# THE NORTH AMERICAN PUBLIC AVALANCHE DANGER SCALE

Grant Statham[1]*, Pascal Haegeli[2], Karl W. Birkeland[3], Ethan Greene[4], Clair Israelson[5], Bruce Tremper[6], Chris Stethem[7], Bruce McMahon[8], Brad White[1], John Kelly[5]

[1]*Parks Canada Agency, Banff, AB*
[2]*Simon Fraser University, Burnaby, BC; Avisualanche Consulting, Vancouver, BC*
[3]*USDA Forest Service National Avalanche Centre, Bozeman, MT*
[4]*Colorado Avalanche Information Centre, Boulder, CO*
[5]*Canadian Avalanche Centre, Revelstoke, BC*
[6]*USDA Forest Service Utah Avalanche Centre, Salt Lake City, UT*
[7]*Chris Stethem & Associates Ltd., Canmore, AB*
[8]*Parks Canada Agency, Rogers Pass, BC*

## ABSTRACT

The Avalanche Danger Scale is an ordinal, five-level warning system that is a cornerstone of public avalanche information. The system was developed in Europe in 1993, and introduced to North America in 1994. Although both Canada and the United States adopted the system, different descriptors of the danger levels were developed in each country. Fifteen years of practical use revealed numerous deficiencies in this danger scale, most notably a lack of clarity during low probability/high consequence avalanche conditions. In 2005, a group of Canadian and American avalanche forecasters and researchers began to revise the system, with the goal of improving clarity and developing a single standard for North America. Initial explorations to define the problem resulted in more questions and uncovered an almost complete absence of formal underpinnings for the danger scale. The magnitude of the project subsequently changed, and in 2007 the project objectives were clarified as: 1) definitions of avalanche hazard, danger and risk; 2) methodology for assessing avalanche danger; and 3) revisions to the danger scale as a public communication tool. This paper concentrates on the third and final objective, and describes the methods and results of producing the North American Public Avalanche Danger Scale. Emphasis is placed on best practice in warning system design and the principles of risk communication, which helped reshape the avalanche danger scale into a more effective communication tool. The revised danger scale will be implemented across Canada and the United States for the 2010/11 season.

## 1. INTRODUCTION

First and foremost, the purpose of the avalanche danger scale is public risk communication. As part of the public avalanche warning system, its primary objective is to accompany an avalanche bulletin and provide a relative measure of avalanche danger that corresponds with a set of definitions for each of the five danger levels. A danger rating is simply a basic ranking of avalanche danger for a period of time over a specific region.

* *Corresponding author address:* Grant Statham, Parks Canada, Box 900, Banff, Alberta, Canada, T1L 1K2; Phone: 403 762 1568; Email: grant.statham@pc.gc.ca

Used in isolation, danger ratings are far too basic to achieve the precision necessary for conventional avalanche forecasting. Although the danger scale contributes to the evaluation of risk, by itself it is not an evaluation of risk. Avalanche bulletins warn of danger, but only the public themselves can determine their own individual vulnerabilities and exposure, thus being in control of their own risk (Statham, 2008).

The danger scale has also historically served an important secondary purpose. The definitions of avalanche danger contained within the scale serve as the primary guidance used by professional forecasters when determining a danger rating. While countless worksheets and checklists to aid the forecasting process have been developed over

time, it is the danger scale's definitions themselves which ultimately bind the forecaster and determine the rating level.

These two purposes are often at odds. Public warnings require basic terminology and simple messages to ensure comprehension at the low-end of the target audience (Laughery and Hammond, 1999), while professional forecasters are science based, and preoccupied with the technical details of weather, snowpack and terrain (Weick and Sutcliffe, 2007).

Accordingly, the revision of the avalanche danger scale sought to bridge the gap between technical analysis and public communication. A second primary goal was to retool an already established warning system to make it communicate with a greater emphasis on consequence. This is important, as one of the strongest and most robust findings in the warnings literature is that warning effectiveness increases with the perceived hazardousness of the product (DeJoy, 1999).

## 2. METHODS

A group of ten subject matter experts (the authors) was assembled in 2005 to collaborate on this project. The intent was to bring together a varied group representing the interests of public forecasting, research, mountain guiding, avalanche education, industry and highway avalanche forecasting. This group remained mostly intact over the five years of project work, which included workshops in Canmore, Revelstoke, Penticton, and Bozeman, along with an extensive schedule of conference calls and email discussion.

The initial work of this committee focused on developing relevant definitions of avalanche hazard, danger and risk (Statham, 2008), and the design of a conceptual model of avalanche hazard (Statham et al., 2010) with the intent of developing a consistent forecasting model. Suspending work on the danger scale itself to first solve these two preconditions was absolutely necessary to ensure a solid foundation upon which to build the danger scale. Subsequent work and the development of early prototypes began in 2008.

