THE AVALANCHE TERRAIN EXPOSURE SCALE

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ABSTRACT: Exposure to avalanche terrain is a fundamental concept and an important parameter for winter routefinding decisions in the backcountry. However, education and communication concerning avalanche terrain has been difficult due to the lack of quantitative measurement tools that can be applied in a comprehensive way. In an attempt to fill this void, Parks Canada has developed and implemented the Avalanche Terrain Exposure Scale (ATES), which provides a framework to comprehensively evaluate, describe and communicate the complexities of avalanche terrain exposure. This classification system for avalanche terrain consists of two models – technical and public communication. The technical model is designed for users skilled in the subtle nuances of interpreting avalanche terrain, while the public communication model is designed to easily communicate the same concepts to a less skilled audience. Parks Canada has applied this classification system to 275 backcountry tours and 75 waterfall ice climbs. These represent the most popular trips in the Mountain National Parks. Information is distributed via brochures and the Internet in both French and English. The Canadian Avalanche Association's Industry Training Program adopted the ATES system in 2005 as a framework for introductory professional avalanche terrain education. A categorical breakdown of avalanche terrain and subsequent classification method has proven a valuable tool in teaching avalanche terrain fundamentals and basic route finding to this audience.

KEYWORDS: avalanche terrain, terrain classification, exposure scale, education

1. INTRODUCTION

The measurement of avalanche terrain is not new, and is in fact a well-established practice in the application of avalanche terrain mapping and zoning. National standards and guidelines have been established in Canada (CAA, 2002) and are applied in many situations. Quantitative measurement indexes such as return interval or coloured zoning provide the basis for establishing mitigating measures to reduce the avalanche risk.

Historically, the formal practice of quantitatively evaluating avalanche terrain has been applied primarily in a non-recreational context, where the elements at risk do not move freely through the terrain. The static nature of roads and buildings allows for a relatively confident evaluation of the terrain that threatens them. Once these exposed elements begin to move freely (i.e. skiers), traditional mapping techniques are no longer practical.

In the recreational context, qualitative evaluation of avalanche terrain has been practiced for years. While no "number" was attached to these evaluations, experts were (and still are) making decisions based on the magnitude of the terrain at hand. Indeed, while snow stability evaluation is a critical input to decision making, it is avalanche terrain evaluation skills which provide the most security during complex decision-making situations. A person can observe terrain and choose how they interact with it.

2. THE NEED FOR STRUCTURED TERRAIN ANALYSIS TOOLS

While experts may possess the intuitive skills for evaluating avalanche terrain, these attributes do not exist in novice backcountry users. Novices require straightforward techniques that allow for a rule-based approach – in other words, quantitative tools to help them understand the significance of what they are observing.

These tools exist for the evaluation of snow stability. Snow profile, rutchblock and compression tests are examples of common techniques for measuring the strength of the snow. These techniques are used extensively in avalanche education – primarily because in an uncertain and intimidating environment, learners benefit from formal measurements that provide organization and order to the chaos.

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Traditionally, avalanche terrain education has focused on the static parameters of terrain, treating each characteristic individually. What lacked were techniques for demonstrating the integration of all the terrain parameters. Students were left to "get out there and get some experience" to figure this out, and while still necessary, tools for quantifying and integrating terrain parameters were also clearly needed.

3. BACKGROUND AND IMPETUS

For many years, avalanche risk communicators have been grappling with how to adequately portray avalanche danger to clients on a given day with a given snow stability. Avalanche danger scales had long since been developed in Europe and then adopted for North American audiences. Bulletin writers were frustrated by the fact that as a stand-alone tool, the actual danger to clients was only partially represented by the Danger Scale.

As the popularity of winter backcountry touring increased, communicators were noting a change in clientele: a new breed of skiers and boarders were emerging from the off-piste crowd. Their skills and appetites for untracked snow slopes were very high. Their route choices were progressing into steeper and more complicated terrain, adding to the frustration of communicators. Concepts pertaining to differences in exposure and the consequences of an avalanche occurring were hard to communicate, and often left to descriptions hidden in the text of daily bulletins.

Concurrently, there was much dialogue in the professional avalanche community as to how to incorporate terrain into the existing communications, but progress was slow and no concrete tools emerged. Terrain, it seemed, was difficult to classify.

On February 1, 2003, 17 students from a Calgary area private school were engulfed in an avalanche in Glacier National Park – seven students died. In the following months, Parks Canada's Backcountry Avalanche Risk Review (O'Gorman et al, 2003) identified 36 recommendations Parks Canada should undertake to improve backcountry avalanche safety within National Parks. These included recommendations on the public communication of risk and the management of youth groups traveling in the backcountry.

