# USING GLOBAL CROWD-SOURCED DATA TO UNDERSTAND TRAVEL BEHAVIOR IN AVALANCHE TERRAIN

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ABSTRACT: This paper will present the results from our first winter season (2013-14) of data collection using a global crowd-sourced approach to collect travel behavior data for people moving in avalanche terrain. To date, most studies of the human dimensions of decision making in avalanche terrain has focused on two areas - post-accident analysis using accident reports/interviews and, the development of tools as decision forcing aids. We present an alternate method for understanding decision-making in avalanche terrain. Our project combines real-time GPS tracking via a smartphone application, with internet based surveys of backcountry skiers as a method to describe and quantify travel practices in concert with group decision-making dynamics, and demographic data of participants during daily excursions into winter backcountry. Preliminary data analysis shows that individual experience levels and regional avalanche danger ratings all influence the ways in which people travel in avalanche terrain. Our results will provide the first analysis of coupled real-time GPS tracking of people moving in avalanche terrain combined with psychographic and demographic correlates. This research will lead to an improved understanding of real-time decision making in avalanche terrain.

KEYWORDS: .Decision making, Terrain analysis, Human factors, Demographics, GPS

## 1. INTRODUCTION & BACKGROUND

The primarily purpose goal of this paper is to present preliminary results of our first full season using global crowd sourced data to understand travel behavior and decision making in avalanche terrain. We propose that our methodology presents a step forward in collecting data to understand decision making process and outcomes in close to real time and without the biases inherent in post hoc accident analysis.

Safe winter backcountry travel in hazardous terrain is a combination of education, experience, judgment, and technology. Detailed trip information that investigates the synergistic role of all factors in individual outings or over the course of a winter season are largely anecdotal or nonexistent. The lack of comprehensive data is problematic given the increasingly wide recognition of the human dimensions of decision- making in minimizing risk during winter backcountry travel.

In an effort to mitigate risk associated with unstable snowpack conditions and resultant avalanche accidents, avalanche field courses and other educational opportunities provide backcountry users with the snowpack assessment and terrain management skills. Skills are augmented and refined by the judgment that comes through experience. Evidence exists that education may play a less important role in avalanche risk mitigation than often assumed and may, in fact, provide a false sense of security to avalanche victims (Atkins 2000; McCammon 2004). Such studies typically rely on post hoc analysis of avalanche accident incident reports and tend to focus on accident features available at the accident site - terrain features, snowpack analysis, weather, and hazard reports. Less common are witness reports, quality demographic data on victims as well as additional "human factors" such as decision-making processes, group dynamics, and terrain management procedures. These human factors are increasingly

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recognized to be significant features of most accidents.

Using winter backcountry (BC) travelers as our sample population, we suggest the methodology described here, and in more detail in Hendrikx and Johnson (submitted) will test the role of topographic/hazard risk factors as they relate to group decision processes stratified by demographic and psychographic variation. Specifically, how do small groups of travelers in the BC use a combination of topographic, environmental, and hazard elements to plan a safe and efficient route in a high-risk/ low probability environment and, integrate demographic and trip-based psychographic motivations into the decision-making process?

To address these questions, we have investigated the intersections of the role of geographical complexity, social demographics and psychographic biases on decision-making while navigating hazardous winter terrain using large scale crowd sourced data collection coupled with GPS tracking, pre and post trip demographic and psychographic surveys. In this paper we will provide preliminary results from our first season of data collection.

## 2. METHODS

During the Winter of 2012/13 we enlisted a small group of volunteers located in Bozeman/Big Sky, Montana, USA to help us examine these issues via a pilot study (Hendrikx et al., 2013). All were experienced backcountry skiers with high levels of avalanche expertise; many were avalanche professionals. As a result of this homogeneity of this group, statistical variation was minimal. The consequence was that results from this pilot study did not generalize to a larger population nor did standard statistical tests of significance apply (Hendrikx et al., 2013). In response to this deficiency a new, global crowd sourcing data collection campaign was initiated. The purpose of this campaign was to sample a more heterogeneous group (i.e. collect data from a more heterogeneous group – multiple locations, multiple skill levels, multiple travel strategies etc.) using.

