

AVALANCHE DANGER RATINGS AND DEATHS, PUTTING THINGS INTO PERSPECTIVE

Terry Eyland^{1*}

¹Bishop's University, QC, Canada

ABSTRACT: Avalanche forecasters spend a lot of time to determine current and predicted avalanche danger levels, but to what extent does this danger rating have an influence on whether people head into the backcountry or not? Some avalanche professionals say that *considerable* is the most deadly avalanche danger. In absolute terms it may be true that *considerable* claims the most deaths, but in relative terms (exposure time) the story may be quite different. For this study, Glacier National Park (Rogers Pass) in British Columbia was the main source of data. The data shows that 80-90% of the days happen at a *moderate* or *considerable* danger rating. We highlight that based on 2016-17 skier days, for each death at *high*, we would have needed 28 deaths at *considerable*, 46 deaths at *moderate* and 25 deaths at *low* to keep relative avalanche danger the same. Moreover, regression results show that skiers are significantly more likely to go skiing when the avalanche danger is *moderate* or *considerable* compared to *high*, which should be obvious. However, the key result is that the coefficient, which represents the increase in skiers, is roughly the same for both danger levels. It is as if *moderate* or *considerable* have the same influence on whether someone decides to head out or not. We recommend the removal of the *extreme* danger rating (which rarely gets used) to separate *moderate* in the lower half and *considerable* in the upper half of the scale.

KEYWORDS: Decision-making, Avalanche Danger Scale, Human Factors, Avalanche Education.

1. INTRODUCTION

Over the years, there have been many discussions amongst avalanche professionals about the avalanche danger scale and what kind of information should be available to the public. Through some of these discussions, some professionals as well as Blake's (2004) article "Considering Considerable and Other Considerations" believe that *considerable* is where there is the highest level of risk. The article stated that most deaths and incidents happen at *considerable* danger level. To verify whether *considerable* claims the most deaths in absolute terms is pretty straightforward and obvious. However, the claim that *considerable* is the riskiest or has the highest probability of getting in an avalanche incident requires a more thorough analysis. To clearly understand why most people die at *considerable* or *moderate* we must understand what relative amounts of people go into avalanche country at those danger levels versus *high* or *extreme*. It is like buying a ticket for a raffle and you can either choose raffle "A" or "B". "A" only has one winner and "B" has 10 winners. When you only take that information into account it

seems you have more chance of winning in raffle "B" (or dying at *considerable*). However, if raffle "A" only sells 100 tickets and raffle "B" sells 100,000 tickets your likelihood of winning is higher in "A" than "B".

Therefore, first getting an idea of what percentage of the yearly visits are done while the avalanche danger is *low*, *moderate*, *considerable*, *high*, and *extreme* would give us a better picture of the situation. Then, overlaying the amount of skier visits on those days will tell us the percentage of skier visits that are at different danger levels. Our hypothesis is that when looking at actual days being toured at *considerable*, the relative risk will not in fact be greater than at *high* or *extreme* but rather smaller. We can then look at whether the avalanche danger forecast has a cause and effect relationship on skier visits? Either we will find that avalanche bulletins have an impact on skier visits and thus influence behaviour or that it has no impact and commitment bias is big. Otherwise, we may also observe a combination of the two effects. As in, a danger level of *high* reduces significantly the number of visitors compared to *considerable*. However, a danger level of *considerable* does not alter significantly behaviour compared to *moderate*.

The purpose of study is to investigate the avalanche danger scale. More specifically, what is the deaths at each avalanche danger required to keep the probability of getting caught the same amongst

* Corresponding author address:

Terry Eyland
Bishop's University, QC, Canada;
tel: 819-822-9600 ext. 2752;
email: teyland@ubishops.ca

all danger levels, as well as what is the influence of snowfall, day of week and danger on the decision of someone to head out into the backcountry. The rest of the paper is as follows. Section 2 will present a short literature review. Then, section 3 will describe the data obtained; provide some descriptive statistics and some regression results. Section 4 will consist of the conclusion as well as extensions and policy recommendations.

2. LITERATURE REVIEW

In his “Considering Considerable and Other Considerations” (Blake, 2004) article, he separates the population of backcountry users with respect to experience. The experience level may have an impact on people’s perception of risk or danger when they hear different avalanche danger levels. The claim though that we seek to verify is whether the risk is highest at the *considerable* danger level. If that were true it would mean for an equal amount of people heading out at all danger levels, *considerable* would lead to the most avalanche accidents. We believe that it is very important here to take into account how many skier days there are at all danger levels in a given season before putting accidents into perspective. It would not make sense to claim that *considerable* is the riskiest if 10 out of 10,000 get into an accident at *considerable* but at *extreme* 3 out of 4 get into an accident. In absolute terms *considerable* would have more, but in relative terms with respect to risk *extreme* or *high* would be a lot more risky.