The BC Coroner's Report for the Glacier Park incident recommended the following: "Parks Canada should complete a snow avalanche risk rating for each ski trail and slope commonly used by the public. This risk rating should become part of the park's information available to the public" (BC Coroner, 2003).

In the wake of these reviews, government land mangers and other officials needed to know more about the avalanche terrain they were responsible for, the public wanted simpler tools to better understand the avalanche situation on public lands, and school boards wanted better tools for communicating with parents about what kind of backcountry travel their children were undertaking.

Although not specifically cited as a recommendation, it was clear that the development of a classification system for recreational use of avalanche terrain would facilitate the implementation of a number of important recommendations. Effective systems were already well established for classifying terrain for climbing and whitewater. The time had come for an avalanche terrain classification system.

4. DEVELOPMENT

Initial models were drawn up using an analogy with the ski area system of green, blue and black runs. This simple system works well for steering people into terrain that is appropriate for their skill level, which is the primary goal of this avalanche classification system. As drafts began circulating, the working group grew to include all of Parks Canada's avalanche forecasters and a number of contributors from outside the agency.

Work soon evolved into the development of two concurrent models – one for the public and another for professionals. Knowing that Parks Canada would be implementing this system throughout its land, avalanche forecasters were uncomfortable with formally classifying terrain based on simple messages targeted for the public. Behind the veil of public messaging was the need for incorporating the best science and expert knowledge available. This led to the development of a "technical model", and it soon became apparent that these two concurrent models were essential for meeting the needs of two specific but very different audiences. Both models say the same thing, delivered in different languages.

5. AVALANCHE TERRAIN EXPOSURE SCALE (ATES)

Figure 1: ATES Public Communication Model (v.1/04)

Description	Class	Terrain Criteria
Simple	1	Exposure to low angle or primarily forested terrain. Some forest openings may involve the runout zones of infrequent avalanches. Many options to reduce or eliminate exposure. No glacier travel.
Challenging	2	Exposure to well defined avalanche paths, starting zones or terrain traps; options exist to reduce or eliminate exposure with careful routefinding. Glacier travel is straightforward but crevasse hazards may exist.
Complex	3	Exposure to multiple overlapping avalanche paths or large expanses of steep, open terrain; multiple avalanche starting zones and terrain traps below; minimal options to reduce exposure. Complicated glacier travel with extensive crevasse bands or icefalls.

Figure 2: ATES Technical Model (v.1/04)

	1 – Simple	2 - Challenging	3 - Complex
Slope angle	Angles generally < 30º	***Mostly low angle, isolated slopes >35º***	***Variable with large % >35º***
Slope shape	Uniform	Some convexities	Convoluted
Forest density	Primarily treed with some forest openings	Mixed trees and open terrain	Large expanses of open terrain. Isolated tree bands
Terrain traps	Minimal, some creek slopes or cutbanks	Some depressions, gullies and/or overhead avalanche terrain	***Many depressions, gullies, cliffs, hidden slopes above gullies, cornices***
Avalanche frequency (events:years)	1:30 ≥ size 2	1:1 for < size 2 ***1:3 for ≥ size 2***	1:1 < size 3 ***1:1 ≥ size 3***
Start zone density	Limited open terrain	Some open terrain. Isolated avalanche paths leading to valley bottom	Large expanses of open terrain. Multiple avalanche paths leading to valley bottom
Runout zone characteristics	Solitary, well defined areas, smooth transitions, spread deposits	Abrupt transitions or depressions with deep deposits	Multiple converging runout zones, confined deposition area, steep tracks overhead
Interaction with avalanche paths	Runout zones only	Single path or paths with separation	***Numerous and overlapping paths***
Route options	Numerous, terrain allows multiple choices	A selection of choices of varying exposure, options to avoid avalanche paths	***Limited chances to reduce exposure, avoidance not possible***
Exposure time	None, or limited exposure crossing runouts only	***Isolated exposure to start zones and tracks***	***Frequent exposure to start zones and tracks***
Glaciation	None	***Generally smooth with isolated bands of crevasses***	***Broken or steep sections of crevasses, icefalls or serac exposure***

6. APPLYING THE TECHNICAL MODEL

Any system for integrating multiple avalanche terrain variables into discreet categories will by nature present grey areas. In an attempt to minimize these, and to weight particular attributes, the following statement accompanies Figure 2.

Any given piece of mountain terrain may have elements that will fit into multiple classes. Applying a terrain exposure rating involves considering all of the variables described above, using some default priorities. Terrain that qualifies under an ***italicized*** descriptor automatically defaults into that or a higher terrain class. Non-italicized descriptors carry less weight and will not trigger a default, but must be considered in combination with the other factors.