Consultation was extensive and included numerous presentations and workshops in Canada and the United States to keep stakeholders informed. Avalanche forecasters from all public forecast centres were consulted for their feedback at varying stages. The European Avalanche Warning Services were consulted several times, and presentations were made at workshops in Slovakia and Austria.

Product testing of an early prototype was undertaken over a two-week period in March 2009, using an online survey linked from avalanche bulletins in Canada and the US (Ipsos Reid, 2009). This was a comprehensive public test of the danger scale. Participants were invited to evaluate scenarios in relation to a stated danger rating, and were tested for comprehension of the situation, and their ability to choose appropriate actions. A total of 4423 respondents from the backcountry community provided feedback, largely rejecting the proposed prototype and favouring the original danger scale.

On consideration of the test results, it was concluded that further improvements to the danger scale were likely to be found in the domain of risk communication, rather than avalanche forecasting. The dichotomy of a sound technical foundation versus simple communication had become a problem that the committee was no longer qualified to resolve. Expertise in risk communication, technical editing and graphic design was sought out at this penultimate stage, and was the key to completing the final version of the danger scale.

Lastly, the danger scale was translated into French by Canada's Federal Translation Bureau, and then reviewed by an avalanche translation committee comprised of avalanche forecasters and professional translators.

3. RESULTS

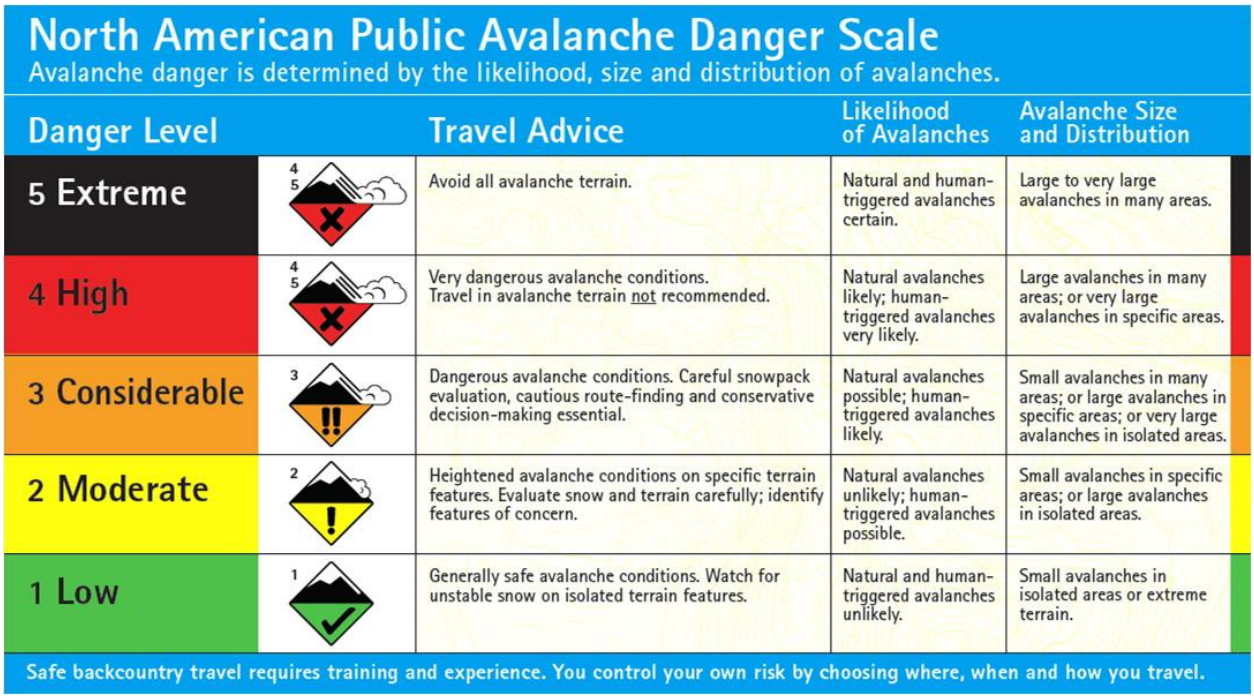


*Figure 1.The North American Public Avalanche Danger Scale.*

4. DISCUSSION

*4.1 Target Audience*

Since 2004, avalanche warning systems in North America and Europe have evolved towards a tiered approach to public communication (Statham and Jones, 2006). This structure delivers different kinds of information to different kinds of audiences, as shown in Table 1.

Table 1: Tiered avalanche warning system and target audiences.

| Target Audience | Level of Knowledge | Examples of Products |
|---|---|---|
| Tier 1 | None | Icons, colors, signal words |
| Tier 2 | Basic | Bulletins, terrain ratings |
| Tier 3 | Advanced | Snow profiles, raw data |

A thorough understanding of the target audience characteristics is necessary for effective risk communication. Laugherty and Breslforst (1991) implored warning designers to 'know thy user' with regard to (1) demographics and age, (2) familiarity with the product, (3) competence (technical knowledge, language, reading ability) and, (4) hazard perception.

