Understanding Travel Behaviour in Avalanche Terrain: A New Approach

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ABSTRACT: 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. While both methods inform our study of decision-making, each has limitations with respect to construct validity (Are we actually measuring what we think we are measuring? i.e. decisions) and, the role the decision tools play with respect to forcing vs. enhancing decisions.

We present an alternate method for understanding decision-making in avalanche terrain. Our project combines GPS tracking and logbook 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. Data gathering for this small pilot project took place during winter 2012/2013. We will present findings that shed light on real time decision-making while traveling in potential avalanche terrain and small group decision-making practice.

KEYWORDS: Decision Making, Human Factors, Heuristics, GPS, GIS, Terrain Analysis.

1 INTRODUCTION

Safe winter backcountry travel in hazardous terrain is a combination of education, experience, judgment, and technology. To date, detailed trip information that tests the synergistic role all factors play in individual outings or over the course of a winter season was 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 in winter travel.

Avalanche field courses and other educational opportunities provide backcountry users with the snowpack assessment and terrain management skills that mitigate risk from unstable snowpack conditions and resultant avalanche accidents. These skills are augmented and refined by the judgment that comes with experience. Evidence exists however 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 recognized to be significant features of most accidents. One method to collect these missing data before accidents happen is through the use of GPS tracking and logbook entries that accompany each backcountry excursion. By doing so we can build a model of the complex travel and social dynamics inherent in winter backcountry travel.

2 BACKGROUND

Avalanches are high risk/low probability events dominated by incomplete information about risk and likelihood of a dangerous release. Along with snowpack assessment and other strategies, skiers utilize terrain and geographical features to adapt to conditions and to mitigate risk; avalanche education places great emphasis on the use and interpretation of such features. Slope aspect and angle are two important factors used to predict avalanche hazard. They are relatively simple variables the backcountry traveller can use to minimize risk. Additionally, it has been suggested by McCammon (2004) and others (Fredston, et al., 1994; Haegeli, et al., 2010; Furman, et al., 2010) that the processes by which terrain features are managed may be a contributing factor to accidents. Often, the deci-

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sion making team is a small (2-4 persons) group of like minded individuals seeking to maximize their recreational value of time spent in the backcountry. In doing so, they may fall trap to multiple decision-making pathologies.

Global Positioning System (GPS) technology is potentially an effective tool for understanding how backcountry skies adapt their travel strategies to snowpack conditions. Such technology is widespread across industry and public safety agencies. We suggest here it can be utilized for the analysis of travel patterns by backcountry skiers in potential avalanche terrain.

Negative outcomes of poor decisions in these and similar settings, while rare, often result in personal injury or death. Accidents are often considered random and unexpected when, in fact, they may be more predictable than the literature would suggest. The work described here is applicable to small group decisions in the high stress world of emergency management, wildland fire-fighting, search and rescue scenarios, aviation, combat, and in public/private administrative risk management settings. Paramount among the challenges in such environments is the issue of how to uphold safety while responding to constantly changing conditions and geographical complexity.

3 METHODS

Our methods utilized detailed spatial analysis of individual participant GPS tracks with topographic and hazard data within a Geographical Information System (GIS), combined with a logbook entry for the group for each backcountry excursion.

The sample population for this phase of research was all located in Bozeman/Big Sky, Montana. All were experienced backcountry skiers with high levels of avalanche expertise; many are avalanche professionals. As a result of this homogenous group, statistical variation is minimal. The consequence is that results from this survey are not generalizable to a larger population nor do standard statistical tests of significance apply. This study is largely exploratory in nature and so probability of not committing a type II error is of less concern – that is; confirming an idea that should have been rejected as false. Each participant was issued a GPS devise and logbook and asked to map their trips to the backcountry. For analysis purposes we used only tracks located within the catchment area of the Gallatin National Forest Avalanche Center advisories. Each participant completed a pre-season survey that described their skiing ability, snowpack assessment, and various demographic data.

The geospatial data was collected at the end of the trial and downloaded into the GIS that allowed for the generation of terrain based summary statistics by overlaying these on to a 10m digital elevation model (DEM). The key terrain attributes we considered where: Speed, Duration, Slope, Aspect, Elevation and distance to ridge and trailhead.