7. IMPLEMENTATION

Development of ATES v.1/04 was completed in August 2004, and since that time the system has been applied in various situations.

7.1 National Parks Terrain

The Mountain National Parks represent seven national parks and 29 000 sq km of terrain – clearly it is impractical to classify the area in its entirety. A list of the most popular backcountry touring destinations was developed in conjunction with current guidebook information. This list returned 275 trips requiring classification.

The ATES was designed to classify “trips” rather than individual pieces of avalanche terrain. This necessitated discussion regarding the boundaries of each trip, and highlighted how the link with published guidebook information is critical. Simply providing the public an ATES rating is not enough – they need to understand the details of each trip, including the boundaries of the region under discussion.

Parks Canada avalanche forecasters applied the ATES to each of the trips listed within their park, and the resulting classifications were debated to consensus among the group. Typical of any terrain discussion among experienced professionals, most locations were straightforward and discussion quickly became centered around very specific pieces of terrain on a select few trips.

The resulting list of ATES rated trips was published in November 2004 and revised in 2005 (PCA, 2005). The list uses colour-coded text (Simple = green; Challenging = blue; Complex = black). This was delivered along with the Public Communication Model and strong messages to use this information together with other resources such as maps and guidebooks. Parks Canada has since used the same process to classify the avalanche terrain for 75 of the most popular waterfall ice climbs in the Canadian Rockies, publishing a similar brochure (PCA, 2005). All products are provided in both English and French at www.pc.gc.ca/avalanche.

7.2 Custodial Group Policy

Following the classification exercise outlined above, Parks Canada used the ATES to enable the implementation of public policy regarding custodial groups undertaking winter backcountry travel within National Parks (PCA, 2004). This policy (Figure 3) is legally binding and enforced through the National Parks General Regulations (PCA, 2003).

Figure 3: Parks Canada’s custodial group policy based on the ATES

ATES Terrain Type	Custodial Group Policy
Class 1 - Simple	Custodial groups may travel with no specific leadership or custodial permitting requirements. Parks Canada recommends that custodial groups avoid backcountry travel entirely during Backcountry Avalanche Advisories of POOR.
Class 2 - Challenging	An ACMG certified guide must lead all custodial groups. Group size must not exceed 10. Travel on avalanche terrain only when the guide rates the slope specific snow stability as GOOD or VERY GOOD.
Class 3 - Complex	Custodial groups are not permitted in complex terrain under any conditions.

7.3 Recreational Avalanche Course Policy

The Canadian Avalanche Centre (CAC) supports the delivery of national standardized curriculum for Recreational Avalanche Courses (RAC). One mechanism of this support is through the Field Trip Policy, which guides course providers on appropriate terrain for course delivery, commensurate with their level of training. The ATES has now been incorporated into the Field Trip Policy.

"Instructors leading Introductory RAC field trips who are CAA Active Members are responsible to ensure those field trips take place on terrain which has been rated as "simple" according to the ATES, in guidebooks or other documentation provided by a responsible third party. In the absence of ATES documentation, only non-avalanche terrain can be used" (CAA, 2006).

7.4 Canadian Avalanche Association (CAA) – Industry Training Programs

For many years, the CAA has been challenged in its Avalanche Operations Level 1 and 2 courses, to find effective ways of teaching advanced terrain concepts to avalanche workers. Areas regularly identified by instructors and students included a lack of comprehensive frameworks describing the interaction of multiple terrain parameters, and a lack of terrain analysis tools to help structure and approach terrain decisions during field exercises.

During the 2004-05 winter, the CAA experimented with the ATES Technical Model as a way of teaching advanced terrain concepts beyond the simple, discrete terrain parameters like slope angle and slope shape. Feedback from instructors was very positive, and there was strong feedback from students that the ATES Technical Model helped them comprehend multiple terrain variables more completely – allowing for a clearer understanding of terrain complexity. The scale was used both in the classroom and in the field, as a way to breakdown, analyze and categorize terrain.

The 2005-06 winter saw full implementation of the ATES method into all CAA Level 1 and 2 courses. The instructional utility of ATES continues to evolve but has so far proven very effective at providing a framework for more thorough and concrete comprehension of terrain parameters, their interaction, resulting complexity and ultimately terrain decisions made during field exercises.

7.5 CAA – Online Learning

On October 1, 2005, the CAA launched an Avalanche First Responder Online Avalanche Course at www.avalanche.ca. Reducing risk in the field and safe route finding fundamentals were key areas of focus during course development, and the ATES was explored for its utility as an online, public education tool.

