/altering how much stock I put in each of the stability evaluation tools and techniques that I use. For me, the relative importance of each tool is different for every given situation, changing with both time and location. Finally, I must stress that my current approach to evaluating stability is not something I came up with on my own; it's a result of field experience and learning from many talented individuals, especially Jon Ueland, Karl Birkeland, and Ron Johnson.

Jürg Schweizer
Research Scientist
SLF Davos, Switzerland
December 24, 2003

When talking about spatial variability it is important to mention the scale. Much of the confusion occurring lately is due to mismatching scales. Variability exists at different scales from 10-4 m to 105 m. Its effect on stability evaluation can be very different.

I am interested in spatial variability because (1) I would like to know how spatial variability affects avalanche formation, (2) I would like to know how snowpack stability tests need to be done and interpreted to provide meaningful information. This type of information is beyond any doubt needed for stability evaluation and avalanche forecasting. For the first question we have studied spatial variability at the slope scale since I think this is the most relevant scale to study the effect on avalanche formation. From this and of course from many of the previous studies I have learned that spatial variability does exist beyond doubt but that in general for typical weak layers the variation is not random but has spatial structure. This means that typical weak layers are rather continuous, and rarely exist in a patchy type of pattern. The correlation length is typical of the order of meters up to more than 10 m. This means that typically two stability tests beside each other will provide similar results. Two stability tests about 10 m apart should show the variation in the given situation.

In conclusion, it seems clear that stability tests done at location where you suspect the slope to be most unstable (targeted sampling) will in most cases provide meaningful results. In other words, I do stability tests, several, and I usually trust them. Saying that I have to point out that I strongly consider the snow stratigraphy (type of weakness, slab) and the type of fracture at least as much as the stability score. As for any observation I am seeking patterns of instability. Now if I know that there is a specific type of weak layer, let's say a buried surface-hoar layer that is not very active any more but some spots might still be found where it can be triggered, I consider that type of spatial variability by additionally reducing the risk. I will not ski the very big and very steep slopes in the shadow despite the fact that the release probability is low.

Ron Johnson
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December 27, 2003

Based on research data and my basic observations, I accept that the snowpack is spatially variable. I'm intrigued by two aspects of spatial variability. One is the scale of variability; the other is how to weight the variability of the snowpack as snowpack instability increases.

First, the scale of variability. I had the opportunity to tag along with Chris Landry when he was gathering field data for his Masters thesis. I can't think of an instance that my initial sense of the stability of the slope—based on my overall impression and snowpit observations—changed even after seeing the variable results from several Quantified Loaded Column Tests. I should point out that these impressions were made in the field; I'm not sure if they would have changed after reviewing the scientific analysis of the QLCT data. This observation leads me to think that the scale of variability is important. The amount of variability across a given slope that is shown by a relatively sensitive test, like the QLTC, may not have a significant influence on how I assess the overall stability of that slope. On the other hand, if I notice significant differences in the results of less sensitive stability tests, such as: the stuffblock, rutschblock, tap test and shear-quality results, I may be more apt to alter my impressions of the overall stability on that slope.

I'm less likely to factor in spatially variable snowpack conditions when the overall stability of the snowpack is good. For instance, if I had these rutschblock scores from several pits on a given slope: RB 4, Shear Quality 3; RB 5, Shear Quality 2, and RB 6, Shear Quality 2, even though the test results indicate variability across the slope, given a lack of any other obvious signs of instability, I probably would not alter my overall impression that the stability of the snowpack on this slope is good. However, if my stability tests results were: RB 4, Shear Quality 3; RB 3, Shear Quality 2; and RB 2, Shear Quality 2, even without other obvious signs of instability, I would consider the variability of the these results to confirm my impression that the overall stability of the snowpack on this slope is poor.

These are just two aspects of spatial variability that I've been thinking about. I look forward to reading how other folks use their knowledge of spatial variability.

SOME SUMMARIZING THOUGHTS & COMMENTS

Karl Birkeland
January 28, 2004

It's been great to read through everyone's thoughts, comments, and experiences about spatial variability. Some of the more perplexing avalanches I experienced as a ski patroller gave me the motivation to go back to school to study spatial variability at the slope scale, so it is exciting to see wide interest and active research in this topic. In reading through the responses above, I can see a few common threads:

- Slope-scale spatial variability is widely recognized by practitioners and researchers, and there are some fairly well-known and understood sources of variability, such as wind and underlying substrate. However, the overall magnitude of the variability, and its link to slope stability, has yet to be fully documented.

- Spatial variability adds uncertainty to our decision-making. As such, avalanche professionals do their best to reduce that uncertainty through a variety of means such as digging more pits and doing more concentrated avalanche mitigation work.

- Most of the responses emphasize the variability in stability test scores and how those scored must be supplemented by additional data for a more reliable assessment of stability. These additional data include the shear quality (or fracture character) of the stability tests and information about the snow structure (i.e., McCammon and Schweitzer's Lemons), as well as a long list of other information about avalanche activity, snow history, weather history, etc.

- Some responses also emphasize the importance of understanding slab properties and fracture toughness as part of our assessment of the stability and slope-scale variability. This is another area of active research and I think (and hope!) that our understanding of this topic will improve over the next several years.

Our collective responses show the difficulty in managing spatial variability. I think it is important not to underestimate the complexity of the situation. Ron Perla said there are no rules of thumb for avalanche forecasting, and I think rules of thumb will be tough to come by for dealing with spatial variability. The research thus far consists of some snapshots of variability at a few select times on a few select slopes. Nearly every situation is different—in the terrain, the snowpack, and the evolution of the snowpack—so I think finding solid rules of thumb will be difficult. Hopefully research will be able to provide some useful guidelines and perhaps a better understanding of the magnitude of uncertainty that spatial variability throws into our stability assessments. The good news is that understanding spatial variability will be an ongoing process. That means there will always be good employment opportunities for experienced folks working with snow avalanches, and those avalanche professionals are going to have to spend time in the field! ❊

THE Avalanche REVIEW

MAY 2004 • VOLUME 22 • NUMBER 3

The Avalanche Review
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