For the Northern Hemisphere Winter of 2013/14 we launched this new approach via our project webpage (www.montana.edu/snowscience/tracks) and used a smartphone application called SkiTracks to track people more easily and enable rapid sharing of their spatial data. Combined with this application, we used a smartphone optimized survey tool to allow for easy and rapid completion of the daily post trip survey / logbook (rather than use a paper based logbook as per Hendrikx et al., 2013). A flow diagram showing the steps involved for participants is shown in Figure 1.

Using this fully digital, smartphone based approach, we collected several hundred tracks from all around the World. We received tracks mainly from people in the Intermountain USA (Montana, Wyoming, Utah, Colorado, Idaho), but also received some tracks from Alaska, Canada, Norway, Austria, France and Slovenia.

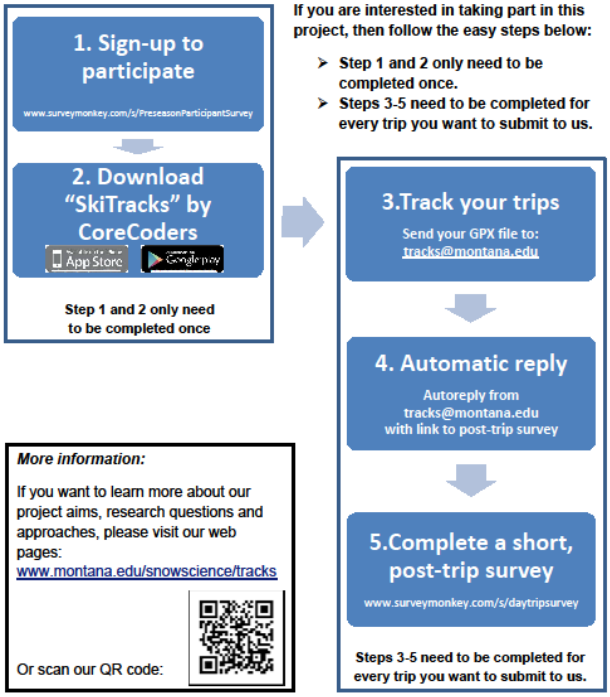


Figure 1: A Flow diagram showing the steps for participation in the crowd sourced project to understand decision making in the avalanche terrain.

Each track was brought into a Geographic Information System (GIS) and overlaid on a Digital Elevation Model (DEM) and key terrain metrics were extracted. These were then linked to the preseason, mainly demographic focused survey, and post-trip, mainly psychographic survey responses. This allowed us to obtain a more complete understanding of the person, their group, their decision making practices and their resulting terrain usage. We also collected avalanche danger ratings for each track, from each area, for each day.

A more in depth discussion of the sampling method, survey design, operationalization of decision heuristics, data processing and analysis methods is presented by Hendrikx and Johnson (submitted).

## 3. RESULTS

### *3.1 Participants demographics*

For brevity, we will only present a few of the key findings here. Overwhelmingly, our respondents were male (84%) with the remaining participants female (16%). Their ages ranged from 17 to 69, but most were in the 26-35 year age bracket (40%). The highest level of education varied, but the most common category was a Bachelor's degree, (46%), followed by a graduate degree (33%). The majority of participants were employed, working 40 or more hours per week (69%). Hereafter a smaller sub set were employed part time (14%), or were active students (11%). They also typically participated in other outdoor sports, with the most frequent being; Hiking or Hill walking (89%); downhill skiing (88%); Camping (82%); Mountain Biking (67%); Trail running (52%) and Rock Climbing (51%).

Based on our demographics data, a typical survey participant was a male, aged 26-35, has a bachelor's degree, is employed full time working 40 or more hours per week, can be either married or never married, has no children, and participated in several outdoor sports with hiking, downhill skiing, camping and mountain biking, trail running and rock climbing being done by 50% or more of the participants.

### *3.2 Participant experience*

The majority of participants identified themselves as expert backcountry travelers (53%), with the remaining identifying themselves as intermediate (43%), and novice (4%). When the number of years skiing (in bounds and BC) was considered for each of these groups, we note the average showed a statistically significant increase from 16 years for novices, to 20 for intermediate, to 30 for expert BC travelers.

When it came to terrain management skills, novice BC travelers expressed moderate (50%) and no confidence in their terrain management skills (34%), with only a small proportion have high confidence (16%). Intermediate BC travelers expressed mainly moderate (44%) and high confidence (39%) in their terrain management skills, with a small number having a high stated proficiency (13%) and a few able to manage any terrain (3%). Expert BC travelers expressed that they had high confidence (33%), were highly proficient (40%) and some could manage any terrain with respect to their terrain management skills (23%). Only 5% of this expert group expressed that they had only moderate confidence in this area. Interestingly, those that stated that they could manage any terrain had all taken at least a level two avalanche course, and had at least 11 years of experience.