Utilizing a series of interactive online exercises, a module was developed teaching fundamentals of both the public communication and technical models. The goal was to allow users to match terrain parameters outlined in the ATES with real life terrain photos. With this recent addition of the "Understanding Avalanche Terrain" module, it is expected that knowledge of Parks Canada's ATES, its use in National Parks, and the fundamental principles within the technical model will strengthen basic understanding of un-rated terrain outside of National Parks.

Since the launch of this online learning program, more than 40,000 unique users have taken the course, and an additional terrain module is being developed that integrates ATES with the Avaluator (see below) for a more comprehensive terrain educational tool.

7.6 Avaluator

The Avaluator (Haegeli et al, 2006) is a simple, rule-based decision tool for amateur winter recreationists. It was developed through the ADFAR (Avalanche Decision Framework for Amateur Recreationists) project of the CAA. The focus of this three-year project was to improve the general understanding of the current decision processes and risk perceptions of amateur recreationists. The results provided the foundation for the development of an effective and useful risk communication tool for the various target groups.

The ATES has been used in several ways throughout the development of the Avaluator:

1) As a component of an online survey tool for examining the decision-making patterns, risk perceptions and

propensities of amateur recreationists when traveling in avalanche terrain.
2) For classifying the terrain of avalanche accidents to statistically validate the Avaluator.
3) As a major input for the public to use in the determination of risk levels during pre-trip planning.

The Avaluator will make its public debut in 2006, and as part of future avalanche course curriculum, it will most certainly further embed the ATES system in the public domain.

7.7 Guidebooks

An initial goal of Parks Canada was to develop a rating system that would logically be incorporated into guidebook information, similar to rock climbing and whitewater. The fourth edition of *Ski Trails in the Canadian Rockies* (Scott, 2005) includes the Public Communication Model and an ATES rating for every ski trip described in the book. This information will provide readers with a necessary categorization for matching their skills with an appropriate type of avalanche terrain.

8. SCALE OF APPLICATION

Parks Canada's initial goal was to build a system for rating "trips" or drainage-scale sections of terrain. Drainage scale ratings are useful for pre-trip planning, but provide limited additional value for slope scale decisions. The ATES is primarily a pre-trip planning tool, and the broad classifications of v.1/04 were not intended to support slope scale decision-making. However, with the implementation of the ATES resulting in generally positive outcomes, further attempts have tried to reduce the scale of application towards "slope". This is proving quite difficult, and although the specifics contained within the technical model are applicable at the slope scale, the effective application of an ATES rating at this scale has yet to be proven.

9. FUTURE CHALLENGES

There is a need to expand the classification of terrain beyond the boundaries of National Parks, into other popular recreation areas. Guidebook authors, the CAA and other government land managers have all indicated a desire to expand ATES coverage, with their primary goal of advancing public information in support of improved decision making.

Opportunities exist to improve the style of presentation – to date only textual lists of rated terrain have been published. The next logical step is to take the presentation style from columns of text, and apply polygons directly to maps. Several GIS based initiatives in this regard are currently underway, including an attempt to provide slope specific ATES classification (Delparte, 2006). These initiatives highlight the scale challenges described earlier, but ultimately the visualization of ATES ratings on terrain maps is the next logical step – regardless of the scale they are applied.

The ATES version presented here has been given a version number and date stamp (v.1/04). Undoubtedly, as experience with the ATES and terrain classification grows, future modifications are likely. Attempts at v.2 have yielded much discussion around the concept of *aspect* – a fundamental terrain parameter that is suspiciously absent from v.1/04. Aspect is irrelevant to larger scale applications, but it cannot be ignored for any slope specific analysis. Aspect can be further reduced to "Exposure to Wind" and "Exposure to Sun", but the resulting descriptions have yet to add value to the ATES. For now, aspect is not considered within the ATES, and classification is largely been kept to the "trip" scale. Reducing the scale of application is a challenge for the future.

10. CONCLUSION

The ATES is a powerful management tool that must be applied carefully – in the words of one local mountain guide, "So that's what you're going to use to tell me where I can and can't go" (M. Klassen, 2004). Indeed, this system provides new tools for controlling access to the landscape. With its application towards the management of custodial groups in the National Parks it has already proven its merits.

It has however, also proven its merits in the evaluation and communication of avalanche terrain specifics. Its general acceptance within the professional avalanche community was rapid and clearly filled a void. Today's students are learning more effectively, government officials are better informed, and public information for where and when to travel in avalanche terrain has never been better. The public has eagerly

accepted this system, and the language contained within the scale is becoming common discourse.

Time will reveal the full implications of the ATES, but during its short life span to date, it has become a useful tool that dispenses common sense and provides an important contribution towards understanding and communicating the principles of avalanche terrain.

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