Each geospatial track was combined with the logbook data for each person, for each day and tagged with a unique and confidential identifier. We utilized data from 29 GPS tracks. A sample track and example output data is displayed below (Figure 1).

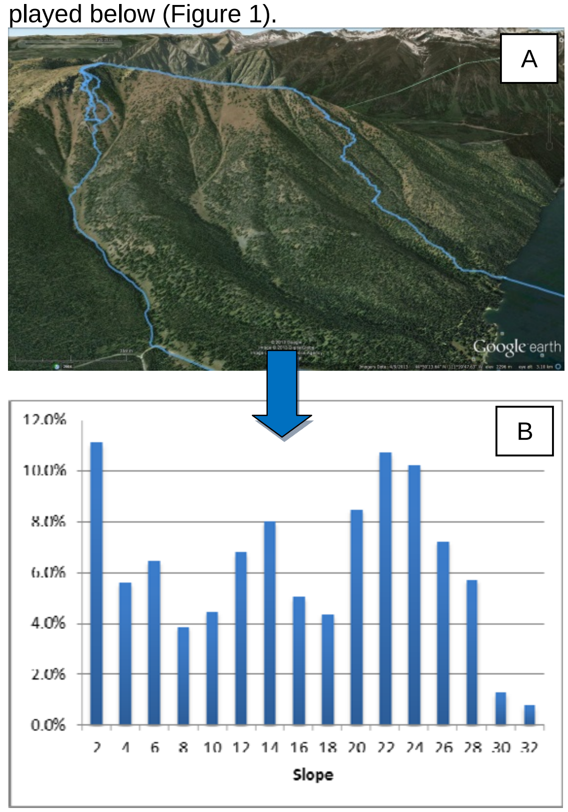

Figure 1. (A) An example of a GPS track log (shown in blue) overlain on Google Earth (Image courtesy of Google Earth, 2013); and (B) Example output data from this track showing the distribution of slope angles travelled on this day.

The second source of information was the use of a log book for recording demographic and psychographic data. The logbook operationalizes variables cited by McCammon (2004) as being important to understanding failures of decision making by asking respondents about assessment strategies, group dynamics and decision making, and assessing items such as focus on the day's goal and commitment. It also collected demographic data, equipment carried by the group, snowpack assessment, and outcomes for the day.

4 RESULTS

In this paper we will only present two relationships. The first is based on slope angle and posted avalanche hazard (Figure 2), and the other is slope and our "goal" parameter (Figure 3), which is a proxy for the commitment heuristic (McCammon 2004).