Hendrikx and Johnson (2014) had an interesting approach to monitor how people behave on different days by using GPS devices and following their tracks. Although, this is a good idea, we believe that only a certain type of person would accept to be monitored and they would potentially alter their behavior/mindset if they know they are being monitored. It would be an amazing idea if we could monitor people without their knowledge.

Saly et al. (2016) used time-lapse photography to monitor Bridger Bowl and gather data. It provides an opportunity to document terrain use in different snowpack and avalanche conditions by travelers in easily accessed backcountry terrain. Hopefully, in the future we can access similar information to get a good representation of how participants who are acting when they believe no one is watching.

Haegeli et al. (2012) found that participating snowmobilers interpret danger ratings on a linear scale and that persistent weak layers does not affect their riding choices. In the event of an increasing avalanche danger, they will first gravitate

towards zones with heavy traffic before avoiding complex or challenging terrain. Eyland (2016) obtained a similar conclusion that if backcountry enthusiasts see tracks, they are more likely going to accept a higher avalanche danger rating to ski that zone.

Kristensen et al. (2012) mention that a faulty perception of probabilities may be an important factor especially with trained user groups. This result, prompts us to wonder if people’s perception of *high* and *extreme* as being dangerous, and of *considerable* of having only a very low probability.

Lastly, we wonder how much the McCammon’s (2004) commitment heuristic comes into play. If people have their mind set on backcountry skiing what danger level will in fact induce them on doing otherwise.

3. DATA

3.1. *Description*

For this study, we wanted data not only on avalanche danger but also on skier visits. The only location we got access to both, as many ski resorts are secretive with some of their data, is from Roger Pass, BC (Glacier National Park). Therefore, the data used in this study either comes from Parks Canada or from Avalanche Canada. We have daily information on:

- The avalanche danger rating for below treeline, treeline, and alpine (2016-18)
- One day snow permit requests (does not take into account pass holders) (2016-17)
- Parking totals per day in the following sectors (Bostock, Loop, Illecillawaet, NRC, RPDC, Hermit, Stone Arch, Beaver) (2017-18)
- Snow (HN24 7am at Fidelity station) (2017-18)
- Which sectors are open or closed (sadly this information was not well compiled and had to be removed due to faultiness)

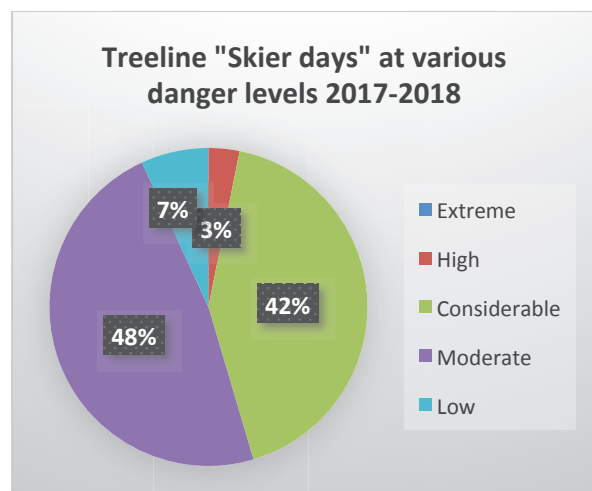
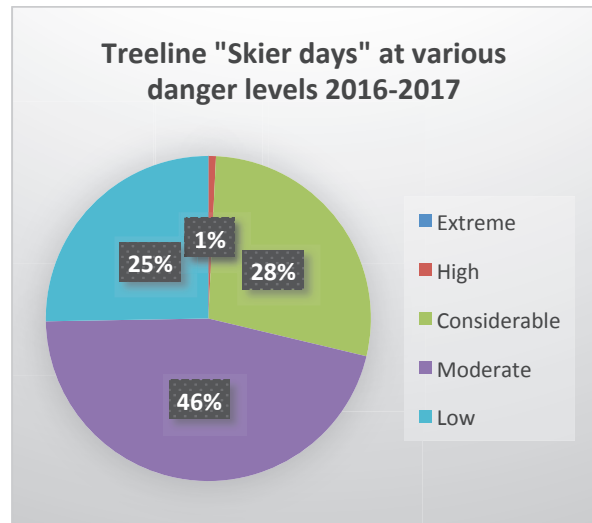
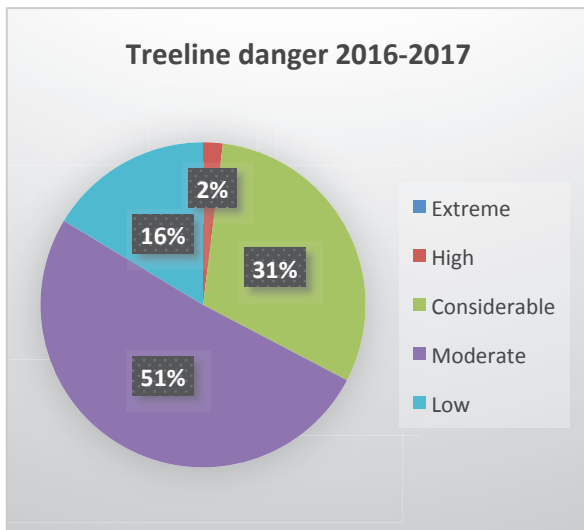
3.2. *Descriptive statistics*