The new danger scale was designed to accommodate a variety of target audiences, and provides options to tailor public warnings for particular audiences using different combinations of products within the scale. While the avalanche forecaster will focus on the interplay between the likelihood and size columns, a snowshoer with minimal avalanche knowledge may be better served with an icon or a color.

*4.2 Number of Levels of Avalanche Danger*

Some of the greatest debate surrounding the danger scale relates to how many levels of avalanche danger are necessary. While the danger scale presents five discrete categories of danger, there is a significant argument for the use of four levels (McClung, 2000), or in other cases

more than five levels. Ultimately it was decided that because the five-level danger scale is by now thoroughly established worldwide, changing the levels of danger in North America only would be detrimental to the key objective of consistency and comprehension between nations.

Avalanche forecasters will undoubtedly continue to debate this matter for years to come. Any future student of avalanche danger theory will quickly discover that often, politics, expediency, self-interest, and litigation influence results. Probably we shall never eliminate the influence of such factors, but the challenge is to incorporate the best scientific information into the process to ensure the most effective results (Sanders, 1999).

*4.3 Signal Words*

Signal words are used in warnings to draw attention to the sign or label and to quickly communicate the level of hazard (Leonard et al., 1988). For the danger scale, these signal words are *Low, Moderate, Considerable, High* and *Extreme*. Avalanche forecasters are typically reluctant to warn using signal words alone, but in recent years this trend has been increasing. The introduction of various decision frameworks that depend on a danger rating has boosted this trend.

Generally speaking, the words *Low, Moderate, High* and *Extreme* are unambiguous and interpreted correctly by most of the target audience. These are terms used commonly in other warning systems, and most people are familiar with what they mean. The same cannot be said for *Considerable*, which when used alone, continues to demonstrate its ineffectiveness at communicating the danger. This term is subject to wide variation in comprehension, as demonstrated clearly in nearly all consultations and product testing (Ipsos Reid, 2009).

However, with a five-level warning system such as the danger scale, and only four signal words offering unambiguous interpretation, what is the best signal word for the third level of danger? The Norwegians proposed a re-ordering the terms into *Low, Moderate, High, Very High* and *Extreme* (Brattlien, 2009). This meant that *High* would replace *Considerable*, and *Very High* would replace *High*. While initially attractive, the potential confusion resulting from such a dramatic redefinition of established terminology ended this idea.

Thus, after much research and deliberation, is was determined to keep the signal word *Considerable* for the third level of danger. A pronounced effort to very clearly define the meaning of *Considerable* was undertaken, with an emphasis on showing the seriousness of this danger level. It is hoped that through education, comprehension of this term will continue to improve, as it is this third level of danger when the greatest percentage of fatal avalanche accident occur (Greene et al., 2006).

*4.4 Numbers*

An unambiguous way to communicate the order and levels of avalanche danger is by using numbers instead of signal words. In areas with multi-lingual audiences, numbers cross the language barrier and solve translation problems. The European countries commonly refer to their danger levels numerically, using phrases such as *Danger Level 4* instead of *High*. The new danger scale now includes the numbers 1-5 matched with each signal word.

Issues regarding the use of numbers centre around three issues. First, avalanche danger does not grow in a linear fashion, as the numbers 1-5 would suggest. *Danger Level 3* is a significant jump from *Danger Level 2*, yet this is not represented by these numbers. This gives the false impression that *Danger Level 3* is simply the middle point of the scale, and conditions are not that bad. Second, a good signal word communicates more meaning about the conditions than a simple number. Used alone, the term *High* provides better information about the conditions than *Danger Level 4*, especially for an audience unfamiliar with the danger scale. Third, an ordinal numbering scheme removes any ambiguity of the placement of danger ratings in their hierarchy. Thus the problem word, *Considerable*, is clearly identified as between *Moderate* and *High*. Despite

these issues, the use of ordinal numbers was adopted.

*4.5 Colors*

Colors associated with danger levels are another important method of communicating avalanche danger. Signs, maps and websites are a few examples of where the use of colors can have an immediate impact. The colors on the revised danger scale remain unchanged from the previous scale, with the exception of clarifying black as the color to be used for *Extreme*, and a slightly modified tone for the green that represents *Low* danger.

Based initially on the Swiss RGB color specifications for each danger level (SLF, 2007) this project updated these specifications by also including standards for CMYK and Web-safe colors (Greene et al., 2010).