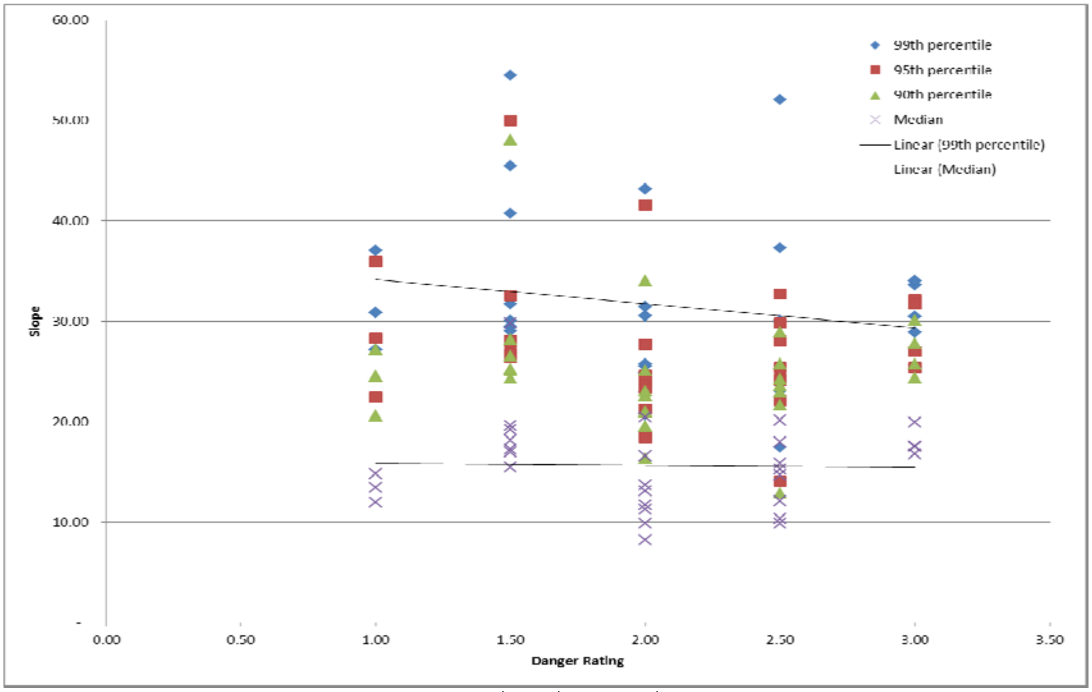

Figure 2. Slope angle (°) for the median, 90th, 95th and 99th percentile of terrain travelled (y axis), plotted against posted avalanche hazard rating (x axis), coded; 1 for low, 2 for moderate and 3 for considerable.

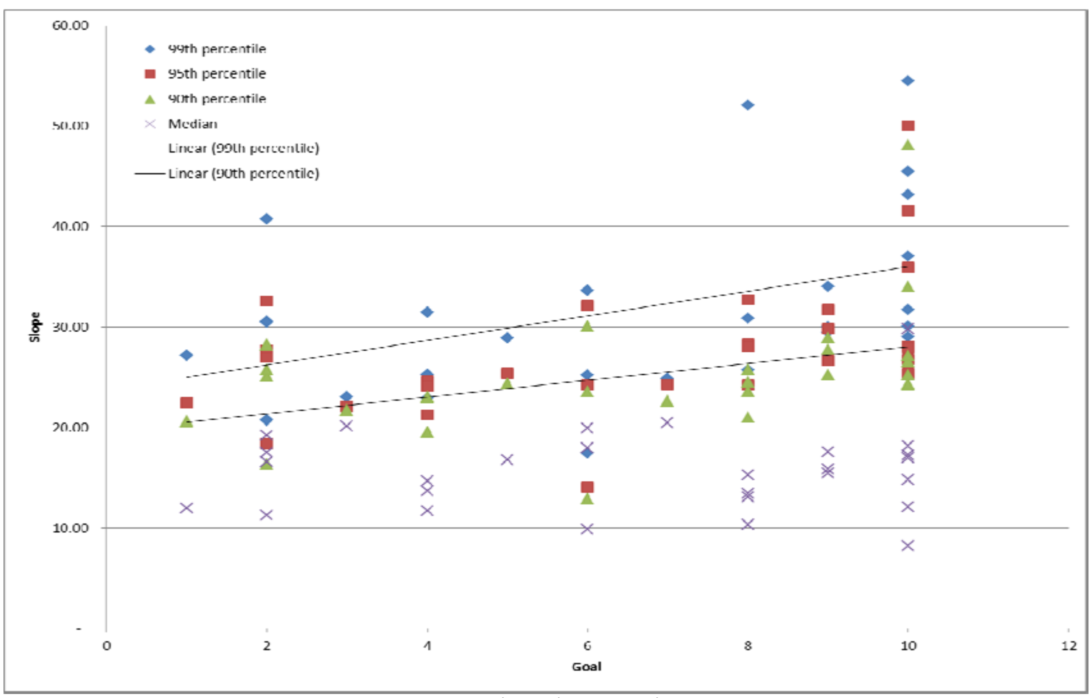

Figure 3. Slope angle (°) for the median, 90th, 95th and 99th percentile of terrain travelled (y axis), plotted against the parameter "goal", where a coded response to "Did your assessment of the snowpack affect the day's goal?" with the response scale 1 = not at all, to 10 = very much.