With the data currently obtained, we found that in the Winter 2016/2017 and 2017/2018 seasons, we never had any days at the *extreme* avalanche danger level for any elevation band. In 2016-2017 *high* only had 12% of the days in the alpine 2% at treeline and 0% below the treeline. Looking at this data, it is easy to see why most deaths happen at

Presented at 2018 International Snow Science Workshop in Innsbruck, Austria

considerable and *moderate* because most of the days happen at one of those two danger ratings with 87% of the days at alpine and 82% at treeline. When we overlay skier visits we get 90% at alpine and 74% at treeline of the total skier visits are when the danger is either *considerable* or *moderate*.

If we only look at treeline, being the mid elevation band, we get the following pie charts for 2016-2017 and 2017-2018. The first pie chart only looks at the percentage of days at various danger levels (note that there were no *extreme* danger level in both years at all elevation bands). The second pie chart looks at the percentage of "skier" days that were at each danger level at treeline. In 2016-2017 we use daily park passes given out as a proxy for skier days and in 2017-2018 we used parking totals as a proxy.



As can be observed, in the first pie chart of both years, there are very few days where we have *high* avalanche danger. Most days are either *considerable* or *moderate*. If you look at the second pie chart the difference is even more notable since on

Presented at 2018 International Snow Science Workshop in Innsbruck, Austria

a daily basis less people go out at *high* avalanche danger. If we come back to the raffle idea of the introduction in 2016-2017 for one death at *high* you would need roughly 28 deaths at *considerable*, 46 deaths at *moderate* and 25 deaths at *low* to have an equal probability of dying in an avalanche relative to the amount of skiers that go out at that danger level (i.e. a raffle that has 1 winner in 1000 has the same likelihood as one that has 100 winners in 100,000 as in both would have a 0.1% chance of winning). When you put things into perspective no wonder most deaths happen at *considerable* and *moderate*. Obviously, these numbers are based on a specific region in a specific season. We would invite others from various regions around the globe to take a good look at fatalities and skier visits at different danger levels.

Sadly with faulty data, we were not able to say too much with respect to how people behaved based on zone closures (what percentage of time were certain zones open/closed) and what kind of terrain they were ridding.

3.3. Regression results

We tried running multiple regressions using the proxy for skier visits (day passes in 2016-2017 and parking totals in 2017-2018) as the dependent variable. Then tried a series of explanatory variables. As there were no cases with the *extreme* avalanche danger rating, we used *high* as the default scenario and assigned different dummy variables if the avalanche danger was *considerable*, *moderate* or *low*. That way the coefficient if significant would tell us how many more visitors should show up if we have *considerable* (or *moderate* or *low*) compared to *high*. New snow was used as another explanatory variable. It is the data that was obtained at 7am from the Fidelity weather station in 2017-2018 and this data was kept continuous. We use weekdays as the default and assigned a dummy of 1 if it was the weekend. Holidays were not taken into account since they can be variable due to the visitors coming from all over. We even tried a dummy variable if there was a drop in danger level compared to the previous day and also if there was an increase (turned out to be non-significant and removed from the final regression).

Overall, in all simulations the weekend variable was positive and significant. Snowfall was generally significant and always had a negative value. An explanation may be that the day of a big snowfall most people go the resort and wait for stability to be better before heading to Glacier National Park.

We tried including information on danger levels for all elevation bands in the same regression but this does not add value and can bring some form of multi-collinearity. Once again we simply focused on including dummy variables and information on the avalanche danger level at the treeline elevation band. The following two tables show the results.