An analysis of the responses regarding terrain management skills, and level of avalanche education were shown to be statistically significant using the Mann-Whitney U Test at the $p < 0.05$ level between self-identified experts and intermediate BC travelers – i.e. Experts were more qualified and responded that they could broadly better manage avalanche terrain.

### *3.3 Participant decision making*

The following decision making related questions showed statistically significant differences in response, between intermediate and expert groups using the Mann-Whitney U Test at the $p < 0.05$ level. These included:

- I try to determine the real issue before starting a decision-making process
- I use a well-defined process to structure my decisions
- Before I communicate my decision, I create an implementation plan

Again, this suggest that self-identified experts do these / consider these issues more frequently than intermediate BC travelers.

### *3.4 Terrain used*

In all cases, the Mann Whitney U test shows that groups with the first skier listed as expert, used on average steeper slopes that those where the first skier was listed as an intermediate. This was evidenced ($p < 0.05$) for the 99$^{th}$, 95$^{th}$ and 90$^{th}$ percentiles of slopes used, and as shown for the 90$^{th}$ percentile in Figure 2.

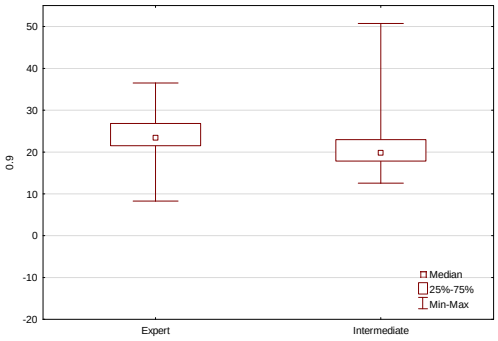


Figure 2: 90th percentile slope angles used by various groups, as divided by the first skier BC skill level. Novices not shown.

## 4. DISCUSSION

The implications of these results are that for the first time, we have a complete view of the demographics, psychographics and terrain usage by a cohort of BC travelers under a range of individual, group and hazard conditions. These data, as a cohesive and combined set, have until now not been available. These data, while still presenting some challenges with respect to the isolation of key driving variables, provide some insight into the type of terrain used (as expressed by the steepest slopes) by various groups and participants with different levels of experience. A smaller scale, more detailed case study approach with fewer degrees of freedom (e.g. Haegeli et al., 2010) may be needed to accompany this larger scale approach to provide a more complete understanding of decision making processes in avalanche terrain.

One of our findings presented here, relates back to the work by McCammon (2004) which suggested that avalanche education and overall proficiency might increase the likelihood of an avalanche fatality. We focused here on the self-assessed BC skills of the participant and we showed that in our data set, for the number of years of skiing, the avalanche education, and the ability to manage terrain was statistically different between intermediates and experts. At the same time, we also showed that experts did use steeper terrain.

Our data show that expert BC travelers do expose themselves to more severe terrain, but at the same time have higher levels of avalanche education, experiences and self assessed levels of avalanche terrain management ability. Are these differences sufficient to outweigh the steeper terrain that experts tend to use? The results from McCammon (2004) suggested that this may not be the case. While we make no statement about the resulting likelihood of avalanche fatalities by the expert group, we can clearly see their use of steeper terrain.

A more in depth analysis of these data, including consideration of a number of other factors related to group size, gender, location and decision making processes was considered outside the scope of this current paper, but is presented in Hendrikx and Johnson (submitted).

## 5. CONCLUSIONS

We have presented preliminary results from our first winter season (2013-14) of data collection using a global crowd-sourced approach to collect travel behavior data for people moving in avalanche terrain. This has shown that our methods can be used at this scale and providing meaningful insights to decision making and travel behavior in avalanche terrain. In this data set, we have observed differences based on experience for both terrain usage and self-assessed terrain management skills. While our approach provides some useful insights, future work will use a combined approach using smaller scale case studies within our larger scale crowd sourced data collection campaign. We anticipate that this will provide additional insights and understanding regarding decision making in avalanche terrain.

## ACKNOWLEDGMENTS

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