*4.6 Icons*

In 2005, Parks Canada and the Canadian Avalanche Centre implemented a new warning system called the Backcountry Avalanche Advisory (Statham and Jones, 2006). This introduced the concept of a tiered warning system, and provided graphical icons for Tier 1 audiences. Following this, the Swiss modified these icons slightly, added one more, and linked them to the danger scale. In 2009, the European Avalanche Warning Services voted to accept these Swiss icons as a common standard across Europe, and following this, they were included with the North American danger scale to make for an international standard.

Each danger level has a different icon, except for *High* and *Extreme* which share the same icon. There are numbers beside each icon, which are intended to help distinguish between them in black & white copy. Icons are yet another component of the danger scale that can be used to communicate a simple message with Tier 1 audiences. The media loves icons, and as the Swiss experience will confirm, there is opportunity here to vastly expand the distribution of basic avalanche warnings.

*4.7 Travel Advice*

This is the column previously known as Recommended Action, now significantly improved to provide strong and clear statements on what the avalanche conditions are, combined with advice on how to travel. The opening statements such as “Dangerous avalanche conditions (*Considerable*), and “Avoid all avalanche terrain” (*Extreme*) are designed to be short and concise, with an immediate impact. The secondary statements such as “Evaluate snow and terrain carefully; identify features of concern” (*Moderate*), and “Careful snowpack evaluation, cautious route-finding and conservative decision-making essential” (*Considerable*) are intended to convey the single most important piece of advice for those conditions. The travel advice can also help forecasters discern between danger levels by referring to this column, and then asking themselves what kind of travel advice they would recommend for a given day.

*4.8 Likelihood of Avalanches*

This column communicates the chance of triggering avalanches, both naturally and human-triggered. The likelihood terms have been re-ordered in accordance with their numerical probability equivalents (Regan et al, 1989). The term *probable* has been eliminated, and the following five likelihood terms are now used: *unlikely, possible, likely, very likely,* and *certain* (Statham et al., 2010).

For avalanche forecasters, the probability column has always been the most important information for determining the danger rating. In fact, it provided the only definition for determining the proper rating. Long debates over the meaning of probable versus possible seemed a diversion from what was most important. There is less room for debate with this revised terminology, and combined with Avalanche Size/Distribution and the Travel Advice, this information now provides a more complete method of determining and understanding the danger level.

*4.9 Avalanche Size and Distribution*

Providing definitions for avalanche size and distribution, and linking them to danger levels, introduces a new and significant piece of information, both for forecasters and the public. Avalanche danger is defined as a combination of likelihood and size (Statham, 2008), thus the addition of size and distribution makes the system risk-based by introducing consequence into the danger scale. Avalanche size is a key indicator of avalanche danger, but until now had not been formally considered in the evaluation. Table 2 shows the destructive size ranges for each term relative to an unprotected person being caught.

Table 2. Danger Scale terms for avalanche size and their corresponding destructive size.

| Danger Scale Term | Avalanche Size Range |
|---|---|
| Small | < Size D2 |
| Large | Size D2 to D3 |
| Very Large | > Size D3 |

The Conceptual Model of Avalanche Hazard (Statham et al, 2010) defines three levels of spatial distribution: isolated, specific and widespread. Matched with avalanche size, this information is a general overview of where, and how big the avalanches might be. This benefits avalanche forecasters in their analysis, as it provides a second (with likelihood) definitive measure for reference when determining avalanche danger. For the public, messages such as “Large avalanches in many areas” or “small avalanches in isolated areas or extreme terrain” further illustrate the impact of the conditions by describing some of the consequences of triggering an avalanche.

## 5. SUMMARY

The North American Public Avalanche Danger Scale will be implemented throughout Canada and the United States for the 2010/11 avalanche season. The scale is a five-level warning system that communicates the likelihood of avalanches being triggered, their expected size, how widespread the situation is and recommends actions for backcountry travel. In addition to its acceptance in North America, the scale will be adopted in New Zealand for the 2011 southern hemisphere winter (Hobman, pers. com., 2010).

We believe this new scale, and its underlying framework, is already having a significant impact on public avalanche risk management. By clearly defining avalanche hazard, danger and risk (Statham, 2008), developing a transparent forecasting model for determining avalanche danger (Statham et al., 2010), and then revising the principal system for communicating avalanche danger, we have developed a comprehensive avalanche warning system based on the best available science and practice in avalanche forecasting and risk communication. We expect this to pay dividends in the form of better education for both professionals and the public.

Many have asked what took so long, and why all the complications? Why not just change a few words on the scale and get on with it? Well, in the end it’s just a scale; nothing more than a table of carefully crafted words, symbols and colors designed with the best of intent to help the public better understand and manage their risk. The scale is simply one more step in the larger process of understanding avalanche risk. Although fleshing out this process was time consuming, it has resulted in a more solid foundation upon which to base our knowledge of avalanche risk and public warnings.

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