2016-2017			
Multiple R	0.4994		
R Square	0.2494		
Adj. R square	0.2291		
Observations	153		
	Coeff.	t Stat	P-value
Intercept	29.7994	0.7819	0.4355
Weekend	48.6018	4.0886	0.000
TL Con	62.8468	-6.282	0.000
TL Mod	67.1386	-3.392	0.001
TL Low	140.088	2.396	0.017

Tbl. 1: Regression results for 2016-2017

2017-2018			
Multiple R	0.4787		
R Square	0.2292		
Adj. R square	0.2018		
Observations	147		
	Coeff.	t Stat	P-value
Intercept	29.1117	3.2711	0.0013
Fid HN	-0.5841	-2.1520	0.0331
Weekend	20.4556	4.6926	0.0000
TL Con	25.8023	2.9732	0.0035
TL Mod	22.1695	2.4840	0.0142
TL Low	14.9756	1.3287	0.1861

Tbl. 2: Regression results for 2017-2018

In both cases, weekend is significant at the 99% level. The coefficient is different (but the average number was different due to different proxies X day passes per day in 2016-17 versus Y cars per day in 2017-18) a weekend day typically attracts 20.4 more day passes or 48.6 more cars in the parking. Then the dummy for *considerable* and *moderate* is at the 99% level in 2017-2018 and around the 90% level in 2016-2017. The interesting part is that in both years the coefficients for *considerable* and *moderate* are roughly the same. The interesting observation is that if the danger

level has an impact on the decision of the backcountry users, they seem to put *considerable* and *moderate* in the same category (as they attract roughly the same amount of visitors). *High* clearly gathers less. *Low* is not significant in 2017-2018 and very significant (99%) in 2016-2017 with a higher coefficient than *considerable* and *moderate*.

4. CONCLUSION

Through this study, we have first noticed most skier days (74-90%) are either at *considerable* or *moderate*. This fact should make people wary of someone saying that since most deaths happen at *considerable* or *moderate* those are the danger levels with the greatest risk/probability.

We have also noticed through regressions that a danger of *considerable* or *moderate* seem to have the same impact on people's decision to go skiing or not. We would agree with Kristensen et al. (2012) that people put *extreme* and *high* in a category and treat *considerable* as much less dangerous.

Our policy recommendations are that since *extreme* is very rarely used (not once in two seasons at all elevation bands), it should be removed.¹ You would remain with the first 4 categories and how they are currently defined. *Extreme*, which is close to stating "certain avalanche danger", could simply be omitted similarly to the "certain of no avalanche danger" category, which does not exist. We believe that the removal of *extreme* will make people treat what is now known as *considerable* as in the upper half of danger potential compared to its current vague middle ground. For some the word *considerable* is also vague so we may want to keep the definitions of the first four categories, but call the old *considerable* as *high* and the old *high* as *extreme*.

Future research can be done to observe whether the danger rating significantly change the decision to ski or rather changes where the people choose to ski? Such as downgrading to a safer slope when danger goes up? Or do people adjust their choice based on what is open and take for granted that what is open is good to go? Similar question can specifically be applied to the slackcountry. Some people may believe that once a backcountry

gate is open the conditions are deemed safe enough (explaining why so many still cross without the proper avalanche equipment and training). There is still more research required to understand how people behave and how to 'nudge' them in taking the best decision.

CONFLICT OF INTEREST

No company supported financially or materially the creation of this document.

ACKNOWLEDGEMENTS

We acknowledge Parks Canada and Avalanche Canada for the data used in this study.

REFERENCES

- Blake, S. 2004: Considering Considerable and Other Considerations. *International Snow Science Workshop Proceedings*, Jackson Hole, United States, pp. 470-475.
- Eyland, T. 2016: What is the Risk Threshold that Backcountry Enthusiasts are Willing to Accept and How Does Their Perception Align with the Actual Risk Involved? *International Snow Science Workshop Proceedings*. Breckenridge, United States, pp. 759-765.
- Haegeli, P., Strong-Cvetich, L., Haider, W. 2012: How Mountain Snowmobilers Adjust their Riding Preferences in Response to Avalanche Hazard Information Available at Different Stages of Backcountry Trips. *International Snow Science Workshop Proceedings*, Anchorage, USA
- Hendrikx, J., J. Johnson, 2014: Using Global Crowd-Sourced Data to Understand Travel Behavior in Avalanche Terrain. *International Snow Science Workshop Proceedings*. Banff, Alberta, Canada.
- Kristensen, K., Genswein, M., and Munter, W. 2012: Perception of Risk in Avalanche Terrain. *International Snow Science Workshop Proceedings*, Anchorage, USA.
- McCammon, I., 2004: Heuristic Traps in Recreational Avalanche Accidents: Evidence and implications. *Avalanche News*, 68(1), pp.1-10.
- Saly, D., Hendrikx, J., Johnson, J., Richmond, D. 2016: Using Time-Lapse Photography to Monitor Avalanche. *International Snow Science Workshop Proceedings*. Breckenridge, United States, pp.192-198.

¹ For the people who wish to keep the *extreme* rating, another option would be to introduce a danger level that would be a situation of "no" avalanche danger. It would probably almost never get used, but so does *extreme* seldomly get used.