Figure 2 depicts a relationship between the posted avalanche danger rating from the Gallatin National Forest Avalanche Center (i.e. the local avalanche forecaster center) for the day of the track (x axis) and slope angle in ° from the GPS track (y axis). For slope angle we have only shown the median, the 90th percentile, 95th percentile and 99th percentile from each track for each day. We have elected to do this as we hypothesis that these higher percentiles will show the most variation as they represent the steepest slopes that a skier will encounter in a day. From figure 2 it appears that at the higher slope angles (i.e. 99th percentile) there is a very weak negative relationship (R^2 = 0.029) between the angle of slope skiers negotiated and the posted avalanche danger rating (please note our caveat in the methods regarding statistical significance). In other words, given a higher danger rating for the day, the steepest slopes that skiers negotiated were less steep on either the approach or descent.

Figure 3 indicates a weak positive relationship (R^2 = 0.17) between slope angle in ° from the GPS track (y axis) and the variable "goal". Goal represents a response to the following question in the logbook: "Did your assessment of the snowpack affect the day's goal?" The response scale was 1 = not at all, to 10 = very much. The question is intended to query respondents with respect to a common heuristic – anchoring (Tversky & Kahneman, 1974). The results suggest skiers adjusted their goal for the day based, in part, on the slope angle. While some still negotiated steep lines (40° and above), they report that the specific slope (and its assessed stability) was a factor in their decision. We surmise they utilized knowledge of slope angle and local, small scale stability, to make their travel determination but the conclusion is open to multiple interpretations (see discussion below).

5 DISCUSSION

This preliminary exploratory research accomplished several goals. First, it demonstrates the efficacy of GPS tracking of backcountry skiers and the logbook exercise. Several important relationships that explore how skiers manage terrain and mitigate hazard shed light on real time decision-making while traveling in avalanche prone locations. Use of the GPS ensures potentially subjective variables such as slope, aspect, duration, elevation gained and lost, and distance covered are recorded accurately for efficient analysis. The ability to extract terrain features and avalanche hazard within the GIS removes variability due to individual interpretation from the analysis of the tracks.

The findings presented in the two graphs (Figure 2 and 3) are examples and are open to interpretation, but provide a good starting point for discussion. Interpretation of the two graphs is likely more powerful when considered together. Where we suggest a weak negative relationship between the angle of slope skiers negotiated and the avalanche danger rating we should also consider how and when expert backcountry skiers make their decisions about where to ski. Often, these decisions are made before departing on the day's tour (e.g. morning meeting / discussion at the trail head). Prior information with respect to the decision point is missing in chart two. Based on the general trend in the data in Figure 3, it is possible that given a favorable avalanche hazard report, or assessment of local snow conditions, that skiers adjusted their goal upward – i.e. Their assessment of the snowpack affected the day's goal, in an upwards / more steep direction. Further, this presentation does not delineate between up and down tracks although with further analysis that is possible. While there is indication that skiers adapt to terrain differently given different snow conditions, the tracks show that even high level skiers can, and do make potentially marginal terrain choices. This may be reflected in the relatively high number of steep slopes skied as depicted in figure 3.

Finally, this pilot study demonstrates that real world GPS data when combined with logbook entries may be a powerful learning tool for skiers who wish to enhance their terrain management skills. We have a number of other heuristics that we can explore with the data collected to date to provide insight into decision-making in avalanche terrain. We intend to refine the use and viewing of the GPS track to make it user friendly for use in an end-of-the-day review with respect to where and how terrain choices were made by small groups of skiers.

6 CONCLUSIONS

The GPS/Logbook method is potentially a useful set of tools that will allow for a new way to more directly understand the human dimension of decisions made during backcountry travel. The geospatial data is robust and rich, and not subject to skier bias. We will continue to refine the method and expand it to include crowd sourced data collection procedures that will overcome the present issue of small samples.

7 ACKNOWLEDGEMENTS

We would like to thank all of our volunteers that tireless tracked their ski tours and completed their daily logbooks to provide us with data for this project. We also want to thank Mazamas (http://www.mazamas.org/) for a research grant to support this pilot study and the Montana State University Undergraduate Scholar Program for supporting Ellie Southworth, to help with the data analysis. Without this assistance this work would not have been possible.

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